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DANIEL ALMEIDA FERREIRA BARBOSA

ASPECTOS ANATÔMICOS DE REPAROS DA REGIÃO INTERFORAMINAL MANDIBULAR E SUAS CORRELAÇÕES CLÍNICO-CIRÚRGICAS: ESTUDOS COM TOMOGRAFIA COMPUTADORIZADA DE FEIXE CÔNICO E REVISÕES SISTEMÁTICAS DA LITERATURA

FORTALEZA – CE
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Tese apresentada ao Programa de Pós-Graduação em Odontologia da Faculdade de Farmácia, Odontologia e Enfermagem da Universidade Federal do Ceará como requisito parcial à obtenção do grau de Doutor.

Área de Concentração: Clínica Odontológica

Orientador: Prof. Dr. Fábio Wildson Gurgel Costa.
Co-orientador: Prof. Dr. Lúcio Mitsuo Kurita.

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BANCA EXAMINADORA

____
Prof. Dr. Fábio Wildson Gurgel Costa (Orientador)
Universidade Federal do Ceará (UFC)

____
Prof. Dr. Francisco Samuel Rodrigues Carvalho
Universidade Federal do Ceará (UFC), *Campus Sobral*

____
Prof. Dr. Ivo Cavalcante Pita Neto
Centro Universitário Doutor Leão Sampaio (Unileão)

____
Prof. Dr. Frederico Sampaio Neves
Universidade de Federal da Bahia (UFBA)

____
Prof. Dr. Phillipe Nogueira Barbosa Alencar
Centro Universitário Unichristus (UNICHRISTUS)

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“Há tantos quadros na parede
Há tantas formas de se ver o mesmo quadro...
ninguém é igual a ninguém”
Humberto Gessinger

RESUMO

Forame mentual (FM), *loop anterior* (LA), forame mentual acessório (FMA), foramina lingual (FL) e tubérculos genianos (TG) são importantes reparos anatômicos mandibulares que devem ser detalhadamente avaliados por tomografia computadorizada de feixe cônico (TCFC) quando do planejamento de intervenções cirúrgicas. Nesse contexto, a presente tese apresenta cinco capítulos que têm como objetivos principais, respectivamente: 1) realizar revisões sistemáticas (RS) sobre estudos que avaliaram fraturas dos TGs (capítulo 1), FL (capítulo 2) e o FM e LA (capítulo 3) por meio de TCFC; 2) descrever aspectos topográficos do TG em TCFCs e propor uma classificação imaginológica para este (capítulo 4); 3) descrever aspectos topográficos do FM, FMA e FL por meio de TCFC e avaliar o risco estimado em relação a procedimentos cirúrgicos em região anterior mandibular (Capítulo 5). Nos capítulos 1, 2 e 3 foram realizadas RS em diferentes bases de dados, cadastradas na plataforma PROSPERO, e que seguiram os itens do guia *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA). Nos capítulos 4 e 5, foram realizados estudos transversais com TCFC. Foram observados aspectos radiomorfométricos (medições lineares absolutas/relativas, verticais/horizontais e angulares) mandibulares (FM, FMA, FL e TG), bem como foram obtidas informações demográficas. Nos cinco capítulos, foram realizadas análises descritivas e testes estatísticos apropriados, considerando-se valor de $p<0,05$ como significativo. Nos capítulos de RS, observou-se heterogeneidade estatisticamente significante entre os estudos. A prevalência global de até 2 FL foi de 88,54%, sendo que alguns estudos observaram até quatro FL (0,59%). A RS sobre fraturas do TG encontrou 24 casos relatados na literatura, principalmente isoladas e associadas ao edentulismo, comumente diagnosticados por exame radiográfico e tomografias computadorizadas. Em relação ao FM

e LA, a localização anatômica mais frequente do FM foi entre os pré-molares inferiores ou mais próximo ao segundo pré-molar e abaixo do ápice dos dentes. Alguns estudos relataram um maior diâmetro vertical do FM nos homens em relação às mulheres. A prevalência do LA foi de 2,47% a 94% e seu comprimento médio variou de 0,89mm a 3,69mm. No capítulo 5, observou-se prevalência de 89,86% (n=248) de pelo menos um TG, sendo a maioria duplos (57%). Foi proposta uma nova classificação tomográfica para os TGs, sendo o mais frequente o tipo IIIA (38,7%), seguido por IIIB (36,6%), IIA (21,4%) e IIB (3,6%). No capítulo 5, o presente trabalho observou uma prevalência 7,2% do FMA (mulheres, 5,2%; homens, 2%). O LA anterior foi observado em 45,8% das tomografias, não havendo diferença entre os lados, e a FL estava presente em 94,4% dos casos, sendo que em 31% dos indivíduos apresentaram duas FL. A estimativa de risco cirúrgico na região anterior mostrou uma distância de 4mm anterior ao FM, uma profundidade de 4mm em relação à cortical óssea vestibular para coleta de enxertos e osteotomias para genioplastia com uma distância de pelo menos 5mm para o FM como referências relativamente seguras para procedimentos invasivos nesta área.
Palavras-chave: anatomia, mandíbula, forame mentual, tomografia computadorizada de feixe cônico, estudo observacional.

ABSTRACT

Mental foramen (MF), anterior loop (AL), accessory mental foramen (AMF), lingual foramina (LF), and genial tubercles (GT) are important mandibular anatomical structures that must be thoroughly evaluated by cone beam computed tomography (CBCT) when planning of surgical interventions. In this context, the present thesis presents five chapters that have as main objectives, respectively: 1) to carry out systematic reviews (SRs) on studies that evaluated fractures of the GTs (chapter 1), LF (chapter 2), and the MF and AL (chapter 3) through CBCT; 2) describe topographic aspects of TG in CBCTs and propose an imaging classification for this (chapter 4); 3) describe topographic aspects of the FM, FMA and FL using CBCT and assess the estimated risk concerning surgical procedures in the anterior mandibular region (Chapter 5). In chapters 1, 2 and 3 SRs were carried out in different databases, registered on the PROSPERO platform, and followed the items in the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) guide. In chapters 4 and 5, cross-sectional studies with CBCT were carried out. Radiomorphometric aspects (absolute/relative linear, vertical/horizontal, and angular) mandibular measurements (MF, AMF, LF, and GT) were observed, as well as demographic information. In the five chapters, descriptive analyzes and appropriate statistical tests were performed, considering a value of $p<0.05$ as significant. In the SR chapters, there was statistically significant heterogeneity between the studies. The overall prevalence of up to 2 LF was 88.54%, with some studies having four FL (0.59%). The SR on GT fractures found 24 cases reported in the literature, mainly isolated and associated with edentulism, commonly diagnosed by clinical examination and computed tomography. In relation to MF and AL, the most frequent anatomical location of the MF was between the lower premolars or closer to the second premolar. Some studies have reported a greater vertical diameter of the MF in men compared to women. The prevalence of AL ranged from 2.47% to 94%, and its average length ranged from 0.89mm to 3.69mm. In chapter 5, there was a prevalence of 89.86% (n = 300) of at least one TG, the majority being double (57%). A new tomographic classification has been proposed for TGs, the most frequent being type IIIA (38.7%), followed by IIIB (36.6%), IIA (21.4%), and IIB (3.6%). In chapter 5, the present study observed a 7.2% prevalence of AMF (women, 5.2%; men, 2%). The anterior LA was observed in 45.8% of the CT scans, with no difference between the sides, and the FL was present in 94.4% of the cases, with 31% of the individuals having two FL. The surgical risk estimate in the anterior region showed a distance of 4mm anterior to the FM, a depth of 4mm for graft harvesting, and osteotomies for genioplasty with a distance of at least 5mm to the FM as relatively safe references for invasive procedures in this area.

Keywords: anatomy, mandible, mental foramen, cone beam computed tomography, observational study.

LISTA DE ABREVIATURAS E SIGLAS

AL	*Anterior loop*
AMF	*Accessory mental foramen*
CBCT	*Cone-beam computed tomography*
CCD	*Charge-coupled device*
CCI	Coeficiente de correlação intraclasse
CM	Canal mandibular
CMOS	*Complementary metal oxide semiconductor*
CT	*Computed tomography*
DICOM	*Digital imaging and comunications in medicine*
DTP	*Detector Technology Project*
FL	Foramina lingual
FLS	Foramina lingual superior
FLI	Foramina lingual inferior
FM	Forame mentual
FMA	Forame mentual acessório
FOV	*Field of view*
LA	*Loop Anterior*
RS	Revisão sistemática
PRISMA	*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*
PROSPERO	Registro prospectivo internacional de revisões sistemáticas
SPSS	*Statistical package for the social sciences*

STROBE	*Strengthening the reporting of observational studies in epidemiology*
TC	Tomografia computadorizada
TCFC	Tomografia computadorizada de feixe cônico
TG	Tubérculo geniano

LISTA DE SÍMBOLOS

cm	centímetros
k	valor de Kappa
mm	milímetros
n	amostra
p	nível de significância estatística
r	coeficiente de correlação de Pearson ® marca registrada
®	marca registrada

SUMÁRIO

Introdução

1. INTRODUÇÃO

A mandíbula é um osso que compõe o sistema estomatognático e se articula com o osso temporal, o que permite a realização de movimentos de abertura e fechamento da boca, retrusão, protrusão e lateralidade da mandíbula (MADEIRA, 2010). A mandíbula possui diversos reparos anatômicos, alguns são formados em virtude da presença de origens e inserções musculares, como os tubérculos genianos (TG), localizados na face interna da região anterior, onde se inserem os músculos genioglosso e geniohióideo (GALLEGO *et al*., 2007; WAN; BOWE; MADHAVARAJAN, 2017).

Adicionalmente, a mandíbula abriga importantes estruturas nervosas como o nervo alveolar inferior, ramo do nervo mandibular que inerva os dentes inferiores por meio dos ramos terminais, dando origem ao nervo mentoniano que é responsável pela inervação da pele, dentes e mucosa da região anterior da mandíbula. Ainda na região anterior da mandíbula, encontra-se a foramina ou foraminas linguais (FL), as quais são canais intraósseos que desembocam em aberturas na face lingual na região da linha média e abrigam feixes vasculares oriundos de ramificações de artérias e veias. A origem desse conteúdo ainda não foi determinada, porém alguns autores acreditam haver uma anastomose entre ramos terminais das artérias sublinguais bilaterais que penetram nesse reparo anatômico (MRAIWA *et al*., 2003; KAWAI *et al*., 2006).

Clinicamente, a região entre os forames mentuais (FM) mandibulares tem sido considerada segura para a realização de uma variedade de procedimentos cirúrgicos tais como: instalação de implantes dentários nos protocolos mandibulares, remoção de enxertos ósseos em bloco, instalação de sistemas de fixação interna (placas e parafusos mini-microfragmentos, técnica de lag-screw), além de procedimentos para correção de deformidades dentofaciais (instalação de distratores e mentoplastia por exemplo). Entretanto, embora incomuns, deve-se considerar o risco de lesão a determinadas estruturas neurovasculares nobres existentes na zona interforaminal da mandíbula (POMMER *et al*., 2008; BARBOSA *et al*., 2019). Em relação aos reparos anatômicos da região mandibular anterior, diversos autores têm proposto, por meio de estudos tomográficos e/ou cadavéricos, margens cirúrgicas de segurança mínima frente a procedimentos tais como técnicas de genioplastia *mini wing* (CORDIER *et al*., 2019), *chin wing* (TRIACA *et al*., 2010), genioplastia estética (JAPATTI *et al*., 2020), genioplastia deslizante (SEIFELDIN *et al*., 2014) e Wedge osteotomy (COSTA *et al*., 2018), remoção de enxerto ósseo livre de mento (HUNT;JOVANOVIC, 1999; POMMER *et al*., 2008) e inserção de implantes dentários adjacentes ao FM (MAGNUSSON, 1992; APOSTOLAKIS;BROWN, 2012). Nesse cenário, ressalta-se a importância de estudos com TCFC que se proponham a obter dados de prevalência e demográficos de reparos anatômicos mandibulares, como medidas lineares relacionadas a tais estruturas.

A FL é uma importante estrutura que se localiza na região anterior da mandíbula, próxima à linha média, por onde passam vasos oriundos, provavelmente, de vasos maiores como as artérias e veias sublinguais. Pela localização da FL, a cirurgia para instalação de implantes osseointegráveis ou coleta de enxerto ósseo autógeno em região mentual pode eventualmente provocar danos a esta estrutura. Tem sido relatado a formação de grandes hematomas, acompanhados de edema em soalho de boca quando há colocação de implantes na região anterior, em que a cortical lingual é perfurada (MORDENFELD, 1997; WOO *et al.*, 2006; DEL CASTILLO-PARDO *et al.*, 2008).

Em relação aos TG, estes podem apresentar-se com diferentes formatos e tamanhos. Clinicamente, essas projeções ósseas localizadas ao redor da FL, por apresentarem a inserção dos músculos geniohióideo e genioglosso, devem ser consideradas quando se lança mão de cirurgias de avanço da musculatura relacionada a eles como opção terapêutica frente à apneia obstrutiva do sono (CHANG *et al*., 2019). Além disso, outra situação clínica retratada por relatos de casos são os casos de fraturas espontâneas dos TG relacionada à hipertrofia destes, especialmente em edêntulos.

O FM representa um dos mais importantes reparos anatômicos mandibulares sob o ponto de vista clínico, apresentando notória variabilidade em um mesmo indivíduo e entre indivíduos (KHOJASTEPOUR *et al*., 2015). Injúrias relacionadas à região onde se encontra o FM podem levar a alterações de sensibilidade, tais como parestesia ou anestesia em lábio inferior, mucosa adjacente, mento e dentes associados (GREENSTEIN *et al*., 2006). Nesse contexto, após a colocação de implantes dentários na região adjacente ao FM, distúrbios neurossensoriais (permanentes ou temporários), têm sido reportados (WISMEIJER *et al*., 1997; BARTLING *et al*., 1999; WALTON, 2000). Além disso, variações anatômicas relacionadas ao FM como o *loop anterior* (LA) e o forame mentual acessório (FMA) apresentam grande relevância clínica frente a procedimentos cirúrgicos periodontais, periapicais e de inserção de implantes dentários (IWANAGA *et al*., 2016).

Sobre estudos de revisão sistemática (RS) com meta-análise envolvendo o FM, ao que tudo indica, também não há, até o presente momento, artigos publicados de estudos que utilizaram a TCFC para avaliação deste reparo, assim como de variações anatômicas associadas a esta estrutura como o LA e a presença de FMA.

A avaliação e o planejamento pré-operatórios são de fundamental importância na determinação do sucesso do tratamento, especialmente nos casos em que uma análise detalhada de reparos anatômicos mandibulares se faz necessária. Para tanto, diferentes métodos de diagnóstico por imagem podem ser utilizados, entretanto a indicação e as limitações de cada técnica devem ser observadas e levadas em consideração durante sua interpretação. Desde o advento da tomografia computadorizada de feixe cônico (TCFC), esta tem demonstrado vantagens com relação à pequena dose de radiação, excelente resolução espacial e resolução de contraste da imagem, além do baixo custo financeiro quando comparada a outras técnicas tomográficas (UCHIDA *et al*., 2009; MAKRIS *et al*., 2010) e possibilidade de fornecer medidas lineares precisas (TIMOCK *et al*., 2011). Nesse cenário, VALDEC *et al*. (2019) recomendaram que, em procedimentos cirúrgicos tais como remoção de dentes inclusos, cirurgia endodôntica periradicular, colocação de implantes dentários e remoção de enxertos ósseos, a TCFC é um recurso importante a ser aventado quando do planejamento pré-operatório. Além do mais, esse exame permite uma detalhada avaliação da espessura da cortical óssea em relação ao canal mandibular e posição do FM em relação a dentes adjacentes (MAKRIS *et al*., 2010).

Ao se considerar a TCFC para análise de reparos anatômicos mandibulares, o profissional deve considerar parâmetros técnicos inerentes a essa modalidade de imagem, visto que estes podem exercer influência na visualização dessas estruturas (TIMOCK *et al*., 2011). Desde o desenvolvimento da TCFC, os aparelhos diferem em alguns aspectos importantes como a posição do paciente no momento da aquisição da imagem, podendo esta ser sentada ou supina. Entretanto, tem sido evidenciado que a posição do paciente durante a aquisição da TCFC não influencia na formação de artefatos por movimentação (YILDIZER *et al.,* 2021).

Diversos fatores podem influenciar na resolução espacial das TCFC, portanto uma complexa cadeia está relacionada à qualidade final da imagem. Em relação aos parâmetros de aquisição, o campo de visão, ou *field of view* (FOV), é um parâmetro que pode diferir de acordo com cada aparelho tomográfico sendo que o tamanho do FOV descreve o volume de varredura de uma máquina de TCFC específica e depende do tamanho e da forma do detector, da geometria de projeção do feixe e da capacidade para colimar o feixe. O tipo de sensor dos aparelhos de TCFC influenciam na qualidade da imagem, sendo os mais comumente utilizados *charge-coupled device* (CCD), *complementary metal oxide semiconductor* (CMOS) e *Detector Technology Project* (DTP). Outro fator é o tamanho e número dos voxels, que correspondem à unidade tridimensional formadora da imagem, e que nas TCFC esses cubos apresentam os lados iguais, e por isto são chamados de isotrópicos (DILLENSEGER *et al*., 2015; DILLENSEGER *et al*., 2016).

Ademais aspectos geométricos do processo de aquisição da imagem também influenciam na resolução espacial, que são sensivelmente especialmente influenciados pelo tamanho do ponto focal e da colimação. Além disso, o processo de obtenção dos volumes depende do tempo de rotação, número de projeções e o ângulo de rotação que podem ser modificados ou programados de acordo com as especificidades do aparelho utilizado (DILLENSEGER *et al*., 2015; DILLENSEGER *et al*., 2016). Por fim, os processos de reconstrução como os algoritmos utilizados para a formação das imagens ou a utilização dos tipos de "Kernel" podem resultar em imagens de melhor qualidade (DILLENSEGER *et al*., 2015; DILLENSEGER *et al*., 2016).

Em relação à aplicabilidade clínica da TCFC, pode-se listar: 1) planejamento de implantes; 2) Ortodontia; 3) endodontia; 4) patologia; 5) seios maxilares; 6) trauma e cirurgia; 7) articulação têmporo-mandibular; 8) periodontia; 9) vias aéreas (NASSEH e AL-RAWI, 2018). Tem-se enfatizado o emprego da TCFC na avaliação de reparos anatômicos de estruturas da face, principalmente da maxila e mandíbula, devido à sua maior precisão, qualidade e possibilidade de obtenção de imagens em reconstruções axiais, coronais e sagitais, o que proporciona ampla vantagem em relação às imagens radiográficas, como as radiografias panorâmicas e periapicais, além da possibilidade de obtenção de reconstruções tridimensionais (3D) (NEVES *et al.*, 2012).

A evidência científica advinda da análise de reparos anatômicos mandibulares em TCFC tem sido suportada por estudos de RS (BARBOSA *et al., 2019)*, os quais são investigações científicas que têm por objetivo reunir, avaliar criticamente e conduzir uma síntese dos resultados de múltiplos estudos primários (COOK *et al*., 1997). Tais tipos de estudos também objetivam responder a uma pergunta claramente formulada, utilizando métodos sistemáticos e explícitos para identificar, selecionar e avaliar as pesquisas relevantes, coletar e analisar dados de estudos incluídos na revisão. Quando aliados a métodos estatísticos tais como meta-análises, tornam-se ferramentas robustas para analisar e sumarizar os resultados dos estudos primários incluídos (CORDEIRO *et al*., 2007; HAAS *et al*., 2016).

Portanto, dada a escassez de estudos epidemiológicos relacionados a essas estruturas mandibulares e relatos de casos de fratura dos mesmos, reforça-se a necessidade de melhor conhecer os aspetos morfológicos e morfométricos dos TG em TCFC, bem como reunir as principais características clínico-imaginológicas e terapêuticas frente a fraturas envolvendo tais proeminências ósseas.

Nesse cenário, considerando-se a necessidade de agregar à literatura existente mais informações sobre os aspectos epidemiológicos de reparos anatômicos mandibulares, visto que tais estruturas anatômicas exibem marcante variabilidade intra- e inter-individual.

Revisão de Literatura

2. REVISÃO DE LITERATURA

2.1. Foramina Lingual

Na linha média da sínfise mandibular encontra-se a FL que, apresenta-se como um reparo anatômico que abriga estruturas nervosas e vasculares, como ramificações da artéria lingual, artéria submentual e anastomoses, bem como ramificações colaterais do nervo milohióideo (NAKAJIMA *et al.*, 2014). A FL é uma pequena estrutura localizada na face lingual da sínfise mandibular (Figura 1). Foi documentada em 1994, por McDonnell et al. tendo seu conteúdo determinado, suas relações com os tubérculos genianos demonstradas e foi estabelecida sua incidência (MCDONNELL *et al.*, 1994).

Figura 1. Imagem anatômica de uma FL em uma mandíbula seca pela vista lingual.

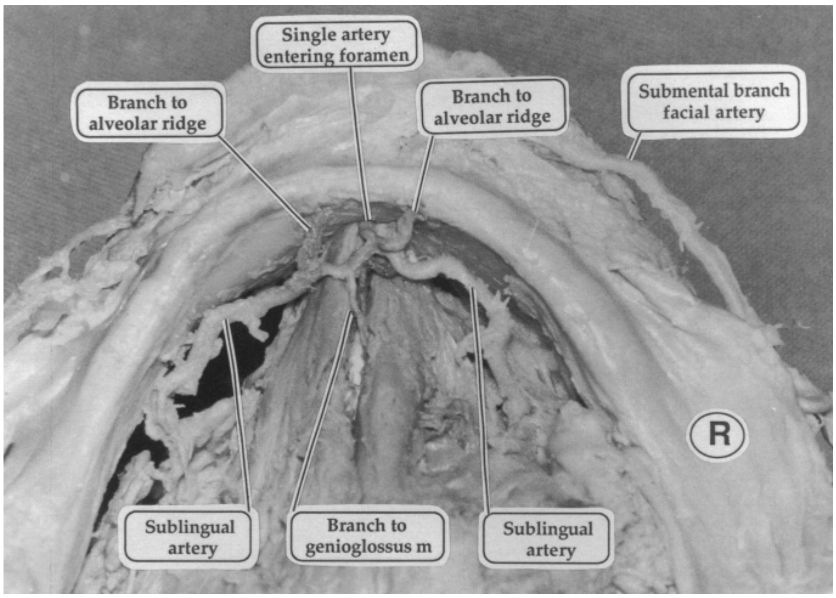
Fonte: ARQUIVO PESSOAL.

O primeiro autor que ilustrou esta estrutura anatômica foi Ennis, em 1937, (ENNIS, 1937). Ao longo dos anos, a FL recebeu diversas nomenclaturas. Thomson em 1915 utilizou o termo forame supraespinhal, o próprio Ennis denominou de forame interespinhal, enquanto Ingram em 1950 chamou de forame infraespinhal (THOMSON, 1915; INGRAM, 1950). O termo forame inominado também já foi utilizado em referência à FL (POYTON;PHAROAH, 1989).

Diversas foraminas acessórias podem ser encontradas na mandíbula em diferentes regiões (SUTTON, 1974). Considerando aspectos morfológicos, alguns relatos indicaram risco em procedimentos clínicos realizados nesta região em virtude da existência da FL (LIANG *et al.*, 2004; ROSANO *et al.*, 2009).

Liang *et al.*, (2005), apresentaram a existência de anastomose das artérias sublinguais formando um único vaso que penetra na FL acompanhada de suas ramificações venosas e de terminações nervosas (LIANG *et al.*, 2005) (Figura 2). Liang, *et al.*, (2007) identificaram ramos da artéria, veia e nervo lingual que penetram na foramina situada acima ou no meio da espinha geniana e ramos do nervo milohióideo e da artéria e veia sublingual e/ou submentual que penetram na foramina abaixo da espinha geniana caracterizando assim um feixe neurovascular (LIANG *et al*., 2007; PROVENZANO, 2012).

Figura 2. Dissecação do assoalho da boca, ilustrando uma anastomose dos ramos sublinguais direito e esquerdo das artérias linguais para formar um único vaso que entra no forame.



Fonte: MCDONNELL, 1994.

Em relação à frequência da FL, considerando os estudos cadavéricos, esta apresenta-se alta variando de 97 a 100%. Adicionalmente, os estudos cadavéricos reportaram que a FL estava associada com canais intraósseos e um particular plexo vascular na região anterior da mandíbula (MCDONNELL *et al*., 1994; VANDEWALLE *et al*., 2007; LIANG *et al*., 2007; KAWAI *et al*., 2007; ROSANO *et al*., 2009).

Em relação à incidência da FL, sabe-se que esta tem se apresentado em grande parte das mandíbulas estudadas por meio de estudos cadavéricos. Os estudos conduzidos por Shiller & Wiswell (1954) e Sutton (1974) relataram uma prevalência de 88,9% e 85%, respectivamente, de FL observadas em mandíbulas secas (SHILLER;WISWELL, 1954; SUTTON, 1974). Ao passo que Já McDonnell *et al*., (1994) identificaram a FL em 99,04% das mandíbulas analisadas, estando este reparo anatômico ausente em apenas 3 espécimes 0,96%, tal fato reforça que a FL se caracteriza como um achado consistente.

Um estudo cadavérico realizado em mandíbulas secas evidenciou que ramificações provenientes das artérias lingual e submentual percorrem através das FL (KAWAI *et al*., 2007). Isto mostra que apesar de a região anterior da mandíbula ter sido durante bastante tempo uma região segura para procedimentos cirúrgicos, esta área apresenta riscos reais de hemorragia caso ocorra um trauma na cortical lingual e, consequentemente, as ramificações anteriormente mencionadas sejam lesadas quando da intervenção em áreas subjacentes (LONGONI *et al*., 2007). A formação de hematoma na região sublingual em decorrência da hemorragia de vasos que percorrem a FL pode evoluir rapidamente, o que pode resultar em extenso edema nesta área e projetar a língua contra o palato, ocasionando obstrução das vias aéreas (MAIWRA *et al*., 2003).

Mais recentemente, a TC tem sido utilizada para estudar a FL. O estudo conduzido por Kawai *et al.*, em 2007, avaliou a frequência da FL em 68 cadáveres e, por meio de TC, encontrou uma frequência de 97%, ao passo que Vandewalle *et al.,* em 2006, estudaram 354 cadáveres tanto através de dissecção como por meio de TC e reportaram uma frequência de 98% (VANDEWALLE *et al*., 2003; KAWAI *et al*., 2007). Um estudo apresentado por Togaya *et al.,* (2009) com 200 exames de tomografia computadorizada observou que a maioria das FL prevalecem acima da espinha geniana e as foraminas no mesmo nível da espinha tem menos predominância (TAGAYA *et al*., 2009).

Além da frequência, o diâmetro da FL é uma medida radiomorfométrica bastante analisada. Os estudos reportam esta medida em variação ou média, ou ainda com ambas as informações. O estudo cadavérico de Rosano *et al.,* (2009), encontrou uma frequência de 100% da FL e uma variação de 0,5 a 0,9mm do diâmetro da FL superior e 0,4 a 0,8mm para a FL inferior (ROSANO *et al*., 2009). Wang e *et al.*, em 2015, evidenciaram o diâmetro da FL variando de 0,25mm a 1,9mm, com uma média de 0,61mm, com uma frequência de 96% nos 101 exames analisados (WANG *et al*., 2015).

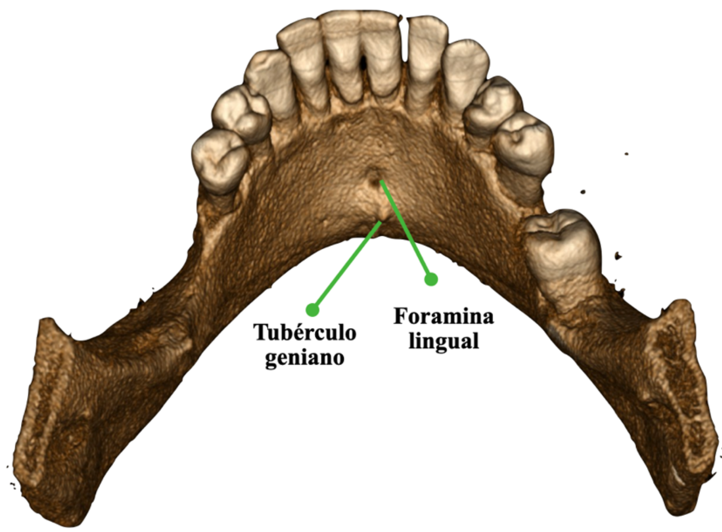
2.2 Tubérculo Geniano

Além da FL, encontra-se na linha média o TG, que é parte integrante da mandíbula e tem sua formação iniciada na 4ª semana do desenvolvimento embrionário com a individualização do 1º arco faríngeo, que dará origem à mandíbula (MOORE;PERSAUD, 2008).

Do ponto de vista histológico, o TG é uma estrutura óssea e, portanto, é formado por tecido ósseo a partir da ossificação intramembranosa, sendo composto por células ósseas (osteócito, osteoblasto e osteoclasto) e matriz óssea.

Além disso, por estar localizado na região da sínfise mandibular, os TG possuem uma quantidade considerável de tecido ósseo primário, mesmo na fase adulta (JUNQUEIRA;CARNEIRO, 2008). Anatomicamente, os TG localizam-se logo abaixo da FL e se caracterizam como uma saliência dupla, mediana e irregular (Figura 3). O primeiro é o maior dos músculos extrínsecos da língua e age na protrusão e na depressão da mesma, enquanto o segundo auxilia o músculo digástrico na retrusão e abaixamento da mandíbula.

Figura 3. Reconstrução 3D evidenciando o TG e FL.

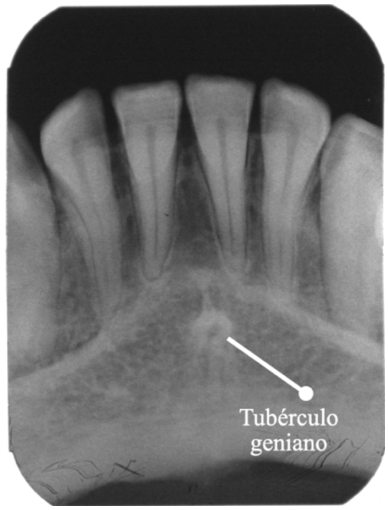


Fonte: ARQUIVO PESSOAL.

Na região da linha média da mandíbula, encontram-se os TG que são projeções ósseas localizadas na face lingual da região de sínfise mandibular, entre a borda superior e a inferior da mandíbula. Pode-se encontrar até quatro tubérculos, sendo que os superiores servem de ancoragem para o músculo genioglosso e os inferiores, para o músculo gênio-hióideo (WAN;BOWE; MADHAVARAJAN, 2017; GALLEGO *et al*., 2007). Baldissera *et al*., (2012) define os TG como pequenas protuberâncias ósseas localizadas na superfície lingual da mandíbula na região de sínfise, um pouco acima da borda inferior da mandíbula. Os TGs têm forma de espinha e estão divididos em direito e esquerdo, e superior e inferior (BALDISSERA *et al*., 2002).

Em radiografias periapicais, os TG apresentam-se como um anel radiopaco com centro radiolúcido, correspondente à FL, sendo observado no plano mediano pouco acima da BM (Figura 4) (MADEIRA, 2013).

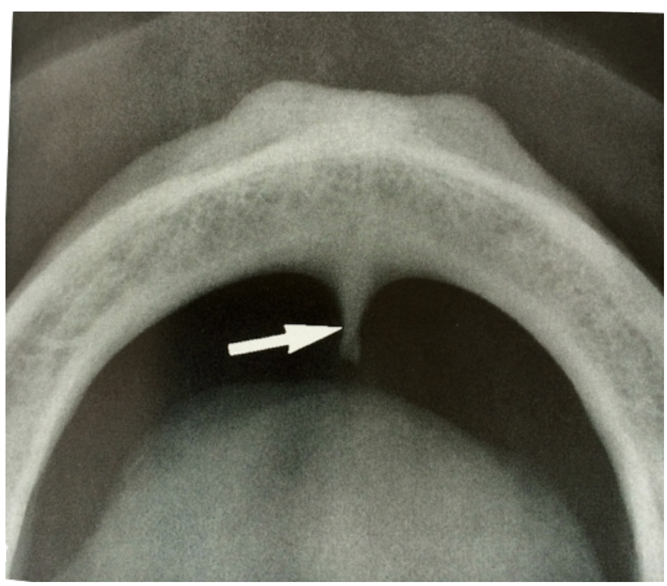
Figura 4. Aspecto radiográfico dos TG observados em radiografia periapical da região anterior da mandíbula.



Fonte: ARQUIVO PESSOAL

Em radiografias oclusais ou em reconstruções axiais de TCFC, o TG tem um aspecto de projeção óssea, localizado na linha média ou ligeiramente deslocado para um dos lados, com uma base mais larga que o ápice, e quando presente, bem evidente e de fácil identificação (Figuras 5 e 6).

Figura 5. Aspecto radiográfico dos TG observado em radiografia oclusal.



Fonte: WHITE;PHAROAH, 2007.

Figura 6. Aspecto imaginológico dos TG observado em reconstrução axial de uma TCFC.

Fonte: ARQUIVO PESSOAL.

Também conhecidos como a coluna vertebral da mandíbula (LEE *et al*., 2016), podem apresentar diversas variações anatômicas. Em um estudo conduzido por Thomson, no ano de 1915, em que foram avaliadas 1670 mandíbulas, os seguintes achados foram relatados referentes aos TG: podem ser ausentes; exibir tamanhos reduzidos, sendo mais comuns, como em episódios de aglutinação numa única projeção de cerca de 3 a 5 mm de comprimento; ou manifestar um alargamento raro (THOMSON, 1915). Uma hipertrofia do TG foi reportada por Rubira-bullen *et al*., (2009) no qual uma mulher de 70 anos apresentava queixa de dor e inchaço no soalho da cavidade oral, e, após exame clínico e imaginológico por meio de TC, foi observado um acentuado desenvolvimento dos tubérculos, aproximadamente de 18 mm de comprimento. Apesar de a paciente citada não possuir nenhuma alteração patológica que justificasse a expansão dos tubérculos, esse aumento exacerbado costuma estar associado à calcificação degenerativa do ligamento do músculo genioglosso e à atrofia da crista alveolar mandibular. (RUBIRA-BULLEN *et al.,* 2009; VAN LEEUWEN; MEIJ; VISSCHER, 2014).

Em virtude de os TG serem estimulados ação muscular, a superfície lingual da mandíbula nesta área constitui-se como uma zona óssea estática, impedindo a reabsorção óssea. Entretanto, como mencionado anteriormente uma reabsorção óssea, pode ocorrer em casos de edentulismo e na consequente atrofia da crista alveolar, quando este reparo se configura como uma continuação do sulco alvéolo-lingual e, dessa forma, projeta-se de maneira acentuada. Tal evento contribui para a dificuldade na técnica de confecção, levando à necessidade de avaliar cuidadosamente a morfologia dos tubérculos, a fim de se alcançar a reabilitação protética. Hughes, em 1965, relata um caso de remoção dos TG a fim de confeccionar uma prótese total inferior, em virtude da não adaptação da prótese (HUGHES, 1965; PĂUNA; BABIUC; FARCAŞIU, 2015).

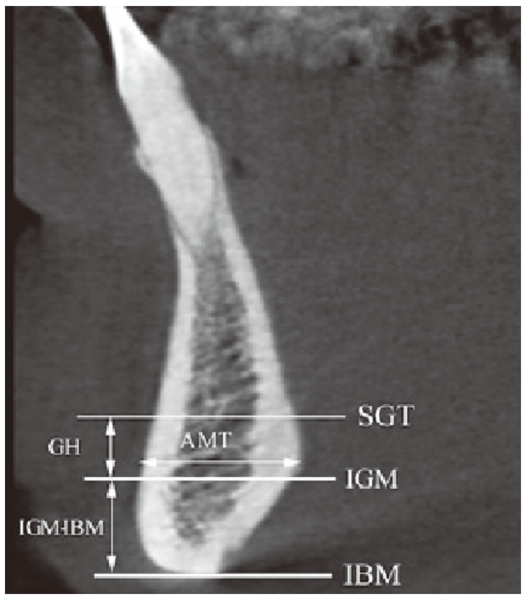
Ainda se tratando da importância clínica destes reparos anatômicos, é mister salientar as implicações dos tubérculos genianos no tratamento da Síndrome da Apneia Obstrutiva do Sono (SAOS), caracterizada pela interrupção do fluxo de ar durante o repouso. A causa dessa disfunção respiratória se dá pela diminuição no tônus do músculo genioglosso, responsável pela dilatação faríngea durante a inspiração, e, como forma de solucionar essa obstrução das vias aéreas, tem sido muita realizada a osteotomia mandibular para avanço do músculo em questão. Desse modo, a avaliação altamente precisa da localização e da morfologia dos tubérculos tornou-se indispensável na cirurgia de avanço geniano, garantindo a recuperação da tensão muscular e, portanto, evitando o prolapso ventilatório ao facilitar a expansão do diâmetro orofaríngeo. (HUEMAN *et al*., 2007; PARK *et al*., 2017).

Além desses direcionamentos clínicos tem sido investigados marcos cefalométricos que sirvam como referência de ponto médio para a mandíbula, tendo em vista que o Menton (Me), que se encontra no ponto mais inferior do queixo, é considerado um marco inexato para eventos de assimetrias mandibulares. Para tanto, os tubérculos já foram mencionados na ortodontia como ponto de referência para verificar a alteração da linha média dos incisivos inferiores, nos casos de assimetria, porém ainda não existe um consenso sobre o assunto. (LEE *et al*., 2017).

Apesar de as radiografias convencionais terem oferecido um importante suporte aos diagnósticos, sobretudo em casos de fraturas dos TG, a imagem bidimensional e a junção de fatias de representações em 2D (bidimensional) não foram capazes de alcançar reais dimensões. Além disso, Van Leeuwen *et al*., em 2012, mostraram que a TC é a modalidade de exame por imagem indicada para visualização de fraturas dos TG (VAN LEUWEEN *et al*., 2012). Somente em 1998, a TCFC traz o aprimoramento à odontologia no universo da imagem tridimensional. No contexto do emprego da TCFC para o estudo dos TG esta justifica-se pela necessidade de determinações precisas dos aspectos morfométricos como distância deste reparo às estruturas adjacentes, comprimento, altura e largura da base, bem como aspectos topográficos de localização e número de TG presentes (MOZZO *et al*., 1998; TIMOCK *et al*., 2011).

Um estudo conduzido por Hueman *et al*., em 2007, avaliou a acurácia da TCFC na determinação da localização dos TG utilizando 17 crânios de cadáveres humanos adultos. Neste estudo as distâncias do TG à BM, a espessura da mandíbula na região do TG e o comprimento do TG foram investigados, e concluiu-se que não havia diferença estatisticamente significante entre as medidas lineares obtidas nas imagens tomográficas e as medidas reais realizadas nos crânios (HUEMAN *et al*., 2007). Portanto, a TCFC apresenta-se como um exame preciso e indicado para medidas lineares dos TG.

Figura 7. Reconstrução tomográfica transversal mostrando medidas lineares de um estudo morfológico do TG.



Fonte: (KOLSUZ *et al*., 2015).

Até o presnete momento, existem poucos estudos na literatura que avaliam as dimensões dos TG (LOPES, 2016). Em 2012, Wang *et al.,* conduziram um estudo em uma população do Taiwan, no qual foram realizadas medidas lineares em indivíduos de tipo facial classe I e classe II, encontrou que a largura do TG apresentou um valor aproximado da altura em todos os grupos, variando de 7,1 a 8,2 mm e 6,5 a 7,9mm, respectivamente. E que a distância do TG para a borda da mandíbula foi maior em indivíduos classe II do sexo masculino (8,4± 2,3mm) do que em mulheres do tipo facial classe II (7,1±3,0mm). Adicionalmente, a espessura da mandíbula na região do TG foi maior em homens do tipo classe I (14,6 ± 2,9mm) do que em mulheres do tipo classe II (12,7 ± 2,1mm) (WANG *et al*., 2012).

No Brasil, um estudo em 2017 conduzido por Nejaim *et al*., (2017) observou aspectos morfológicos do comprimento e largura dos TG em indivíduos classe I, II e III. Concluiu-se que o tipo facial não apresentou influência no comprimento e largura dos TG, bem como na espessura da mandíbula. Entretanto, o TG apresentou-se mais longo nos homens quando comparado com as mulheres. A partir deste achado, sugere-se que o comprimento dos TG possam ser utilizados para diferenciar homens de mulheres, ao passo que os aspectos morfológicos dos TG não podem ser utilizados para determinar o padrão facial do indivíduo (NEJAIM *et al*., 2017).

2.3 Forame Mentual

O complexo maxilomandibular possui inúmeros reparos anatômicos que são de interesse para a prática clínica odontológica. O conhecimento dessas estruturas permite aos cirurgiões-dentistas diagnosticar corretamente alterações que podem influenciar no tratamento dos pacientes, em especial na região entre os FM, que, durante bastante tempo, era considerada como sendo uma região segura para procedimentos invasivos (ANDRADE, 2001).

O FM representa uma abertura na superfície lateral da mandíbula é uma importante estrutura associado a procedimentos cirúrgicos na região de pré-molares, pois no seu interior está o feixe vásculo-nervoso mentual que promove a sensibilidade dos dentes e lábio inferior ipsilateral e, dessa forma, sua identificação por meio de exames imaginológicos pode prevenir danos nervosos durante cirurgias mandibulares, bem como pode contribuir para altas taxas de sucesso durante o procedimento de anestesia local. O referido reparo anatômico pode apresentar variações quanto ao seu tamanho, localização, forma e tamanho a depender da população estudada (AHER, 2012; GADA, 2014)

Este reparo anatômico é completamente formado pela décima segunda semana gestacional, momento no qual o nervo mentual se separa em diferentes fascículos localmente (THANKUR *et al*., 2011). Quando ocorre a separação do nervo mentual antes da completa formação do FM, tal fato leva à origem de um ou mais FMAs (CAGIRANKAYA *et al*., 2008).

Existem algumas variações anatômicas relacionadas ao CM, dentre as quais, pode-se citar a forma como o CM emergirá no FM. Sendo assim, Al-Mahalawy *et al.,* (2016) classificou o término do CM em três situações possiveis: 1) Linear: quando a trajetória do CM para o CM possui pouca angulação; 2) Perpendicular: quando há uma angulação para cima do CM na região do FM: 3) Loop anterior: quando o CM segue em direção anterior e realiza ma curva, com um aspecto de alça, antes de emergir no FM (Figura 7).

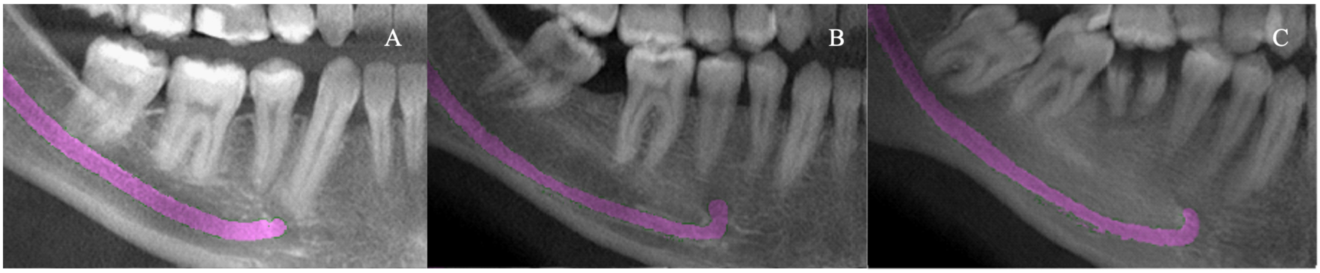


Figura 7. Padrões do canal alveolar inferior: A) padrão linear; B) padrão perpendicular; C) *loop anterior* Fonte: AL-MAHALAWI *et al.,* 2017.

Além disso, tem sido relatado a presença de forames mentuais acessórios na região do FM. OS FMA são descritos como pequenos forames, normalmente com diâmetro vertical e horizontal menores quando comparados com o FM e que possuem uma comunicação o CM ou com o CIM (AYTUGAR *et al.,* 2019). O número de FMA pode variar, sendo a presença de uma única foramina o achado mais frequente, seguido de dois FMAs, e já foi relatada a presença de até quatro FMAs em um mesmo lado da mandíbula, sendo este achado extremamente raro (CABANILLAS-PADILHA et al., 2014).

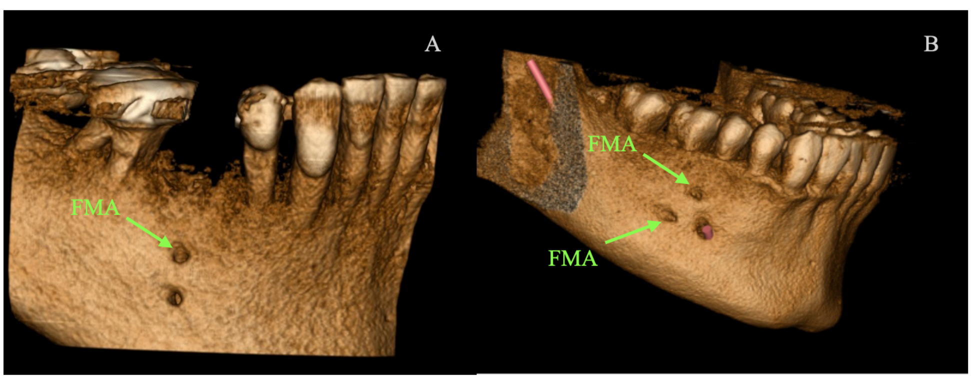


Figura 8. A) presença de um FMA no lado direito (seta); B) presença de dois FMA no lado direito (setas) Fonte: ARQUIVO PESSOAL.

Objetivos

3. OBJETIVOS

3.1 Objetivo geral

Avaliar aspectos imaginológicos relativos a reparos anatômicos mandibulares (FL, TG, FM e FMA) em TCFC de indivíduos brasileiros.

3.2 Objetivos específicos

1. Sumarizar a evidência científica sobre aspectos epidemiológicos e parâmetros imaginológicos da FL em TCFC através de revisão sistemática com meta-análise;
2. Sumarizar a evidência científica sobre aspectos epidemiológicos, imaginológicos e terapêuticos de fraturas de TG através de revisão sistemática com meta-análise;
3. Sumarizar a evidência científica sobre aspectos epidemiológicos e parâmetros imaginológicos do FM em TCFC através de revisão sistemática com meta-análise;
4. Avaliar a prevalência, variáveis demográficas e quantitativas dos TGs, bem como propor nova classificação topográfica destes, em TCFCs de indivíduos brasileiros;
5. Avaliar a prevalência, variáveis demográficas e quantitativas do FM, FMA e FL em TCFCs de indivíduos brasileiros, bem como estimar o risco de injúria a essas estruturas frente a procedimentos cirúrgicos na região anterior mandibular.

Proposição

4. PROPOSIÇÃO

A presente dissertação será apresentada por meio dos seguintes capítulos:

Capítulo 1: *Systematic review and meta-analysis of lingual foramina anatomy and surgical-related aspects on cone-beam computed tomography: a PROSPERO-registered study.*

Capítulo 2: *Clinical, imaging, and therapeutic aspects of genial tubercle fractures: a systematic review.*

Capítulo 3: *Mental foramen and anterior loop anatomic characteristics: a systematic review and meta-analysis of cross-sectional imaging studies.*

Capítulo 4: *Surgical-related morphometric aspects and proposal of a new classification of genial tubercles in cone-beam computed tomographs.*

Capítulo 5: Aspectos anatômicos do forame mentual, *loop anterior*, forame mentual acessório e da foramina lingual com tomografias computadorizadas de feixe cônico.

Capítulos

5. CAPÍTULOS

A presente tese está baseada no Artigo 46 do Regimento Interno do Programa de Pós-Graduação em Odontologia da Universidade Federal do Ceará que regulamenta o formato alternativo para dissertações de Mestrado e teses de Doutorado e permite a inserção de artigos científicos de autoria ou coautoria do candidato (ANEXO I). Por se tratar de pesquisa envolvendo seres humanos, o projeto de pesquisa referente ao trabalho desenvolvido nos capítulos 4 e 5 foi submetido à apreciação do Comitê de Ética em Pesquisa em Seres Humanos da Universidade Federal do Ceará, tendo sido aprovado (27692619.3.0000.5054) (ANEXO II) e conduzido de acordo com a declaração de Helsinki. Desta forma, a tese é composta por cinco capítulos, conforme descrito abaixo:

Capítulo 1: *Systematic review and meta-analysis of lingual foramina anatomy and surgical-related aspects on cone-beam computed tomography: a PROSPERO-registered study.*

O presente artigo foi submetido, aceito e publicado na revista "*Oral Radiology*" (ISSN 0911-6028; fator de impacto 1.852 [ano base 2020]) sob o título "*Systematic review and meta-analysis of lingual foramina anatomy and surgical-related aspects on cone-beam computed tomography: a PROSPERO-registered study*." (disponível em: https://doi.org/10.1007/s11282-021-00516-8).

Capítulo 2: *Clinical, imaging, and therapeutic aspects of genial tubercle fractures: a systematic review.*

O presente artigo foi submetido aceito e publicado na revista "*Journal of Oral and Maxillofacial Surgery*" (ISSN 0278-2391; fator de impacto 1.895 [ano base 2020]) sob o título "*Clinical, imaging, and therapeutic aspects of genial tubercle fractures: a systematic review*." (disponível em: https://doi.org/10.1016/j.joms.2019.03.030).

Capítulo 3: *Mental foramen and anterior loop anatomic characteristics: a systematic review and meta-analysis of cross-sectional imaging studies*.

O presente artigo foi submetido e aceito na revista "*Journal of Endodontics*" (ISSN 0099-2399; fator de impacto 4.171 [ano base 2020]) sob o título "*Mental foramen and anterior loop anatomic characteristics: a systematic review and meta-analysis of cross-sectional imaging studies.*" O status da submissão está no Anexo III.

Capítulo 4: *Surgical-related morphometric aspects and proposal of a new classification of genial tubercles in cone-beam computed tomographs.*

O presente artigo foi submetido na revista "*Journal of Oral Biology and Craniofacial Research*" e está sendo avaliado (ISSN 2212-4268; fator de impacto 1.56) sob o título "*Surgical-related morphometric aspects and proposal of a new classification of genial tubercles in cone-beam computed tomographs*." As normas de submissão da revista "*Journal of Oral Biology and Craniofacial Research*" estão no Anexo IV e o status da submissão está no Anexo V.

Capítulo 5: *Aspectos tomográficos do forame mentual e loop anterior forame mentual acessório e foramina lingual em TCFC e estimativa de risco de injúria a essas estruturas relacionada a procedimentos cirúrgicos orais.*

O presente artigo será submetido na revista *"International Journal of Oral and Maxillofacial Implants"* (ISSN 0882-2786; fator de impacto 2.804). As normas de submissão da revista *"International Journal of Oral and Maxillofacial Implants"* encontram-se no Anexo VI.

Capítulo 1

5.1 CAPÍTULO 1

Oral Radiology
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REVIEW ARTICLE

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Systematic review and meta-analysis of lingual foramina anatomy and surgical-related aspects on cone-beam computed tomography: a PROSPERO-registered study

Daniel Almeida Ferreira Barbosa[1] · Diego Santiago de Mendonça[1] · Francisco Samuel Rodrigues de Carvalho[2] · Lúcio Mitsuo Kurita[1] · Paulo Goberlânio de Barros Silva[3] · Frederico Sampaio Neves[4] · Fábio Wildson Gurgel Costa[1]

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Abstract

Purpose This study aimed to summarize the evidence regarding lingual foramen (LF) characteristics using cone-beam computed tomography (CBCT).

Materials and methods A registered systematic review (#42,019,145,962) was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statements. An electronic search without date or language restrictions was performed in five databases, including grey literature (Google Scholar and ProQuest). The Meta-Analysis of Statistics Assessment and Review Instrument was used to evaluate the selected studies.

Results A total of 6641 articles were identified, and 26 studies (8255 CBCT scans) were selected after a three-step selection process. There was a female predominance, and age ranged between 10 and 93 years. A total of 4336 LFs were observed among men ($n=2042$) and women ($n=2294$). Of this LF-related sample, 43.5% of the studies were from Asia, followed by Europe (33.5%), North America (14%), and South America (9%). Different distances from the LF to the alveolar crest (11.04–20.4 mm), buccal (4.73–4.91 mm), and lingual (8.75 mm) cortices and the inferior border of the mandible (8.48–26.59 mm) were evaluated.

Conclusion In summary, this systematic review found that LF is an anatomical structure with a high prevalence among the included studies (greater than 90%), regardless of the population evaluated. The occurrence of at least one LF was the most common pattern.

Keywords Lingual foramina · Cone-beam computed tomography · Systematic review

Introduction

Replacement of lost teeth in the anterior region of the mandible through implant placement is a relatively common procedure performed in the dental office [1, 2]. The interforaminal mandibular region is considered relatively safe for dental implant treatment. However, this region includes some critical anatomical structures, such as the incisive canal, mandibular bone concavity, and lingual foramina (LF). In addition to the installation of dental implants, genioplasties [3, 4], bone grafts [5–7], dental extractions, removal of the torus mandibularis, biopsies [8], and orthognathic surgery are other procedures that require anatomical knowledge of the region, especially the lingual mandibular foramen [9].

In addition, LFs have been described as small openings in the lingual region of the mandible. Radiographically, they can appear as small radiolucent circumferences located 10 mm below the apices of the anterior teeth. The size is variable, with a diameter usually of 1–2 mm, but with possible variations in location, number, and length, which makes detection of the LF with a conventional radiographic evaluation difficult [8, 10, 11]. Studies on cadavers have shown that the branches of the sublingual and submental arteries pass through these

Daniel Almeida Ferreira Barbosa
danielodontologia@gmail.com

1 Division of Oral Radiology, Programa de Pós-Graduação em Odontologia, Federal University of Ceará, Rua Monsenhor Furtado, 1273, Rodolfo Teófilo, CEP, Fortaleza, CE 60430-355, Brazil

2 Division of Oral and Maxillofacial Surgery, Federal University of Ceará, Campus Sobral, Sobral, Brazil

3 Division of Oral Pathology, Christus University (UNICHRISTUS), Fortaleza, Brazil

4 Division of Oral Radiology, Federal University of Bahia, Salvador, Brazil

structures [12]. It is noteworthy that study of this anatomic structure is essential in the field of oral and maxillofacial surgery. Thus, the scientific evidence compilation of the literature through systematic reviews (SRs) is an adequate approach to summarize the main clinical-related imaging aspects of the LF.

Clinically, imaging studies of LF should be highlighted, mainly due to surgical complications associated with procedures performed in the LF-related region, which include perforation of the lingual cortex and injury to the sublingual and submental arteries, resulting in severe and even life-threatening hemorrhage, which have been discussed in several reports [13, 14].

Two-dimensional pre-surgical radiological evaluation, such as panoramic and periapical radiographs, generally fails to show visibility and details of this anatomical structure [15, 16]. Contemporary imaging techniques, such as cone-beam computed tomography (CBCT), may be particularly suitable for preoperative planning, as three-dimensional visualization and high-resolution analysis of the entire mandible provide adequate information that can prevent complications during surgical procedures such as hemorrhage caused by perforations in the lingual bone plate [17].

A SR is an essential study that summarizes and appraises scientific evidence from secondary data, providing relevant information for clinical practice, mainly when associated with meta-analyses [18]. Registration of these studies contributes to the protection against reporting bias, maintenance of a permanent public protocol containing its most relevant aspects, and avoidance of duplication of studies [19].

CBCT examinations allow for a detailed view with a high contrast of the bone architecture. It offers tomographic sections, which, in regions with a thin bone width, facilitate visualization without data loss. As the LF attracts the attention of dental surgeons who seek to identify areas at risk of vascular damage, especially during implant placement, an adequate imaging evaluation must be performed by a radiologist before surgical procedures. The purpose of this SR with meta-analysis was to quantitatively summarize the characteristics of the LF, since this anatomic structure is of high relevance in oral surgery-related studies and anatomic topographic evaluations.

Methodology

Protocol and registration

The methodology described in this study followed the sequence of SR-related studies previously published by this research group [20, 21], and it was designed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [22]. The search strategy was implemented in November 2019, after registration in the International Prospective Register of Systematic Reviews (PROSPERO) platform (protocol number CRD42019145962), and it was updated on June 24, 2020.

Information and search planning

The Population/Exposure/Control/Outcome/Study design (PECOS) strategy was formulated to answer the following research question: what are the main aspects of the LF obtained from CBCT-based in vivo assessments?: This was based on the following items:

1. Population (P): CBCT obtained from humans.
2. Exposure (E): LF.
3. Control (C): no control or comparator groups.
4. Outcome (O): prevalence of LF, quantitative measurements, location of LF, and relationship between this anatomic structure and adjacent teeth.
5. Study design (S): cross-sectional and observational studies.

A customized search algorithm, without search filters or restrictions regarding the year of publication, was generated for the PubMed database to restrict the literature review. It used the Medical Subject Headings terms and free keywords that were combined with the Boolean operators "OR" and "AND" (Table 1). Additional search algorithms were adapted for Elton B. Stephens Company (EBSCO), Web of Science, Scopus, and Scielo bibliographic databases. The references of the selected studies were verified through a manual search to identify additional studies. Grey literature was verified using Google Scholar and ProQuest Dissertations and Theses Full-text databases (Table 1).

Eligibility criteria

The present investigation included only observational studies that assessed the LF of individuals using CBCT scans. The exclusion criteria included studies that did not evaluate the LF, other study designs such as in vitro or ex vivo approaches, and studies that used imaging modalities other than CBCT.

Study selection and data acquisition

Potential studies were selected in three phases: (1) exclusion of duplicate reports, (2) reading of titles and abstracts, and (3) reading of the full text. In phase 1, which was performed by two authors (Francisco Samuel Rodrigues de Carvalho and Lúcio Mitsuo Kurita), the articles obtained from the

Table 1 Specific search terms for each database and truncations

Eletronic Database	Search strategy used	Items found
PubMed	#1 ((“mandible”[MeSH Terms] OR “lingual foramina”[All Fields] OR “midline lingual foramina”[All Fields] OR “accessory foramina”[All Fields] OR “accessory mandibular foramina”[All Fields] OR “lingual foramen”[All Fields] OR “lingual mandibular foramina”[All Fields] OR “lateral lingual canal”[All Fields] OR “lateral lingual foramen”[All Fields] OR “foramen lingual”[All Fields] OR “median lingual foramina”[All Fields]))	1715
	#2 ("cone-beam computed tomography"[MeSH Terms] OR "cone-beam computed” [All Fields] OR "cone-beam computed tomography”[All Fields] OR “Cone-Beam CT Scan”[All Fields] OR “Cone-Beam CT Scans” OR “Cone Beam Computed Tomography”[All Fields] OR “Cone-Beam Computerized Tomography”[All Fields] OR “Cone-Beam Computer-Assisted Tomography”[All Fields] OR “Cone Beam Computerized Tomography”[All Fields] OR “Cone-Beam CT”[All Fields] OR “Cone Beam CT”[All Fields])	
	Algoritm ((“mandible”[MeSH Terms] OR “lingual foramina”[All Fields] OR “midline lingual foramina”[All Fields] OR “accessory foramina”[All Fields] OR “accessory mandibular foramina”[All Fields] OR “lingual foramen”[All Fields] OR “lingual mandibular foramina”[All Fields] OR “lateral lingual canal”[All Fields] OR “lateral lingual foramen”[All Fields] OR “foramen lingual”[All Fields] OR “median lingual foramina”[All Fields])) AND ("cone-beam computed tomography"[MeSH Terms] OR "cone-beam computed” [All Fields] OR "cone-beam computed tomography”[All Fields] OR “Cone-Beam CT Scan”[All Fields] OR “Cone-Beam CT Scans” OR “Cone Beam Computed Tomography”[All Fields] OR “Cone-Beam Computerized Tomography”[All Fields] OR “Cone-Beam Computer-Assisted Tomography”[All Fields] OR “Cone Beam Computerized Tomography”[All Fields] OR “Cone-Beam CT”[All Fields] OR “Cone Beam CT”[All Fields])	
Scopus	#1 “mandible” OR “lingual foramina” OR “midline lingual foramina” OR “accessory foramina” OR “accessory mandibular foramina” OR “lingual foramen” OR “lingual mandibular foramina” OR “lateral lingual canal” OR “lateral lingual foramen” OR “foramen lingual” OR “median lingual foramina”	2799
	#2 "cone-beam computed tomography" OR "cone-beam computed” OR “Cone-Beam CT Scan” OR “Cone-Beam CT Scans” OR “Cone Beam Computed Tomography” OR “Cone-Beam Computerized Tomography” OR “Cone-Beam Computer-Assisted Tomography” OR “Cone Beam Computerized Tomography” OR “Cone-Beam CT” OR “Cone Beam CT”	
	Algoritm (TITLE-ABS-KEY ("mandible" OR "lingual foramina" OR "midline lingual foramina" OR "accessory foramina" OR "accessory mandibular foramina" OR "lingual foramen" OR "lingual mandibular foramina" OR "lateral lingual canal" OR "lateral lingual foramen" OR "foramen lingual") OR TITLE-ABS-KEY ("median lingual foramina") AND TITLE-ABS-KEY ("cone-beam computed tomography" OR "cone-beam computed" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Cone Beam Computed Tomography" OR "Cone-Beam Computerized Tomography") OR TITLE-ABS-KEY ("Cone-Beam Computer-Assisted Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT"))	
Web of Science	#1 “mandible” OR “lingual foramina” OR “midline lingual foramina” OR “accessory foramina” OR “accessory mandibular foramina” OR “lingual foramen” OR “lingual mandibular foramina” OR “lateral lingual canal” OR “lateral lingual foramen” OR “foramen lingual” OR “median lingual foramina”	974
	#2 "cone-beam computed tomography" OR "cone-beam computed” OR “Cone-Beam CT Scan” OR “Cone-Beam CT Scans” OR “Cone Beam Computed Tomography” OR “Cone-Beam Computerized Tomography” OR “Cone-Beam Computer-Assisted Tomography” OR “Cone Beam Computerized Tomography” OR “Cone-Beam CT” OR “Cone Beam CT”	
	Algoritm “mandible” OR “lingual foramina” OR “midline lingual foramina” OR “accessory foramina” OR “accessory mandibular foramina” OR “lingual foramen” OR “lingual mandibular foramina” OR “lateral lingual canal” OR “lateral lingual foramen” OR “foramen lingual” OR “median lingual foramina” AND "cone-beam computed tomography" OR "cone-beam computed” OR “Cone-Beam CT Scan” OR “Cone-Beam CT Scans” OR “Cone Beam Computed Tomography” OR “Cone-Beam Computerized Tomography” OR “Cone-Beam Computer-Assisted Tomography” OR “Cone Beam Computerized Tomography” OR “Cone-Beam CT” OR “Cone Beam CT”	
Scielo	#1 (mandible) OR (lingual foramina) OR (accessory foramina)	10
	#2 (cone-beam computed tomography) OR (cone-beam ct) OR (cone beam computed tomography)	
	Algoritm (mandible) OR (lingual foramina) OR (accessory foramina) AND (cone-beam computed tomography) OR (cone-beam ct) OR (cone beam computed tomography)	

Table 1 (continued)

Eletronic Database	Search strategy used	Items found
EBSCO	#1 "mandible" OR "lingual foramina" OR "midline lingual foramina" OR "accessory foramina" OR "accessory mandibular foramina" OR "lingual foramen" OR "lingual mandibular foramina" OR "lateral lingual canal" OR "lateral lingual foramen" OR "foramen lingual" OR "median lingual foramina"	1143
	#2 "cone-beam computed tomography" OR "cone-beam computed" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Cone Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone-Beam Computer-Assisted Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT"	
	Algoritm "mandible" OR "lingual foramina" OR "midline lingual foramina" OR "accessory foramina" OR "accessory mandibular foramina" OR "lingual foramen" OR "lingual mandibular foramina" OR "lateral lingual canal" OR "lateral lingual foramen" OR "foramen lingual" OR "median lingual foramina" AND "cone-beam computed tomography" OR "cone-beam computed" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Cone Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone-Beam Computer-Assisted Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT"	
Grey literature		
Livivo	"lingual foramina" AND "cone-beam computed tomography"	39
Google Scholar	"lingual foramina" OR "midline lingual foramina" AND "cone-beam computed tomography" OR "Cone-Beam CT"	87
OpenGrey	"lingual foramina" OR "cone-beam computed tomography"	0

search strategy were imported into the Endnote reference management program (EndNote, Thomson Reuters, Philadelphia, PA, USA), excluding duplicates. In phase 2, the Ravvan qcri web and mobile app program (Qatar Computing Research Institute, Doha, Qatar) was used by two authors (Daniel Almeida Ferreira Barbosa and Diego Santiago de Mendonça) to evaluate titles and abstracts based on the adopted eligibility criteria. The selected articles were read entirely during the third phase of the study selection process. In addition, these authors searched for additional references in the final included articles. In phases 2 and 3, a third author (Fábio Wildson Gurgel Costa) judged any discordance between the researchers. The studies that met all the eligibility criteria were critically analyzed, and the extracted data were organized into Microsoft Excel spreadsheets before statistical analysis.

Risk of bias in individual studies

The risk of bias (RoB) followed the Meta-Analysis of Assessment and Review Instrument (MAStARI). Based on previous reviews of observational studies [20, 21], the RoB was estimated regarding the proportion of "yes" items as follows: high (up to 49%), moderate (50–69%), and low (> 70%). The RevMan program (Review Manager, version 5.3 software, Cochrane Collaboration, Copenhagen, Denmark) was used to adapt and manage the table with the eight MAStARI questions and to generate the RoB figures.

Statistical analysis

Data were tabulated in Microsoft Excel and exported to the MedCalc Statistical Software (version 16.4.3; MedCalc Software bv, Ostend, Belgium; https://www.medcalc.org; 2016) for meta-analysis. The total effects of overall prevalence were calculated using the random-effects method. Moreover, the total effects of the prevalence of each LF type (1, 2, 3, or 4 LF) were obtained using the random-effects method. The meta-analysis of the prevalence was performed only in studies in which the data were described and when described in absolute numbers. All data were subjected to heterogeneity analysis, and the *I*-square (I^2) coefficient was calculated. A 95% confidence level was considered for all statistical assessments.

Results

Study selection

The initial database search resulted in 6641 articles, of which 2426 were removed in the first phase because they were duplicates. After phase 2, 34 potential articles were selected for full text reading. Eight studies were excluded because they did not meet the eligibility criteria (Appendix Table 6). Then, 26 studies were selected for data synthesis (Fig. 1).

Study characteristics

The general study characteristics are described in Tables 2, 3. Among the 8,255 CBTC scans, 4336 described data according to sex. The sex distribution in the studies included in the SR was 2042 males and 2294 females. Ages ranged from 10 to 93 years. The distribution of LF in terms of sex showed its occurrence mainly in females ($n = 1129$). Of this LF-related sample, 43.5% of the studies were from Asia, followed by Europe (33.5%), North America (14%), and South America (9%) (Table 2).

This SR found articles that reported different mean distance values from the LF to the alveolar crest (11.04–20.4 mm), buccal (4.73–4.91 mm), and lingual (8.75 mm) cortices and the inferior border of the mandible (8.48–26.59 mm) (Table 4). Some investigations also reported length (5.81–10.55 mm), as well as vertical (0.68–1.39 mm) and horizontal (0.89–1.12 mm) diameters of this anatomic structure on CBCT scans (Table 5). Regarding the methodological aspects of the measurements, most of the articles used software for image analysis and adopted standardized criteria to establish reference plans and the method to perform the measurements.

Meta-analysis for prevalence and characterization according to number of LF

Among the 18 studies included in the meta-analysis, the pooled data showed significant heterogeneity ($p < 0.001$; $I^2 = 99.74\%$ [95% CI = 99.71–99.76%]), and no study was shown to be within the Funnel Plot-related confidence interval. The overall prevalence of LF in CBCT scans was 90.11% (95% CI = 71.51–99.41%). Katakami et al. [23], Eshak et al. [24], and Von Arx et al. [10] showed

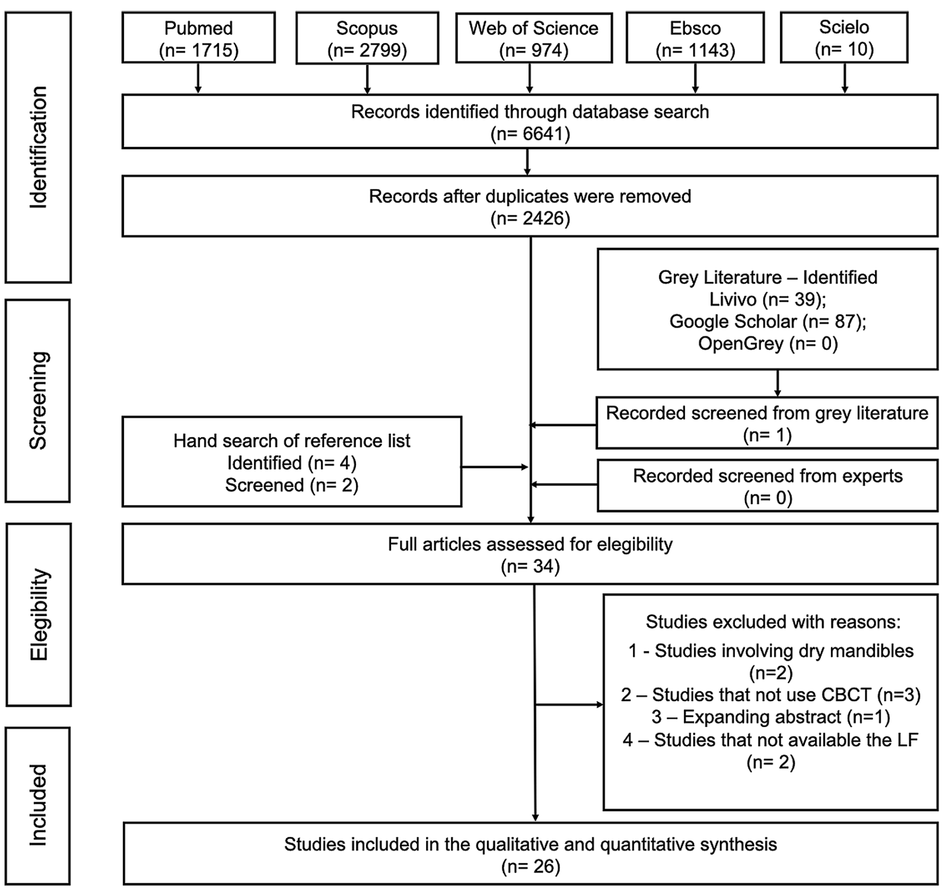


Fig. 1 Process of study selection

Table 2 General characteristics of included studies

Author (year)	Country	Continent	CBCT Unit	Voxel size	FOV type	Software for image analysis	Observers (n)	Radiologist	ICC
Aoun et al. [43]	Lebanon	Asia	PaX-Zenith3D	NI	Small	NI	2	Yes	NI
Aps [45]	Belgium	Europe	ProMax 3D Max	NI	Small/Medium	Romexis	1	No	0.9
Babiuc et al. [25]	Romanian	Europe	Picasso Trio	NI	NI	EzImplant-Plus	1	NI	NI
Bernardi et al. [26]	Italia	Europe	NI	NI	NI	Micerium Implant Planning	NI	NI	NI
Bulut and Kose [46]	Turkey	Europe	I-Cat	NI	0.3	iCATVision	1	Yes	0.94
Denny et al. [17]	Indian	Asia	Promax	NI	NI	NI	1	NI	NI
do Carmo Oliveira et al. [32]	Brazil	South America	OP300	0.2	Small	On Demand 3D	2	NI	NI
Ebrahimi et al. [47]	Hong Kong	Asia	I-Cat 3D	0.2	Medium	Denti Planversion	1	NI	NI
Eshak et al. [24]	USA	North America	I-Cat next generation	0.2–0.4	NI	NI	1	Yes	NI
Gilis et al. [30]	Belgium	Europe	ProMax	NI	NI	Romexis	NI	NI	NI
He et al. [39]	China	Asia	Kodak 9500	0.2	NI	CS 3D	NI	NI	NI
Katakami et al. [23]	Japan	Asia	PSR 9000 N	0.1	Small	Exavision SX	1	Yes	NI
Laçin et al. [27]	Turkey	Europe	NewTom 5G	0.2	Large	NI	1	Yes	Yes
Makris et al. [5]	Greece	Europe	Newtom 5G	NI	NI	Newtom 3G	NI	NI	NI
Marzook et al. [33]	Egypt	Africa	NI	NI	NI	Romexis	NI	NI	NI
Palma et al. [9]	Brazil	South America	NI	NI	NI	Dental Slice	NI	NI	NI
Romanos et al. [41]	Germany	Europe	KaVo 3D eXam	NI	NI	NI	2	NI	NI
Sanchez-Perez et al. [11]	Spain	Europe	ProMax 3D Max	0.2	NI	NI	2	NI	0.96
Sanhueza et al. [28]	Chile	South America	Orthophos XG	NI	NI	Galileos	NI	NI	NI
Sekerci et al. [31]	Turkey	Europe	Newtom 5G	0.25	NI	ExaVision SX	2	Yes	NI
Sheikhi et al. [4]	Iran	Asia	NI	0.25	NI	Galileos	NI	NI	NI
Sokhn et al. [34]	Lebanon	Asia	NI	0.3	NI	NI	NI	NI	NI
Von Arx et al. [10]	Swirtlan	Europe	3D Accuitomo XYZ Slice View Tomograph	0.08	NI	NI	NI	NI	NI
Wang et al. [42]	Taiwan	Asia	i-CAT Cone Beam 3D Dental Imaging System	NI	NI	i-CAT 3D Dental Imaging System	NI	NI	NI
Xie et al. [40]	China	Asia	NewTom VG	0.3	Small	NNT viewer	NI	NI	NI
Zangh et al. [29]	China	Asia	i-CAT	0.25	NI	iCATVision	2	1 Radiologist	NI NI

NI not informed

Table 3 Studies characteristics regarding sample, sex, age and LF prevalence

Author (year)	Sample study (total)			Age (range)	Age mean (SD)	Sample study (LF)		
	n	Male	Female			*n*	Male	Female
Aoun et al. [43]	90	41	49	18–72	39.34 (14.79)	83	NI	NI
Aps [45]	74	37	37	NI	NI	54	NI	NI
Babiuc et al. [25]	36	20	16	25–70	NI	36	NI	NI
Bernardi et al. [26]	56	NI	NI	NI	NI	56	NI	NI
Bulut and Kose [46]	48	24	24	28–64	48.1	NI	NI	NI
Denny et al. [17]	116	69	47	14–70	35.99 (5.4)	116	69	47
do Carmo Oliveira et al. [32]	202	61	141	15–89	NI	196	57	139
Ebrahimi et al. [47]	4051	NI	NI	NI	NI	592	NI	NI
Eshak et al. [24]	50	NI	NI	20–83	48	50	NI	NI
Gilis et al. [30]	200	97	103	10–70	27	170	NI	NI
He et al. [39]	181	56	125	NI	51	21	NI	NI
Katakami et al. [23]	350	186	164	NI	NI	350	164	186
Laçin et al. [27]	100	48	52	10–80	54.9	81	NI	NI
Makris et al. [5]	46	11	35	NI	50	46	NI	NI
Marzook et al. [33]	299	121	178	13–93	45.36	209	102	157
Palma et al. [9]	111	49	62	18–74	50	111	49	62
Romanos et al. [41]	138	43	95	20–83	NI	138	43	95
Sanchez-Perez et al. [11]	500	263	237	19–64	30.25	476	NI	NI
Sanhueza et al. [28]	102	57	55	21–91	52.37 (13.33)	102	NI	NI
Sekerci et al. [31]	40	14	26	20–60	NI	39	NI	NI
Sheikhi et al. [4]	179	64	115	11–87	42.7	52	NI	NI
Sokhn et al. [34]	101	46	55	27–77	55	98	NI	NI
Von Arx et al. [10]	1008	521	487	NI	41.1 (14.81)	916	473	443
Wang et al. [42]	299	163	136	18–81	40.2	299	NI	NI

NI not informed

prevalence rates below 30%, which was significantly lower than the estimated global prevalence in the meta-analysis. According to Fig. 2, several investigations reported a 100% prevalence of LF [4, 9, 25–30].

Regarding the occurrence of a single LF, 15 studies included 3098 patients. There was significant heterogeneity among the studies ($p < 0.001$), and the overall prevalence of this presentation was 53.20% (95% CI = 40.15–66.02%) (Fig. 3).

Two LF in each CBCT scan were observed in 16 studies, which involved a sample of 3690 individuals. These studies showed a significant heterogeneity ($p < 0.001$), and the overall prevalence of this pattern was 35.54% (95% CI = 21.46–51.04%) (Fig. 4).

The prevalence of three LF was observed in 15 studies ($n = 3634$). There was significant heterogeneity in these studies ($p < 0.001$), and the overall prevalence was 11.25% (95% CI = 5.92–18.03%) (Fig. 5).

The overall prevalence of four LF was 0.59% (95% CI = 0.83–2.23%). It was reported among 1127 patients from four studies, which showed significant heterogeneity ($p = 0.0005$) (Fig. 6).

Risk of bias

The RoB was determined to be high in five papers, moderate in 18, and low in three (Fig. 7). An overview of the percentage responses for each item is presented in Fig. 8.

Discussion

From a practical perspective, clinicians should be familiar with terms related to LF. Several nomenclatures were found in this SR, including lingual foramen [30], medial lingual foramen [27], LF [23], mandibular LF [31], lingual symphyseal foramen [32], median lingual foramen [33], accessory foramina [24], and endosseous canal [9].

It is noteworthy that LF can be evaluated using conventional radiographs; however, three-dimensional imaging exams allow the visualization of detailed anatomical aspects, location, path pattern, and presence of any accessory canals in the midline mandibular region. CT was first used to assess LF in the early 2000s, but this tomographic modality has some limitations because it does not allow the

Table 4 Mean LF distances (mm) to the alveolar crest, buccal cortex, lingual cortex, and mandible base

Author	Alveolar crest		Buccal		Lingual		MB	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Aoun et al. [43]	16.24	2.82	NI	NI	NI	NI	14	2.32
Aps [45]	NI	NI	NI	NI	NI	NI	NI	NI
Babiuc et al. [25]	14.2	4.34	NI	NI	NI	NI	11.2	3.1
Bernardi et al. [26]	NI	NI	NI	NI	NI	NI	NI	NI
Bulut and Kose [46]	15.6	5.1	NI	NI	NI	NI	12.3	3.8
Denny et al. [17]	17.89	NI	NI	NI	NI	NI	10.46	NI
do Carmo Oliveira et al. [32]	NI	NI	NI	NI	NI	NI	NI	NI
Ebrahimi et al. [47]	20.4	3.47	NI	NI	NI	NI	NI	NI
Eshak et al. [24]	NI	NI	NI	NI	NI	NI	NI	NI
Gilis et al. [30]	NI	NI	NI	NI	NI	NI	16.33	2.11
He et al. [39]	16.82	8.24	NI	NI	NI	NI	12.69	7.89
Katakami et al. [23]	NI	NI	NI	NI	NI	NI	NI	NI
Laçin et al. [27]	NI	NI	NI	NI	NI	NI	NI	NI
Makris et al. [5]	NI	NI	NI	NI	NI	NI	15.27	1.8
Marzook et al. [33]	NI	NI	NI	NI	NI	NI	NI	NI
Palma et al. [9]	NI	NI	NI	NI	NI	NI	8.56	4.82
Romanos et al. [41]	NI	NI	NI	NI	NI	NI	NI	NI
Sanchez-Perez et al. [11]	11.4	3.24	4.91	1.38	8.75	0.86	8.48	2.75
Sanhueza et al. [28]	NI	NI	NI	NI	NI	NI	NI	NI
Sekerci et al. [31]	12.04	3.05	NI	NI	NI	NI	18.36	4.02
Sheikhi et al. [4]	14.39	4.82	4.73	1.85	NI	NI	14.12	2.49
Sokhn et al. [34]	NI	NI	NI	NI	NI	NI	NI	NI
Von Arx et al. [10]	NI	NI	NI	NI	NI	NI	9.99	4.88
Wang et al. [42]	NI	NI	NI	NI	NI	NI	10.2	5.24
Xie et al. [40]	NI	NI	NI	NI	NI	NI	NI	NI
Zangh et al. [29]	NI	NI	NI	NI	NI	NI	13.79	2.15

NI not informed; *MB* mandible base

clear visualization of small structures such as LF and its relationship with adjacent structures [23].

The visualization of the LF depends on the technical factors that influence the image quality and reconstruction time of the three-dimensional images. Conventional CT (spiral CT) presents lower resolution images for small structures, such as LF, than CBCT [23, 34]. Currently, there are a wide variety of CBCT units, each with specific settings (mA, kV, rotation degree, scan mode, voxel size, and field of view). In general, the mA ranges from 1 to 32 and kV from 50 to 120. It is possible to acquire images using half- or full-scans. The field of view may be small, medium, or large. In addition, the voxel size may vary from 0.05 to 0.6 mm [35]. All these factors may influence the visualization of the anatomical structures [36, 37]. These settings are mainly determined by the manufacturers and may be adjusted (depending on the CBCT unit) by the clinical technician. In addition, the use of different CBCT settings may influence the overall image quality by changing the spatial resolution, contrast-to-noise ratio, and beam-hardening artifacts [37, 38]. For instance, smaller voxel dimensions may be associated with better spatial resolution and may, thus, be necessary when a high level of detail is required [38]. From a clinical point of view, the visualization of small anatomical structures such as the LF is directly related to the image quality. In the current systematic review, some studies have not reported CBCT settings, highlighting the importance of future investigations that address this aspect.

Methodologically, the most assessed variable was the number of LF per evaluated examination. The main clinical aspect related to the number of LF is the possibility of hemorrhagic events and their severity in surgical procedures involving the anterior mandibular region. Due to the fact that the sublingual artery is an important branch of the lingual artery and supplies this anatomical region through intraosseous channels, a greater number of LF suggests a more abundant vascularization in that area. In addition, the larger the diameter of these bony channels, the more calibrated the vessel that travels inside [39]. Such anatomical

Table 5 Mean LF length and vertical and horizontal diameters (mm)

Author	Lenght		Vertical diameter		Horizontal diameter	
	Media	SD	Media	SD	Media	SD
Aoun et al. [43]	5.81	1.6	NI	NI	NI	NI
Aps [45]	NI	NI	NI	NI	NI	NI
Babiuc et al. [25]	NI	NI	0.86	0.3	NI	NI
Bernardi et al. [26]	NI	NI	0.8	0.17	1.24	0.29
Bulut and Kose [46]	NI	NI	NI	NI	NI	NI
Denny et al. [17]	NI	NI	NI	NI	NI	NI
do Carmo Oliveira et al. [32]	NI	NI	NI	NI	NI	NI
Ebrahimi et al. [47]	NI	NI	NI	NI	NI	NI
Eshak et al. [24]	NI	NI	NI	NI	NI	NI
Gilis et al. [30]	NI	NI	NI	NI	NI	NI
He et al. [39]	NI	NI	0.73	0.26	NI	NI
Katakami et al. [23]	NI	NI	NI	NI	NI	NI
Laçin et al. [27]	NI	NI	NI	NI	NI	NI
Makris et al. [5]	NI	NI	NI	NI	NI	NI
Marzook et al. [33]	NI	NI	NI	NI	NI	NI
Palma et al. [9]	NI	NI	1.13	0.26	1.12	0.25
Romanos et al. [41]	9.25	1.99	1.39	0.46	NI	NI
Sanchez-Perez et al. [11]	10.55	NI	NI	NI	NI	NI
Sanhueza et al. [28]	NI	NI	NI	NI	NI	NI
Sekerci et al. [31]	NI	NI	1.16	0.39	0.89	0.32
Sheikhi et al. [4]	7.83	2.25	0.68	0.17	NI	NI
Sokhn et al. [34]	NI	NI	NI	NI	NI	NI
Von Arx et al. [10]	NI	NI	1.01	0.4	0.97	0.37
Wang et al. [42]	NI	NI	0.61	0.33	NI	NI
Xie et al. [40]	NI	NI	NI	NI	NI	NI
Zangh et al. [29]	NI	NI	0.65	0.19	NI	NI

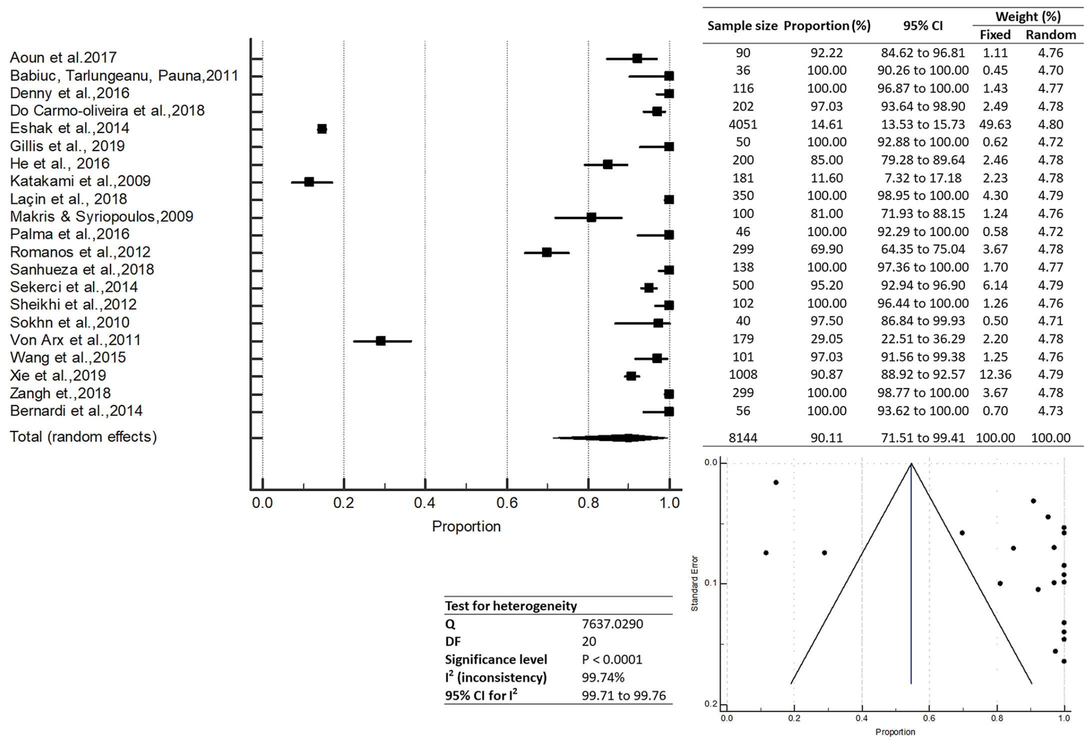
NI not informed

characteristics may suggest that a greater amount of LF could be considered a risk factor for more severe bleeding related to injuries from mandibular surgical procedures. In this context, the present SR highlights the importance of anatomical tomographic knowledge of LF before surgical procedures are performed to anticipate the management of hemorrhagic complications, especially in cases of multiple LF and those with a more pronounced caliber.

In this SR, up to two LF were usually found in the included articles, and the prevalence of one LF per CBCT scan was high in almost all studies. The studies by Xie et al. [40] and Romanos et al. [41], who reported the highest prevalence rates, were carried out in China and Germany. In contrast, Sheiki et al. [4], Wang et al. [42], Zangh et al. [29], and Sanhueza et al. [28] showed a significantly low prevalence of one LF compared to the overall prevalence found in the meta-analysis. These data suggest that the occurrence of only one LF does not seem to be associated with ethnicity since the studies with a low single LF prevalence originated from different populations, such as Iran [4], Taiwan [42], China [29], and Chile [28].

Romanos et al. [41] and Xie et al. [40] demonstrated a significantly low prevalence of two LF in comparison with the estimated global prevalence, which differed from the high rate observed by Eshak et al. [24]. In an exploratory study conducted with a sample from the USA and using images acquired with a 0.4-mm voxel size, the occurrence of two mandibular LF was the most frequent finding among the total of accessory foramina in the maxilla and mandible. This fact also reinforces the suggestion that the mentioned technical parameters are not decisive in LF visualization.

Among the 15 studies that reported the existence of three LF, some studies reported a significantly high percentage, such as 27.7% [42], 30.7% [29], and 34.6% [28], when compared with the general prevalence. This could probably be explained by the fact that these studies reported more cases with three LF than those with one LF (21.1%, 15.95%, and 23.8%, respectively). Among other studies, Aoun et al. [43]



Study	Sample size	Proportion (%)	95% CI	Weight (%) Fixed	Weight (%) Random
Aoun et al.2017	90	92.22	84.62 to 96.81	1.11	4.76
Babiuc, Tarlungeanu, Pauna,2011	36	100.00	90.26 to 100.00	0.45	4.70
Denny et al.,2016	116	100.00	96.87 to 100.00	1.43	4.77
Do Carmo-oliveira et al.,2018	202	97.03	93.64 to 98.90	2.49	4.78
Eshak et al.,2014	4051	14.61	13.53 to 15.73	49.63	4.80
Gillis et al., 2019	50	100.00	92.88 to 100.00	0.62	4.72
He et al., 2016	200	85.00	79.28 to 89.64	2.46	4.78
Katakami et al.,2009	181	11.60	7.32 to 17.18	2.23	4.78
Laçin et al., 2018	350	100.00	98.95 to 100.00	4.30	4.79
Makris & Syriopoulos,2009	100	81.00	71.93 to 88.15	1.24	4.76
Palma et al.,2016	46	100.00	92.29 to 100.00	0.58	4.72
Romanos et al.,2012	299	69.90	64.35 to 75.04	3.67	4.78
Sanhueza et al.,2018	138	100.00	97.36 to 100.00	1.70	4.77
Sekerci et al.,2014	500	95.20	92.94 to 96.90	6.14	4.79
Sheikhi et al.,2012	102	100.00	96.44 to 100.00	1.26	4.76
Sokhn et al.,2010	40	97.50	86.84 to 99.93	0.50	4.71
Von Arx et al.,2011	179	29.05	22.51 to 36.29	2.20	4.78
Wang et al.,2015	101	97.03	91.56 to 99.38	1.25	4.76
Xie et al.,2019	1008	90.87	88.92 to 92.57	12.36	4.79
Zangh et.,2018	299	100.00	98.77 to 100.00	3.67	4.78
Bernardi et al.,2014	56	100.00	93.62 to 100.00	0.70	4.73
Total (random effects)	8144	90.11	71.51 to 99.41	100.00	100.00

Test for heterogeneity	
Q	7637.0290
DF	20
Significance level	P < 0.0001
I^2 (inconsistency)	99.74%
95% CI for I^2	99.71 to 99.76

Fig. 2 Meta-analysis regarding the overall LF prevalence

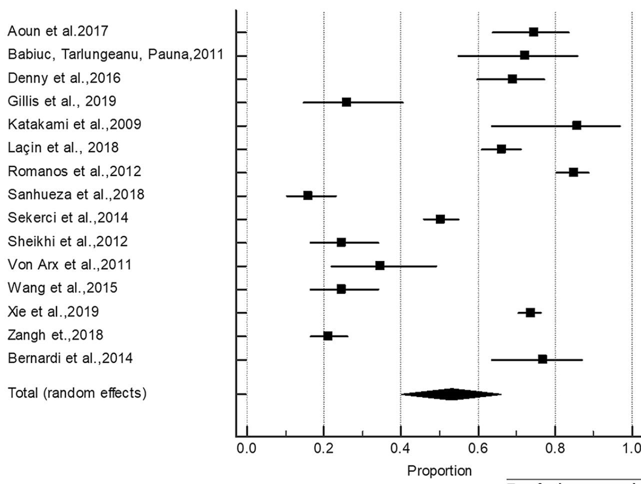
reported only one case of three LF (1.1%); Denny et al. [17], two cases (1.7%); Sanchez-Perez et al. [11], four cases (4.08%); and Xie et al. [40], 21 cases (2.1%) from the total sample. From a clinical perspective, as two Chinese investigations [29, 40] reported markedly different prevalence rates, this SR highlights the importance of further prevalence studies performed in the same country. Since the placement of implants in the anterior region of the mandible has been related to trans- and postoperative hemorrhagic events [44], knowledge about the possibility of three LF should be considered by the surgeon.

More than three LF was an uncommon finding among the studies evaluated in this review. Only five studies mentioned four LF per tomographic image ($n=15$ cases), and the prevalence rates were 0.15% [24], 1% [29], 2.9% [4], 3.1% [25], and 4% [42].

The anatomical position of the LF was evaluated using different methods. He et al. [39] used the tooth apex (above or below) as a reference. Marzook et al. [33] classified it according to the canal opening location as upper, middle, and lower, which could be lingual or buccal. Another classification mostly adopted concerns the genial tubercle, classifying it as upper or lower LF [25, 26, 30, 31, 43, 45, 46]. Other studies based on the genial tubercle classified the LF position as superior, medium, and inferior [40–42].

Some studies have reported different distances from the LF to the adjacent cortical bone, especially the upper LF. This aspect is of great clinical importance because LF in a more superior position is a potential structure that is susceptible to damage during implant placement or even in invasive surgical procedures. Based on available data, the mean distance between the upper LF and the alveolar crest showed significant variability among the included studies, ranging from 11.4 ± 3.24 mm [11] to 20.4 ± 3.47 mm [47]. The methodology used may partially explain the occurrence of these different values in each study. For example, Sanchez-Perez et al. [11] performed two measurements: (1) from the lowest point of the LF to the apex of the adjacent tooth (11.4 ± 3.24 mm in dentate individuals); (2), up to the alveolar crest (12.19 ± 3.25 mm in edentulous individuals).

This SR found articles with a wide age range, including young individuals in some studies. Regarding the rationale of childhood exposure to radiation, Von Arx et al. [10] performed a retrospective study with the examination of



Sample size	Proportion (%)	95% CI	Weight (%) Fixed	Weight (%) Random
83	74.69	63.96 to 83.60	2.70	6.67
36	72.22	54.81 to 85.80	1.19	6.32
116	68.96	59.70 to 77.22	3.76	6.76
50	26.00	14.63 to 40.34	1.64	6.49
21	85.71	63.65 to 96.95	0.71	5.93
350	66.28	61.06 to 71.22	11.28	6.90
305	84.91	80.40 to 88.74	9.83	6.89
138	15.94	10.26 to 23.13	4.47	6.79
476	50.42	45.83 to 55.00	15.32	6.92
102	24.51	16.53 to 34.02	3.31	6.73
52	34.61	21.96 to 49.08	1.70	6.50
98	24.49	16.36 to 34.21	3.18	6.72
916	73.58	70.59 to 76.41	29.46	6.95
299	21.07	16.58 to 26.13	9.64	6.89
56	76.78	63.58 to 87.02	1.83	6.53
3098	53.20	40.15 to 66.02	100.00	100.00

Test for heterogeneity	
Q	693.3013
DF	14
Significance level	P < 0.0001
I^2 (inconsistency)	97.98%
95% CI for I^2	

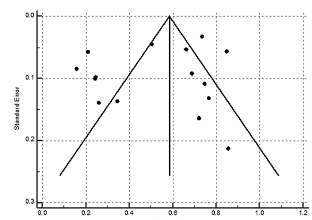
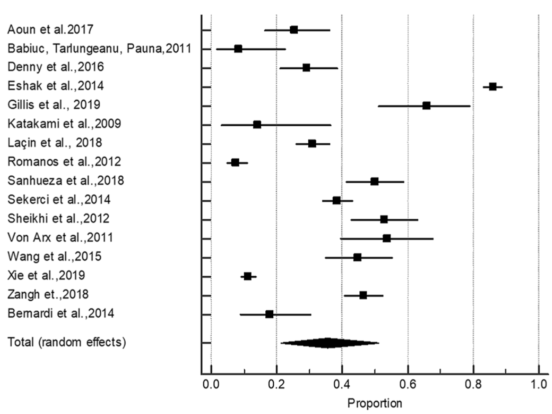


Fig. 3 Meta-analysis regarding prevalence of one LF



Sample size	Proportion (%)	95% CI	Weight (%) Fixed	Weight (%) Random
83	25.301	16.394 to 36.039	2.27	6.25
36	8.333	1.753 to 22.469	1.00	6.02
116	29.310	21.227 to 38.481	3.16	6.30
592	86.149	83.101 to 88.830	16.00	6.40
50	66.000	51.235 to 78.795	1.38	6.13
21	14.286	3.049 to 36.342	0.59	5.77
350	30.857	26.055 to 35.986	9.47	6.39
305	7.541	4.840 to 11.100	8.26	6.38
138	50.000	41.376 to 58.624	3.75	6.32
476	38.445	34.054 to 42.981	12.87	6.40
102	52.941	42.804 to 62.903	2.78	6.28
52	53.846	39.470 to 67.769	1.43	6.14
98	44.898	34.833 to 55.279	2.67	6.27
916	11.354	9.372 to 13.588	24.74	6.41
299	46.488	40.727 to 52.320	8.09	6.38
56	17.857	8.910 to 30.397	1.54	6.16
3690	**35.548**	**21.464 to 51.046**	**100.00**	**100.00**

Test for heterogeneity	
Q	1301.6135
DF	15
Significance level	P < 0.0001
I^2 (inconsistency)	98.85%
95% CI for I^2	98.60 to 99.05

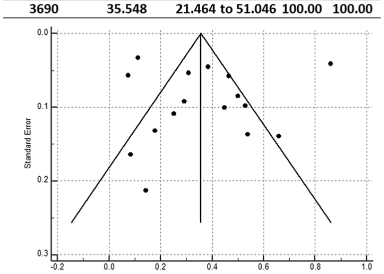
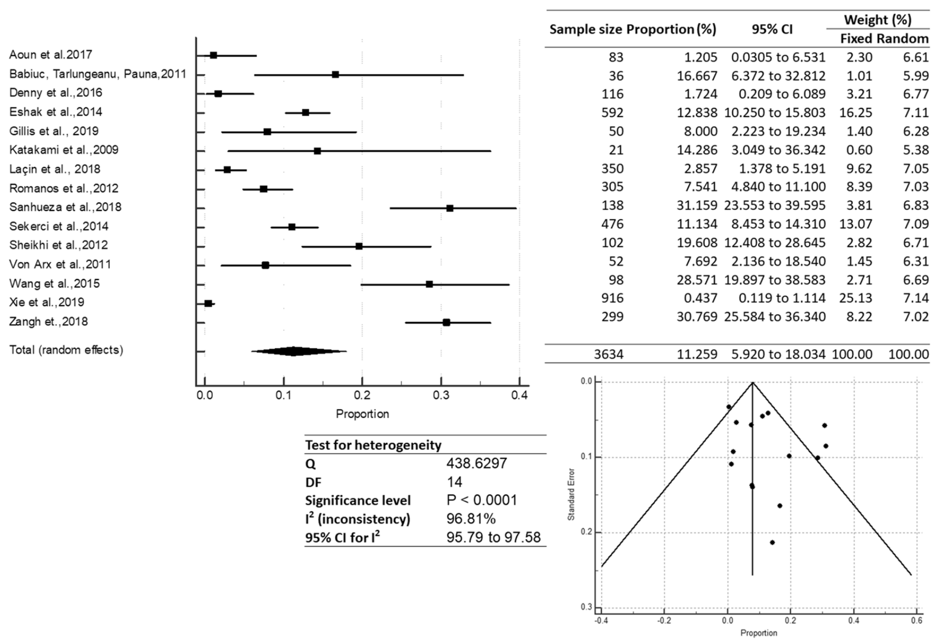


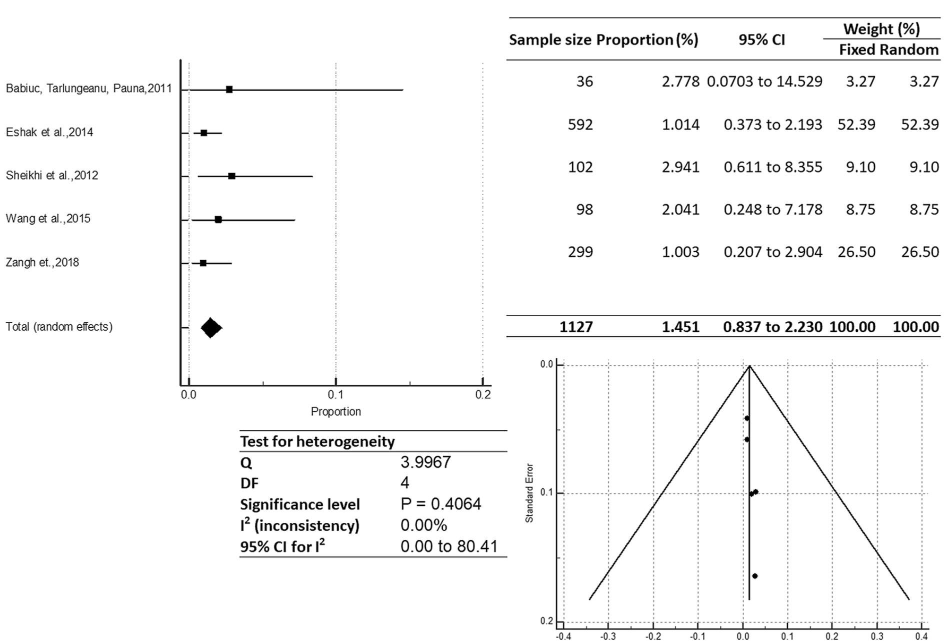
Fig. 4 Meta-analysis regarding prevalence of two LF



Study	Sample size	Proportion (%)	95% CI	Weight (%) Fixed	Weight (%) Random
Aoun et al.2017	83	1.205	0.0305 to 6.531	2.30	6.61
Babiuc, Tarlungeanu, Pauna,2011	36	16.667	6.372 to 32.812	1.01	5.99
Denny et al.,2016	116	1.724	0.209 to 6.089	3.21	6.77
Eshak et al.,2014	592	12.838	10.250 to 15.803	16.25	7.11
Gillis et al., 2019	50	8.000	2.223 to 19.234	1.40	6.28
Katakami et al.,2009	21	14.286	3.049 to 36.342	0.60	5.38
Laçin et al., 2018	350	2.857	1.378 to 5.191	9.62	7.05
Romanos et al.,2012	305	7.541	4.840 to 11.100	8.39	7.03
Sanhueza et al.,2018	138	31.159	23.553 to 39.595	3.81	6.83
Sekerci et al.,2014	476	11.134	8.453 to 14.310	13.07	7.09
Sheikhi et al.,2012	102	19.608	12.408 to 28.645	2.82	6.71
Von Arx et al.,2011	52	7.692	2.136 to 18.540	1.45	6.31
Wang et al.,2015	98	28.571	19.897 to 38.583	2.71	6.69
Xie et al.,2019	916	0.437	0.119 to 1.114	25.13	7.14
Zangh et.,2018	299	30.769	25.584 to 36.340	8.22	7.02
Total (random effects)	3634	11.259	5.920 to 18.034	100.00	100.00

Test for heterogeneity	
Q	438.6297
DF	14
Significance level	P < 0.0001
I^2 (inconsistency)	96.81%
95% CI for I^2	95.79 to 97.58

Fig. 5 Meta-analysis regarding prevalence of three LF

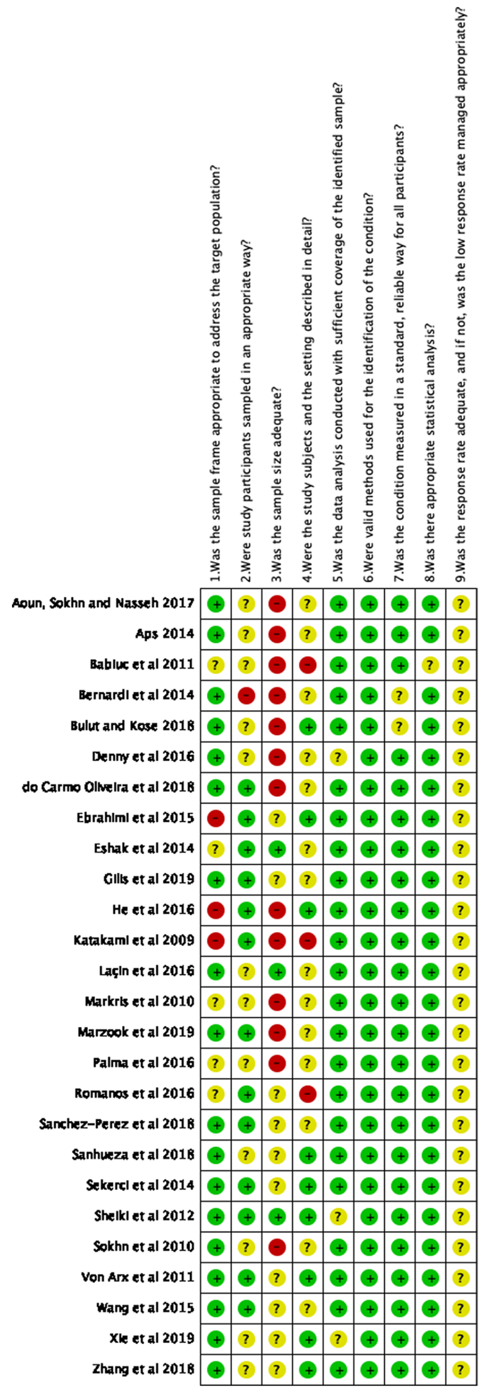


Study	Sample size	Proportion (%)	95% CI	Weight (%) Fixed	Weight (%) Random
Babiuc, Tarlungeanu, Pauna,2011	36	2.778	0.0703 to 14.529	3.27	3.27
Eshak et al.,2014	592	1.014	0.373 to 2.193	52.39	52.39
Sheikhi et al.,2012	102	2.941	0.611 to 8.355	9.10	9.10
Wang et al.,2015	98	2.041	0.248 to 7.178	8.75	8.75
Zangh et.,2018	299	1.003	0.207 to 2.904	26.50	26.50
Total (random effects)	1127	1.451	0.837 to 2.230	100.00	100.00

Test for heterogeneity	
Q	3.9967
DF	4
Significance level	P = 0.4064
I^2 (inconsistency)	0.00%
95% CI for I^2	0.00 to 80.41

Fig. 6 Meta-analysis regarding prevalence of four LF

Fig. 7 Risk of bias as assessed by the critical appraisal tools of the ▸ Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI). Risk of bias was categorized as High when the study scored up to 49% of "yes" responses, Moderate when the study scored from 50 to 69% of "yes" responses, and Low when the study scored more than 70% of "yes" responses



individuals referred for dental evaluation. This author stated that the as low as reasonably achievable (ALARA) principles were followed to minimize radiation, justifying CBCT examinations for cases that required additional three-dimensional imaging evaluation for diagnosis and treatment purposes. Makris et al. [5] reported that the acquisition parameters were appropriately standardized for each patient, and CT scans were required for several reasons. He et al. [39] used tomographic images of individuals treated for various conditions at the Stomatology Hospital of the Sichuan Medical School (China), and reported that relatives of patients under 18 years of age signed a consent form. Thus, we strongly recommend that future studies follow the ALARA principles, and the reasons for requesting CT scans in young patients should be explained.

He et al. [39] separated the sample into age groups: Group 1 (10–19 years), Group 2 (20–49 years), and Group 3 (over 50 years), and found that the distance from the upper LF up to the apex of the tooth for the each group was G1 (7.17 ± 1.96 mm), G2 (5.44 ± 2.26 mm), and G3 (4.03 ± 2.31 mm). In contrast, the distance from the lower LF to the apex of the tooth was greater in the older group (G3 13.91 ± 8.83 mm) than in the younger group (G1 12.69 ± 7.89 mm). No difference in diameter nor in the distances from the LF to the base of the border of the mandible and to the alveolar crest was found.

In surgical procedures related to bone graft placement, adequate buccal bone cortical limits should be carefully planned. This study found only two studies that reported the distances from the LF to the buccal bone cortex; they showed mean values of 4.73 ± 1.85 mm [4] and 4.91 ± 1.38 mm [11]; thus, further studies addressing this variable should be conducted since bone graft collection procedures in the anterior region of the mandible are commonly performed in clinical practice.

In only 14 studies, the distance between the LF and the inferior border of the mandible was used to plan surgical procedures. Accumulated data regarding this distance showed a mean variation between 8.56 ± 4.82 mm [9] and 18.36 ± 4.02 mm [31], and these results originated from investigations in Brazil and Turkey, respectively. Another study carried out in Turkey found different results since it reported a mean of 12.3 ± 3.8 mm [46].

A limitation of this study was the impossibility to establish a safe implant size in relation to the distance from the LF to the alveolar crest (Fig. 9), since it ranged between 11.4 [11]

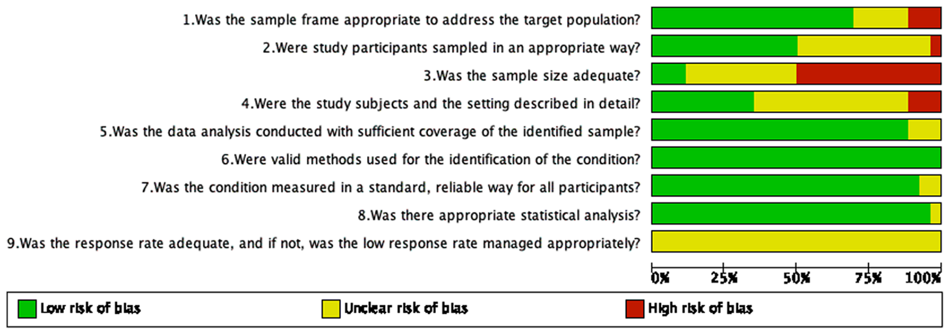


Fig. 8 A RoB graph: a review of authors' judgments about each RoB item presented as percentages across all of the included studies

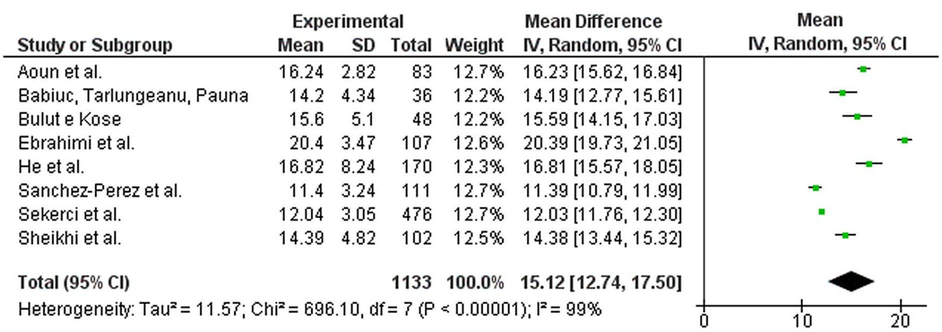


Fig. 9 Meta-analyses of the LF distance to the alveolar crest

and 20.4 mm [44]. The heterogeneity related to the lack of standardization of field of view and resolution was the main aspect found in these studies. Thus, it is necessary to carry out future studies with similar methodological aspects, such as a large sample size, to establish appropriate implant dimensions in the anterior region of the mandible midline when LF is observed. Moreover, since most of the selected articles were from Asia and Europe, the present results cannot represent the equal distribution in each international region. In addition, it is noteworthy that there was high heterogeneity in relation to the sample size and use of different CBCT-related acquisition parameters. Thus, this SR highlights the importance of future investigations using samples from different countries.

Conclusion

In summary, this SR found that the LF is an anatomical structure with a high prevalence among the included studies (greater than 90%), regardless of the population evaluated, and the occurrence of at least one LF was the most common pattern. Of clinical relevance, the measurements related to the adjacent structures, such as the alveolar crest, showed a broad variation, probably due to methodological heterogeneity. Therefore, future well-designed imaging-based anatomic studies from different populations are essential to strengthen the evidence regarding the morphometric parameters of LF.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval Not applicable.

Informed consent Not applicable.

Appendix See Tables 6, 7.

Table 6 Excluded articles and reasons for exclusion ($n = 8$)

Author, year	Reason for exclusion
De chaves et al. 2019	3
Ikuta et al. 2016	4
Gahleitner et al. 2001	2
Jaju et al. 2010	2
Kim et al. 2013	2
Ogawa et al. 2016	4
Sener et al. 2017	1
Soto et al. 2018	1

1- Studies involving dry mandibles; 2- Studies that not use CBCT; 3- Poster presented in scientific congress 4- Studies that not available the LF

Table 7 List of acronyms

ALARA	As low as reasonably achievable
CBCT	Cone-beam computed tomography
EBSCO	Elton B. Stephens Company
FOV	Field of view
GT	Genial tubercle
LF	Lingual foramen
MAStARI	Meta-analysis of assessment and review instrument
MESH	Medical Subject Headings
PECOS	Population/exposure/control/outcome/study design
PRISMA	Preferred reporting items for systematic reviews and meta-analyzes
PROSPERO	International prospective register of systematic reviews
RoB	Risk of bias
SR	Systematic review
USA	United States of America

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Capítulo 2

5.2 CAPÍTULO 2

Clinical, Imaging, and Therapeutic Aspects of Genial Tubercle Fractures: A Systematic Review

Daniel Almeida Ferreira Barbosa, DDS, MSc, *
Thamara Manoela Marinho Bezerra, DDS, PhD,†
Paulo Goberlânio Barros Silva, DDS, PhD,‡
Alynne Vieira Menezes Pimenta, DDS, PhD,§
Lúcio Mitsuo Kurita, DDS, PhD,|| *and Fábio Wildson Gurgel Costa, DDS, PhD*¶

Purpose: The present study reviewed the clinical, imaging, and therapeutic aspects of genial tubercle fracture (GTF).

Materials and Methods: A 2-phase systematic search of the literature was performed. Search strategies were developed for specific databases (PubMed, Scopus, Web of Science, Cochrane, and LILACS), including the gray literature (Open Grey and Google Scholar). The descriptors "genial tubercle," "fractures, bone," "mentalis," "spinae," and "mandible" were searched without restriction to year of publication. The CARE guideline was applied to evaluate methodologic aspects, and the Meta-Analysis of Assessment and Review Instrument was used to assess the risk of bias. The adopted level of significance was .05.

Results: Of 1,970 articles, 1,948 were excluded after applying the eligibility criteria. Furthermore, 2 studies were added through a manual search of the reference lists, totaling 24 articles. Occurrence of GTF was most common in women older than 61 years and men younger than 60 years (difference in age at occurrence was statistically significant; $P = .019$). The main clinical findings were edentulism, sublingual edema, and pain ($P < .001$). Previous trauma was commonly absent in women and present in men ($P = .018$). A cracking sound was mainly reported by women ($P = .009$). Isolated panoramic and occlusal radiographs were the most commonly performed examinations ($P < .001$). Diagnosis of sialolithiasis occurred in 37.5% of cases, and conservative treatment was performed in 76.6% of cases.

Conclusion: GTF was mainly observed in older women, edentulous patients, and those without previous trauma. Conventional radiography and nonsurgical treatment were frequently reported.

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Genial tubercles (GTs) are bony projections on the lingual surface of the mandibular symphysis region between the upper and lower borders of the mandible. Up to 4 tubercles can be found, with the upper ones serving as an anchorage for the genioglossus muscle and the lower ones serving as an anchorage for the

*Postgraduate Student, Division of Oral Radiology, Federal University of Ceará, Fortaleza, Brazil.

†Postgraduate Student, Division of Oral Pathology, Federal University of Ceará, Fortaleza, Brazil.

‡Professor, Division of Oral Pathology, Unichristus University Center, Fortaleza, Brazil.

§Radiologist and Professor, Division of Oral Radiology, Federal University of Ceará, Fortaleza, Brazil.

||Radiologist and Professor, Division of Oral Radiology, Federal University of Ceará, Fortaleza, Brazil.

¶Oral Maxillofacial Surgeon and Professor, Division of Oral Radiology, Federal University of Ceará, Fortaleza, Brazil.

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Address correspondence and reprint requests to Dr Barbosa: Programa de Pós-graduação em Odontologia, Rua Monsenhor Furtado, 1273, Rodolfo Teófilo, Fortaleza, CE, Brazil CEP 60430-355; e-mail: danielodontologia@gmail.com

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geniohyoid muscle.[1,2] In addition to the topographic importance of GTs in clinical practice, cases of GT fracture (GTF) have been reported.[3] In 1894, the American Gwilym G. Davis, in Philadelphia, reported the first case of jaw fracture with GT separation.[4]

Isolated GTFs also can occur, the etiologies of which can be spontaneous or traumatic; these have predisposing factors (especially in women), such as alveolar tension caused by mandibular atrophy, senility, osteoporosis, and poorly adjusted prostheses.[2,3,5,6]

Clinical findings in the literature show that edema, bruising, sublingual or extraoral hematoma, and, mainly, crepitation followed by pain are the most frequent signs, especially in patients with a history of total edentulism of the lower arch.[7,8] An evaluation serves to select the diagnostic procedure, so a differential diagnosis could include sialolithiasis and plunging ranula, for example.[2,7]

The most appropriate imaging modality for the diagnosis of these fractures is occlusal radiography. However, it is common to perform panoramic radiography.[1] Currently, cone-beam computed tomography (CBCT) has been used as an additional imaging examination, especially for the establishment of the type of treatment to be applied, be it conservative or surgical, because of the accurate visualization of the fractured fragments.[3]

Depending on factors associated with fracture etiology, treatment can be conservative, which includes the prescription of analgesic and anti-inflammatory drugs, antibiotic therapy, or corticoid therapy,[6,7] or surgical.[9,10]

The objective of this study was to perform a systematic review registered in the Prospective Register of Systematic Reviews (PROSPERO) of the clinical, imaging, and therapeutic aspects involving GTFs according to recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Materials and Methods

This systematic review was written according to PRISMA guidelines. The PRISMA guide establishes the main items that guarantee transparent and complete writing of systematic reviews.[11] The research protocol was recorded in the international PROSPERO under reference number CRD42018094418.

A systematic review was performed to answer the following question: what are the clinical and radiographic aspects of GTFs reported in the literature? The review followed the PECOS strategy:

1. Population (P): patients with GTFs
2. Exposure (E): GTFs
3. Control (C): not applicable
4. Outcome (O): prevalence
5. Study design (S): case reports and case series

To identify studies for inclusion in this review, an electronic search in the PubMed, Scopus, Web of Science, Cochrane, and Latin American and Caribbean Latin American and Health Sciences Information Center (LILACS) databases was performed using the resources of the Pharmacy, Dentistry and Nursing Faculty of the Federal University of Ceará (Fortaleza, Brazil) on July 10, 2018 (Table 1). A partial search in the gray literature was performed on Google Scholar and Open Grey. References of the selected articles also were searched individually. All references were manipulated in a reference management program (EndNote, Thomson Reuters, Philadelphia, PA) and duplicate references were removed. The search strategy was appropriately modified for each database to identify eligible studies.

Case reports and case series of GTF were included in the present study. The following articles were excluded: *1)* literature reviews, clinical trials, editor's notes, pilot studies, and in vitro studies; *2)* fractures that did not involve the GTs; and *3)* studies not written in the Latin (Roman) alphabet.

The examiners were trained to apply the selection criteria to the studies in 2 phases. Phase 1 involved the analysis of titles and abstracts of all articles obtained from the databases to select the studies to be read in full; for screening, the Ravvan qcri web and mobile app (Qatar Computing Research Institute, Doha, Qatar) for systematic reviews was used.[12] Phase 2 included complete reading of the articles chosen in phase 1 to assess eligibility by the established inclusion and exclusion criteria. Two authors (D.A.F.B. and T.M.M.B.) participated independently in phases 1 and 2. In phase 2, an additional manual search of references in the selected studies after the complete reading was carried out by 2 researchers with the objective of finding possible articles inadvertently omitted during searches of the databases. In the 2 phases, any disagreement between the 2 researchers was resolved by a third author (F.W.G.C.).

The studies that met the inclusion criteria were carefully analyzed by 2 authors (D.A.F.B. and T.M.M.B.) independently. A previously prepared customized table with the variables of interest in the study was used for the extraction and tabulation of data. If there was any disagreement, the article was discussed between the 2 authors and a third researcher (F.W.G.C.) until a consensus was established.

The included articles were classified by risk of bias (RoB) and methodologic quality using the Meta-Analysis of Assessment and Review Instrument

Table 1. ELECTRONIC DATABASES AND RESEARCH STRATEGIES

PubMed	
#1	“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”
#2	“fractures, bone”[MeSH Terms] OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures”[Mesh] OR “Mandibular Fractures”[Mesh] OR “Mandibular Fracture” OR “Jaw Fracture”
#1 and #2	((“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”)) AND (“fractures, bone”[MeSH Terms] OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures”[Mesh] OR “Mandibular Fractures”[Mesh] OR “Mandibular Fracture” OR “Jaw Fracture”)
Scopus	
#1	“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”
#2	“fractures, bone” OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures” OR “Mandibular Fractures” OR “Mandibular Fracture” OR “Jaw Fracture”
#1 and #2	TITLE-ABS-KEY (“fractures, bone” OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures” OR “Mandibular Fractures” OR “Mandibular Fracture” OR “Jaw Fracture” AND “genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”)
Cochrane	
#1	“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”
#2	“fractures, bone” OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures” OR “Mandibular Fractures” OR “Mandibular Fracture” OR “Jaw Fracture”
#1 and #2	“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae” in Title, Abstract, Keywords and “fractures, bone” OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures” OR “Mandibular Fractures” OR “Mandibular Fracture” OR “Jaw Fracture” in Title, Abstract, Keywords in Trials’
Web of Science	
#1	“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”
#2	“fractures, bone” OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures” OR “Mandibular Fractures” OR “Mandibular Fracture” OR “Jaw Fracture”
LILACS	
#1	“genial” OR “tubercle” OR “genials” OR “tubercles” OR “genial tubercles” OR “genial tubercle” OR “spinae”
#2	“fractures, bone”[MeSH Terms] OR “bone fractures” OR “fracture” OR “Broken Bones” OR “Broken Bone” OR “Bone Fracture” OR “Jaw Fractures”[Mesh] OR “Mandibular Fractures”[Mesh] OR “Mandibular Fracture” OR “Jaw Fracture”

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(MAStARI) and the Case Reports Guidelines—CARE (CARE Guidelines: Consensus-based Clinical Case Reporting Guideline Development), respectively. The RoB is a percentage system based on other studies with similar methodologies and scored according to the percentage of “yes” ratings (high, <49%; moderate, 50 to 69%; low, ≥70%).[13] A third reviewer made the final decision in cases of uncertainty. Review Manager 5.3 (Cochrane Collaboration, Copenhagen, Denmark) was used to generate the RoB summary with adaptation for the 8 questions of the MAStARI.[14] For the CARE instrument, the items used to evaluate the articles correspond to the following sections: title (item 1); key words (item 2); summary (items 3a to 3d); introduction (item 4); patient information (items 5a to 5d); clinical findings (item 6); timeline (item 7); diagnostic assessment (items 8a to 8d); therapeutic interventions (items 9a to 9d); follow-up and outcomes (items 10a to 10d); discussion (items 11a to 11d); patient perspective (item 12); and informed consent (item 13).

The information obtained from the studies was tabulated in Excel 2016 (Microsoft, Redmond, WA) using a previously prepared spreadsheet containing the established data categories to be extracted. Dichotomous data were analyzed with Fisher exact or Pearson χ^2 tests (SPSS 17.0, SPSS, Inc, Chicago, IL) with a significance level of .05.

Results

The search strategy resulted in 1,970 articles. Of these studies, 1,236 reports were present in more than 1 database (duplicates). The authors independently read the titles and summaries of articles related to the topic. Of the 734 articles found, 703 were excluded because they were not related to the subject. After reading the 33 articles, 9 studies were excluded because they did not meet the eligibility criteria. Therefore, 24 articles were included for data synthesis. Figure 1 presents the search results in a flowchart. The search strategy for each database is presented in Table 1. Geographically, the articles were distributed across 5 continents (the Americas, n = 8 [33%]; Asia, n = 3 [12%]; Europe, n = 11 [47%]; Africa, n = 2 [8%]) and 14 countries (Brazil, n = 1; United States, n = 7; India, n = 1; Israel, n = 1; Malaya, n = 1; Netherlands, n = 1; Northern Ireland, n = 1; Germany,

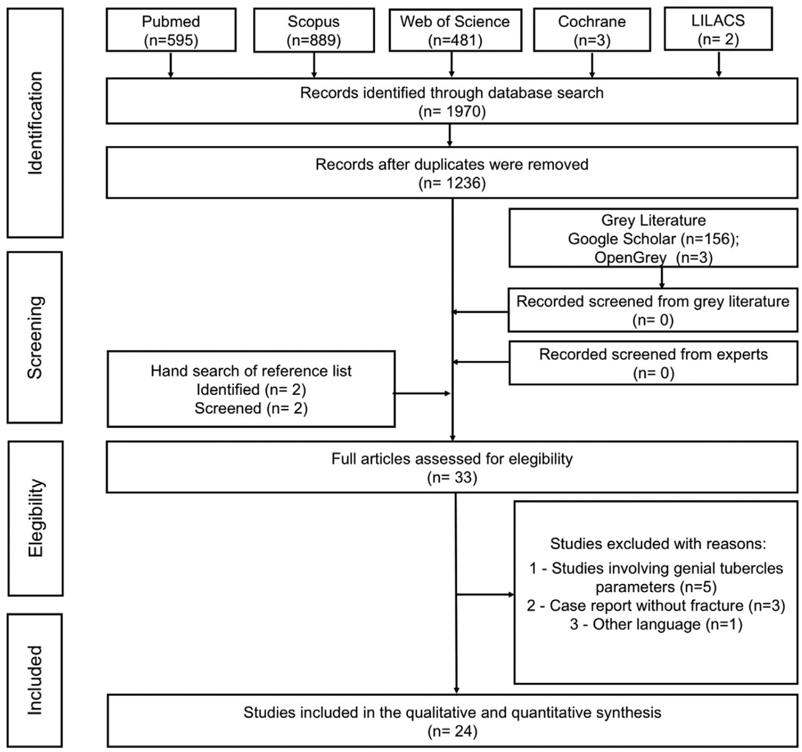

FIGURE 1. Flowchart of study selection process.

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n = 1; Ukraine, n = 1; Italy, n = 1; Spain, n = 2; England, n = 4; Egypt, n = 1; South Africa, n = 1]).

The patients' mean age was 64 ± 18 years (range, 22 to 87 yr), and the age range with the highest prevalence was 61 to 70 years (n = 10; 43.5%), although reports from Maw and Lindsay[15] in 1970 and Smyd[16] in 1957 did not specify the age in the cases reported (Table 2). Women were most affected (n = 16; 66.7%), and a history of trauma was observed in 6 patients (30.0%). Of the articles that reported ethnicity, 7 studies reported on Caucasian patients and 1 mentioned 1 Black patient.

Isolated fractures were reported in 20 cases, and GTFs associated with another jaw fracture were described in 4 reports. In relation to edentulism, in 4 reported cases, patients were dentate in the anterior region of the mandible,[4,10,15,17] whereas 20 had total edentulism of the lower arch associated with atrophy of the mandibular bone. The etiologies of GTFs were trauma (n = 4; 2 auto accidents, aggression, and fall from own height), perforation by firearm projectile (n = 1), and spontaneous (n = 19).

Signs and symptoms are presented in Tables 3 and 4. Edentulism or jaw atrophy was found in all cases of isolated fractures in addition to pain in 22 patients (97.7%), sublingual edema in 20 (83.3%), altered swallowing in 16 (69.6%), and sublingual hematoma in 14 (58.3%). Clinical presentations included other findings, such as a cracking sound (40.0%), odynophagia (44.0%), and limited tongue movement (16.7%).

The most commonly used radiographic examination was occlusal radiography (n = 19; 79.2%; Fig 2), followed by panoramic radiography (n = 10; 41.7%). Combined conventional examinations (panoramic and occlusal radiographs) were used in 7 cases (29.2%), CT was used in 5 (n = 20.8%), and panoramic radiography with CT was used in 4 (16.7%).

The apparent diagnosis of a fracture was observed in most studies (n = 18; 72.0%) and conservative treatment was the main therapeutic approach (n = 19; 76.0%). Mean follow-up time was 6.7 ± 12.5 months (0.2 to 48 months), with most follow-up visits within 1 month (n = 10; 47.6%), 6 (28.6%) within 1 to 6 months, and 5 (23.8%) beyond 6 months.

Men presented at a younger age at occurrence of GTF (P = .019), had a significantly greater likelihood of previous history (P = .018), and the absence of a cracking sound (P = .009). Women were significantly

Table 2. GENERAL CHARACTERIZATION OF STUDIES

	n	%	*P* Value
Continent			
Africa	2	8.0	.153
Americas	8	33.0	
Asia	3	12.0	
Europe	11	47.0	
Age (yr)			
≤60	5	21.7	.640
61-70	10	43.5	
>70	8	34.8	
Gender			
Women	16	66.7	.241
Men	8	33.3	
Trauma history	6	30.0	.197
Clinical presentation			
Edentulism and mandibular atrophy	21*	100.0	<.001
Sublingual edema	20*	83.3	
Sublingual hematoma	14	58.3	
Pain	22*	95.7	
Altered swallowing	16	69.6	
Limited tongue movement	4	16.7	
Cracking sound	10	40.0	
Other clinical sign	12	48.0	
Other clinical symptom	11	44.0	
Imaging evaluation			
Panoramic radiography	10*	41.7	<.001
Occlusal radiography	19*	79.2	
Computed tomography	5	20.8	
Panoramic + occlusal radiography	7	29.2	
Panoramic radiography + computed tomography	4	16.7	
Apparent diagnosis			
Sialolithiasis	7	28.0	.107
Fracture	18	72.0	
GTF treatment			
Conservative	19*	76.6	.059
Surgical	6	24.0	
Maximum follow-up (mo)			
<1	10	47.6	.625
1-6	6	28.6	
>6	5	23.8	

Abbreviation: GTF, genial tubercle fracture.
* $P < .05$ by Fisher exact test or Pearson χ^2 test.

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more likely to be older than 60 years (P = .019), have an absence of trauma history (P = .018), and report the occurrence of a cracking sound (P = .009).

For RoB classification, 4 studies (16.6%) were classified as low risk, 13 (54.1%) were classified as moderate risk, and 7 (29.1%) were classified as high risk (Fig 3), and an overview of the percentage of responses for each item is presented in Figure 4. With the methodologic quality evaluations using the CARE guide, reports of cases were classified as good in 17 studies (70.3%), reasonable in 6 (25%), and bad in 1 (4.1%); no reports were classified as excellent or poor, resulting in a level of homogeneity among studies (Table 5).

Discussion

GTFs are uncommon events, and only 24 articles on this condition have been published to date. The reports are from several countries, with the United States having the largest number of cases recorded (n = 7), including the first case described in the literature.[4] The epidemiology of GTFs shows occurrences on 5 continents and has not been reported in Oceania, which points to a possible dissociation between these fractures and geographic location.

Most studies reported on 1 case of GTF. Only Maw and Lindsay[15] in 1970 and Glendinning and Hirschmann[5] in 1977 described 5 and 2 cases, respectively. In the former study, the description was of 5 American combatants from the Vietnam War who were victims of firearm projectile (FAP), resulting in fracture of the mandibular symphysis and associated GTF.[15] The latter study reported on 2 cases of English women affected by isolated and spontaneous GTFs.[5]

According to articles that reported patients' ages, age at occurrence varied from the second decade of life[15] to beyond the eighth decade of life.[6] Of the 5 cases of patients younger than 60 years, 4 were men; in contrast, the highest prevalence was in women older than 61 years; this difference could be associated with the fact that GTFs from trauma occurred in men.[4,9,10,15,17] In women, GTFs were spontaneous and associated with other factors, such as edentulism and mandibular atrophy.

Ethnicity did not appear to be a relevant factor in the epidemiology of GTFs, because only 7 studies provided this information: 5 patients were Caucasian women,[6,8,23,27,28] 2 were Caucasian men,[24,26] and 1 was a Black man.[9] The authors do not believe ethnicity has an influence on the epidemiology of GTFs.

Cases of isolated GTF were considerably more prevalent than those associated with other mandibular fractures. In the 20 cases of isolated GTFs, patients presented a clinical history of edentulism or atrophy of the mandible; in 14 cases, there was no trauma in the region; in the other 5 cases, this information was not recorded.[5,6,16,27,28] Given this prevalence in reported cases, edentulism and mandibular atrophy can be considered risk factors for spontaneous and isolated GTF. In addition, Clifton et al[1] reported on a patient with a history of Paget disease in which the diagnosis of GTF was reported, whereas Glendinning

Table 3. SAMPLE CHARACTERIZATION ACCORDING TO GENDER

	Women		Men		
	n	%	n	%	*P* Value
Continent					
Africa	1	6.3	1	12.5	.316
Americas	3	18.8	5	62.5	
Asia	2	12.5	1	12.5	
Europe	10	62.5	1	12.5	
Age (yr)					
≤60	1	6.3	4*	57.1	.019
61-70	9*	56.3	1	14.3	
>70	6*	37.5	2	28.6	
Mandibular atrophy					
No	0	.0	0	.0	1.000
Yes	16	100.0	4	100.0	
Trauma history					
No	11*	91.7	3	37.5	.018
Yes	1	8.3	5*	62.5	
Sublingual edema					
No	2	12.5	1	14.3	1.000
Yes	14	87.5	6	85.7	
Sublingual hematoma					
No	6	37.5	4	57.1	.650
Yes	10	62.5	3	42.9	
Pain					
No	1	6.3	0	.0	1.000
Yes	15	93.8	6	100.0	
Altered swallowing					
No	4	25,0	2	33.3	1.000
Yes	12	75.0	4	66.7	
Limited tongue movement					
No	12	75.0	7	100	.273
Yes	4	25.0	0	.0	
Cracking sound					
No	7	43.8	8*	100	.009
Yes	9*	56.3	0	.0	
Other clinical sign					
No	9	56.3	3	37.5	.667
Yes	7	43.8	5	62.5	
Odynophagia					
No	8	50.0	5	62.5	.679
Yes	8	50.0	3	37.5	
Panoramic radiography					
No	8	50.0	5	71.4	.405
Yes	8	50.0	2	28.6	
Occlusal radiography					
No	3	18.8	2	28.6	.621
Yes	13	81.3	5	71.4	
Computed tomography					
No	13	81.3	5	71.4	.621
Yes	3	18.8	2	28.6	
Panoramic + occlusal radiography					
No	10	62.5	6	85.7	.366
Yes	6	37.5	1	14.3	
Panoramic radiography + computed tomography					
No	13	81.3	6	85.7	1.000
Yes	3	18.8	1	14.3	
Apparent diagnosis					
Sialolithiasis	6	37.5	1	12.5	.352
Fracture	10	62.5	7	87.5	
GTF treatment					
Conservative	13*	81.3	5	62.5	.362
Surgical	3	18.8	3	37.3	
Maximum follow-up (mo)					
<1	7	50.0	2	33.3	.440
1-6	3	21.4	3	50.0	
>6	4	28.6	1	16.7	

Abbreviation: GTF, genial tubercle fracture.
* $P < .05$ by Fisher exact test or Pearson χ^2 test.

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and Hirschmann[5] described a patient with a history of rheumatoid arthritis and Carroll[25] reported a case of a patient with breast cancer; these point to a possible association between GTFs and diseases that can alter bone metabolism.

The concomitant occurrence of GTFs with other mandibular fractures is directly related to a trauma etiology. In all cases in which this combination was present, the patients were men and had a history of auto accidents, falls from their own height, or interpersonal or firearm aggression.[4,9,10,15,17] This fact is attributed to the great impact required to generate such fractures and does not occur in spontaneous cases in which edentulism and severe mandibular atrophies are present.

For cases of spontaneous GTF, half these patients reported perceiving a cracking or crackling sensation, usually followed by pain with intensity ranging from mild to severe. Anatomically, this is probably due to posterior traction of the GT by the genioglossus and geniohyoid muscles as they separate from the inner face of the mandible. At the time of fracture, the cracking or crackling sound can be heard and the muscular force will cause tension of the tissues.[1] The most described clinical sign was sublingual edema that was formed by the accumulation of fluid inherent to the inflammatory process, which was present in 23 cases. Edema and sublingual hematoma were the most

Table 4. GENERAL CHARACTERISTICS, SIGNS, SYMPTOMS, AND TREATMENT OF INCLUDED STUDIES

			Clinical Signs						Clinical Symptoms				Treatment
Study	Age(yr)	Gender	Swelling	Hematoma	Ecchymosis	Tongue Movement Limitation	Cracking Sound	Other	Pain	Pain During Tongue Movement	Dysphagia	Other	GTF Management
Clifton et al[1] (2017)	85	M	+	+	–	–	–	–	+	–	–	Odynophagia	Conservative
Bacci et al[6] (2015)	87	F	+	+	–	–	+	Palpable mass	+	–	+	–	Conservative
Buduru et al[9] (2015)	52	M	+	+	+	–	–	Deranged occlusion	+	–	–	–	Conservative*
Freeman et al[18] (2014)	68	F	+	–	–	–	–	Palpable mass	+	–	–	–	Conservative
Van Leeuwen et al[3] (2014)	80	F	–	+	–	+	+	–	+	+	+	–	Conservative
Burnett et al[7] (2012)	62	F	+	+	–	–	+	–	+	–	–	Odynophagia	Conservative
Elshal[10] (2012)	28	M	–	–	–	–	–	Hyperkeratotic area	+	–	–	Odynophagia	Conservative*
Redelinghuys and Holtshousen[8] (2011)	74	F	+	+	+	–	+	–	+	+	–	–	Conservative
Yuen[19] (2011)	68	F	–	+	–	+	–	Hyperkeratotic area	+	+	–	Odynophagia	Conservative
Ryan et al[17] (2010)	22	M	–	–	+	–	–	–	+	–	–	–	Surgical
Gallego et al[2] (2007)	86	F	+	+	–	+	–	–	+	–	+	Odynophagia	Conservative
Yaedú et al[20] (2006)	63	F	+	+	–	–	–	Palpable mass	+	+	–	Odynophagia	Conservative†
Shohat et al[21] (2003)	70	F	+	+	–	+	+	–	+	–	–	Odynophagia	Conservative
Burnett and Clifford[22] (1993)	63	F	+	+	–	–	+	–	–	–	–	Discomfort with function	Conservative
Santos-Oller et al[23] (1992)	68	F	+	+	–	–	–	Hyperkeratotic area	+	+	–	Odynophagia	Surgical

Youngs and Albert[24] (1984)	77	M	+	–	–	–	–	Palpable mass	+	+	+	–	Surgical
Carroll[25] (1983)	68	F	–	+	–	–	–	–	+	+	–	Odynophagia	Conservative
Goebel[26] (1978)	65	M	–	–	+	–	–	Palpable mass	+	+	–	Irritation on FOM	Conservative
Glendinning and Hirschmann[5] (1977)	46	F	–	–	+	–	+	–	+	–	–	–	Conservative
	77	F	+	–	–	–		–	–	–	–	–	Conservative
Shipman[27] (1976)	73	F	+	–	–	–	+	Decreased salivary flow	+	–	–	–	Surgical
Maw and Lindsay[15] (1970)	18-21	5M	NI	NI	NI	NI	–	–	NI	NI	NI	–	Conservative*
Reifman[28] (1969)	70	F	+	–	–	–	+	Decreased salivary flow	+	–	–	–	Surgical
Smyd[16] (1957)	NI	M	–	–	+	–	+	–	+	–	–	–	Conservative
Davis[4] (1894)	26	F	+	–	–	–	–	Avulsed teeth	–	–	+	–	Surgical

Abbreviations: –, absent; +, present; F, female; FOM, floor of mouth; GTF, genial tubercle fracture; M, male; NI, not informed.

* Combined treatment (mandibular fracture and GTF).

† Conservative treatment followed 1 week later by surgical intervention.

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commonly observed clinical signs in these reports.[1,2,6-9,19-22,26]

Ecchymosis was another clinical sign reported in 5 cases[2,8,16,17,26]; some groups observed it in the sublingual region, whereas Gallego et al[2] described it extraorally in the cervical region as an additional finding. Reifman[28] and Shipman[27] found a decrease in salivary flow in the sublingual region but did not include sialolith in the differential diagnosis, whereas Yuen[19] and Elshal[10] reported sublingual hyperkeratotic mucosa; in the former case the GTF was isolated and in the latter case there was an associated mandibular symphysis fracture in addition to dental avulsion.[10,19,27,28] Tongue floor ulcers were reported by Davis[4] (mandibular fracture associated with GTF) and by Santos-Oller et al[23] (isolated GTF), and in none of these cases was another possible diagnosis considered.

Pain was the most common clinical symptom, although Maw and Lindsay[15] did not report the symptoms of the 5 cases of their study. Glendinning and Hirschmann[5] reported that GTF was discovered by chance in 1 case during the investigation of a geographic language diagnosis, so the patient had no complaint of pain.

A change in swallowing (dysphagia or odynophagia) was observed in 16 cases. Van Leeuwen et al,[3] Burnett et al,[7] Redelinghuys and Holtshousen,[8] and Yaedú et al[20] considered a sialolith because of this symptom, but there was no edema in the glands. Burnett and Clifford[22] also included a sublingual hematoma in the differential diagnosis, but it and sialolithiasis were discarded owing to the absence of edema of the gland. Goebel[26] and Freeman et al[18] performed sialography to examine the possibility of sialolithiasis and ruled it out.

Pain with tongue movement was observed in 8 cases and is a symptom that can help differentiate

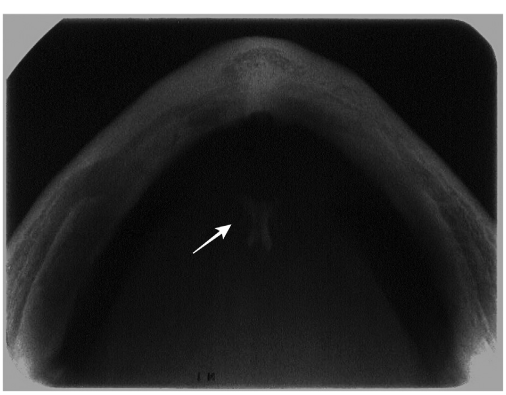

FIGURE 2. Occlusal radiograph of a 66-year-old woman showing a displaced genial tubercle bone fragment (*arrow*). The patient did not report a history of trauma.

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	1.Were patient's demographic characteristics clearly described?	2.Was the patient's history clearly described and presented as a timeline?	3.Was the current clinical condition of the patient on presentation clearly described?	4.Were diagnostic tests or assessment methods and the results clearly described?	5.Was the intervention(s) or treatment procedure(s) clearly described?	6.Was the post-intervention clinical condition clearly described?	7. Were adverse events (harms) or unanticipated events identified and described?	8. Does the case report provide takeaway lessons?
Bacci el at 2015	?	−	+	+	?	−	+	+
Buduru et al 2015	?	−	+	+	+	−	+	+
Burnett et al 1993	?	−	+	+	?	+	+	+
Burnett et al 2012	?	+	+	+	+	−	+	+
Caroll 1983	−	+	+	+	?	−	+	+
Clifton et al 2017	?	+	+	+	?	−	+	+
Davis 1894	?	+	?	+	+	?	?	+
Elshal 2012	?	−	+	+	+	−	+	+
Freeman et al 2014	?	+	+	+	?	−	+	+
Gallego et al 2007	?	−	+	+	+	−	+	+
Glendinning et al 1977	−	+	+	+	?	−	+	−
Goebel 1978	+	−	+	+	?	−	+	+
Maw 1970	−	−	+	+	+	−	−	+
Redelinghuys et al 2011	+	+	+	+	?	+	+	+
Reifman 1967	?	+	+	+	+	−	+	+
Ryan et al 2010	?	−	+	+	+	−	+	+
Santos-Oller et al 1992	?	+	+	+	+	−	+	+
Shipman 1976	+	+	+	−	+	−	+	+
Shohat et al 2003	?	?	+	+	?	−	+	+
Smyd 1957	−	−	+	+	+	−	+	−
Van Leeuwen et al 2014	?	−	+	+	?	−	+	+
Yaedu et al 2006	?	+	+	+	?	−	+	+
Youngs et al 1984	+	−	+	+	?	−	+	+
Yuen et al 2011	?	−	+	+	?	+	+	+

FIGURE 3. Risk of bias as assessed by the critical appraisal tools of the Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI). Risk of bias was categorized as high when the study scored up to 49% of "yes" responses, moderate when the study scored 50 to 69% of "yes" responses, and low when the study scored more than 70% of "yes" responses.

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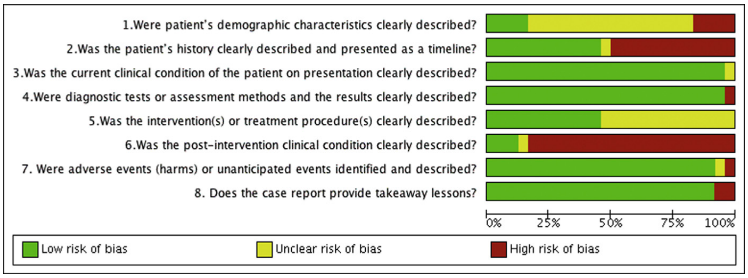

FIGURE 4. Risk of bias graph presents the authors' judgments on each risk of bias item presented as percentages across all included studies.

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GTFs from sialolithiasis, because it is a consistent finding in GTF but less common in gland pathologies.[3,8,19,20,23-26]

The most common imaging examination used for the diagnosis of GTFs was occlusal radiography, which was performed in 19 cases. This radiographic modality is straightforward to access, fast, and low cost and allows visualization of a GTF from the posterior direction with action of the genioglossus and geniohyoid muscles.[1] Radiographically, a generally well-delimited and regular radiopaque structure is visualized, although Reifman,[28] Shipman,[27] and Glendinning and Hirschmann[5] described an irregular mass projected in the midline and soft tissues; reported sizes varied according to the GT. Buduru et al[9] further described the radiographic appearance of the GT as triangular.

In 7 cases, a panoramic radiograph was combined with an occlusal radiograph, but owing to overlapping of the vertebral column inherent to the panoramic image, it was not possible to clearly visualize the GTFs. This fact was confirmed in the 3 cases in which only panoramic radiography was performed as an imaging modality and no GT-related alteration was observed, with only atrophy of the mandible[2,6] or fracture of the mandible[17] visible. The use of oblique lateral and posteroanterior radiographic techniques is described in the literature; however, these radiographs do not provide additional information on the diagnosis of GTFs because of the overlap of anatomic structures.[27,28]

In this comprehensive literature review, occlusal radiography was commonly used for radiographic examination and anteroposterior spatial visualization in cases with suspected GTFs; this allowed the exclusion of other diagnoses such as sialolithiasis, probably because of the associated easy access, low cost, and lower radiation dose.[5,9,27,28] However, some groups have advised that misrepresentation of structures, distortion, magnification, and superimposition are potential limitations of conventional intraoral or extraoral imaging techiniques.[29] In addition, it has been reported that panoramic, posteroanterior, and lateral oblique examinations are not adequate to confirm a conclusive diagnosis of GTF. Occlusal radiography also is not adequate in cases of GTF displaced distally in the floor of the mouth, especially for patients with a hyperactive gag reflex.[3]

In contrast, tomographic imaging modalities, such as CBCT and medical grade CT, have shown a high degree of accuracy in identifying bone fractures, including those related to the GT.[3] Van Leeuwen et al[3] reported no visualization of the GTF with conventional radiographs, although GTF was established with the use of CT. Although CT examinations are considered the standard of care in most practices worldwide, the present systematic review found only 9 cases in which CT was used (isolated, n = 5; combined with panoramic radiograph, n = 4). Thus, limited information from 3-dimensional imaging modalities was obtained for the present systematic review, especially those related to CBCT, because there was no documented study that used this technique for diagnosis of a GT-related fracture. Treatment planning for cases with a provisional diagnosis of GTF would benefit from the use of this imaging modality because it has some advantages over other examinations, including beam limitation, rapid scan time, superior image resolution, and decreased patient radiation dose.[30,31] According to some investigators,[3] CBCT also is preferred over conventional radiography to elucidate the GTF diagnosis and the extent of displacement of the fractured bone fragment.

CT was first used in the diagnosis of a GTF in 2007 by Gallego et al[2] in Spain after an inconclusive diagnosis with a panoramic radiograph. After evaluating the tomographic scans, they found a GT-compatible structure later displaced with the absence of symphysis fractures. In 2012, Elshal[10] found a GTF on CT associated with a symphyseal fracture separation of the lingual cortex extending from the right side of the GT to the right first premolar. In 2010, Ryan et al[17] described a bone fragment that had shifted to a posterior and superior position, in agreement with tomographic findings similar to those of Redelinghuys and

Table 5. STUDY CLASSIFICATION ACCORDING TO CASE REPORT GUIDELINES

Study	1	2	3a	3b	3c	3d	4	5a	5b	5c	5d	6	7	8a	8b	8c	8d	9a	9b	9c	10a	10b	I10c	10d	11a	11b	11c	11d	12	13	Classification
Clifton et al[1] (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	No	Yes	Yes	NA	NA	Good
Bacci et al[6] (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Buduru et al[9] (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Freeman et al[18] (2014)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Van Leeuwen et al[3] (2014)	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Burnett et al[7] (2012)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Elshal[10] (2012)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Yuen[19] (2011)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Redelinghuys and Holtshousen[8] (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Ryan et al[17] (2010)	Yes	No	NA	NA	NA	NA	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Reasonable
Gallego et al[2] (2007)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Yaedú et al[20] (2006)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Shohat et al[21] (2003)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	No	Yes	Yes	No	NA	NA	Good
Burnett and Clifford[22] (1993)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Santos-Oller et al[23] (1992)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	No	Yes	NA	NA	Good
Youngs and Albert[24] (1984)	No	No	NA	NA	NA	NA	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Reasonable
Carroll[25] (1983)	No	No	NA	NA	NA	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Goebel[26] (1978)	No	No	NA	NA	NA	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA	Good
Glendinning and Hirschmann[5] (1977)	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Good

Shipman[27] (1976)	No	No	NA	NA	NA	NA	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Reasonable
Maw and Lindsay[15] (1970)	No	No	NA	NA	NA	NA	Yes	No	No	No	No	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Reasonable
Reifman[28] (1969)	Yes	No	NA	NA	NA	NA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Reasonable
Smyd[16] (1957)	No	No	NA	NA	NA	NA	No	Yes	No	No	Yes	Yes	Yes	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	No	No	Yes	NA	NA	Bad
Davis[4] (1894)	No	No	NA	NA	NA	NA	No	Yes	Yes	Yes	Yes	Yes	No	Yes	NA	Yes	NA	Yes	Yes	NA	NA	Yes	NA	Yes	Yes	Yes	Yes	Yes	NA	NA	Reasonable

Abbreviation: NA, not available.

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Holtshousen[8] in 2011 and Van Leeuwen et al[3] in 2014. In their 2015 study, Bacci et al[6] were more descriptive and characterized a foreign body with a calcified density of approximately 1 cm located below the floor of the mouth and the ventral face of the tongue. They also highlighted the importance of a contrast CT scan in some situations, including atypical cases, in the presence of other mandibular or facial fractures, and to exclude sublingual or submandibular abscesses as possible diagnoses.

During treatment planning, a systematic and accurate examination is essential to exclude other possible diagnoses[20] and indicate the appropriate management for each case. The treatment also should take into account imaging aspects that allow fracture pattern evaluation and detection of any associated mandibular fractures.[3,17] CT has been used for the diagnosis and treatment of GTFs as indicated by Van Leuween et al.[13] However, the present systematic review obtained data from articles published up to 2017[1] and most were reported before the advent of CBCT in 1998.[32] This fact could explain the frequent indication of conventional radiography in suspected GTF cases, notably occlusal and panoramic radiography.[2,23] Of cases in which CT images were analyzed, 2 patients were treated surgically,[10,17] whereas a conservative approach was applied in 4 patients.[2,3,6,8] For imaging modality versus performed therapy, there was no consensus about specific findings from conventional or modern examinations that prompted a surgical or a conservative intervention among the cases obtained for this systematic review. Youngs and Albert[24] suggested a conservative intervention and anticipated a return of function in GTF cases beyond radiographic doubt; however, if the imaging evaluation is sufficient to provide a conclusive diagnosis, then a surgical procedure is suitable.

Some studies have described what aspect elicited a surgical intervention instead of nonsurgical management. Although surgical treatment was not routinely indicated, the need for diagnostic confirmation,[24,27,28] associated mandibular and dentoalveolar fractures requiring an open reduction,[4] complaint of severe discomfort,[20] and prevention of the onset of swelling and pain associated with chronic fibrous hyperplasia of the GT fragment-related surrounding soft tissues[23] prompted a surgical approach. In contrast, conservative treatment was determined by different factors, such as advanced age,[2] preventing medication-related osteonecrosis of the jaw in a medically compromised patient under treatment with oral bisphosphonates,[1] and a surgical team decision based on literature reports that have shown good clinical outcome with conservative management.[3] Glendinning and Hirschmann[5] did not describe any permanent adverse effects, such as limited tongue movement or pain, that would indicate surgery as a necessary intervention in all GTF cases. In fact, complications related to GTF tend to be temporary, as observed in an experimental study that found complete muscle complex reattachment to the mandible 8 weeks after sectioning of the genioglossus muscle origins in rabbits.[33] Also, evidence from a clinical case showed union between the mandible and the previously displaced GT after a 6-month follow-up period.[7]

Conservative or nonsurgical treatment was adopted in 14 reported cases, and medication was prescribed to these patients. The drug prescriptions included analgesics,[1,3,19,21] steroidal and nonsteroidal anti-inflammatory drugs,[8] and antibiotic therapy.[6] In addition, conservative treatment consisted of the suspension of the use of prostheses for a period of 7 to 15 days.[1,2,8,19,20] The conservative treatment presented satisfactory results. However, in the case described by Yaedú et al,[20] they initially adopted a nonsurgical intervention and then performed surgery 1 week later.

In cases in which surgery was selected as the treatment modality, this approach involved repositioning of the muscles and anatomic reduction and internal fixation of the mandible.[9,10] Elshal[10] adopted a surgical treatment for the other mandibular fractures but retained conservative treatment for GTFs. In all cases, regardless of the treatment chosen, the resolution was effective, with patients reporting the absence of symptoms during follow-up.

In summary, GTFs were most commonly observed in women in the seventh decade of life. GTF was most common in edentulous patients without a history of trauma. Isolated occlusal radiography and nonsurgical intervention were frequently performed; however, modern-day imaging modalities combined with an accurate clinical examination would be beneficial to justify treatment options. Although GTFs are uncommon, this registered review followed pre-established criteria and added important findings related to this condition to the scientific literature.

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Capítulo 3

5.3 CAPÍTULO 3

Mental foramen and anterior loop anatomic characteristics: a systematic review and meta-analysis of cross-sectional imaging studies.

Daniel Almeida Ferreira Barbosa[1], Lucca Reis Mesquita[2], Marcela Maria Costa Borges[3] Diego Santiago de Mendonça[1] Francisco Samuel Rodrigues de Carvalho[4,] Lúcio Mitsuo Kurita[1*], Paulo Goberlânio Barros Silva[5], Thyciana Ribeiro Rodrigues[6], Taruska Ventorini Vasconcelos[7], Francisco Haiter Neto[8], Fábio Wildson Gurgel Costa[1]

[1]Division of Oral Radiology, Federal University of Ceará, Fortaleza, Brazil.
[2]School of Dentistry, Federal University of Ceará, Fortaleza, Brazil.
[3]School of Dentistry, Faculdade Paulo Picanço, Ceará, Brazil.
[4]Division of Oral Surgery, Federal University of Ceará, *Campus* Sobral, Sobral, Brazil.
[5]Division of Oral Pathology, Christus University (UNICHRISTUS), Fortaleza, Brazil.
[6]Division of Clinical Dentistry, Federal University of Ceará, Fortaleza, Brazil.
[7]Division of Oral Radiology, Federal University of Bahia, Bahia, Brazil.
[8]Department of Oral Diagnosis, Division of Oral Radiology, Piracicaba Dental School. University of Campinas (UNICAMP), São Paulo, Brazil.

***Correspondence:**

Lúcio Mitsuo Kurita

Programa de Pós-graduação em Odontologia

Rua Monsenhor Furtado, 1273, Rodolfo Teófilo, Fortaleza-CE, Brazil. CEP: 60430-355

Fone: +55 85 33668232 E-mail: luciokurita@gmail.com

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Mental foramen and anterior loop anatomic characteristics: a systematic review and meta-analysis of cross-sectional imaging studies.

Abstract

The present study aimed to review the epidemiological, topographic, and morphometric aspects of the mental foramen (MF) and anterior loop (AL) on CBCT imaging studies. A PROSPERO-registered systematic review (CRD42018112991) was conducted according to the PRISMA guidelines. Two reviewers independently performed data extraction from observational studies that evaluated MF and AL on seven electronic databases. MedCal software was used to perform a meta-analysis with a 95% confidence level. Of 1545 articles, 66 met the inclusion criteria, totaling 14.233 patients from five continents, with a total of 6655 females and 5884 males, with an age range between 8 and 89 years. The most prevalent shapes of MF were oval (48.72%) and circular (44.36%), and the most frequent horizontal positions were between premolars (43.66%) and in line with the long axis of the second premolar (43.12%). Based on the articles that assessed AL, the mean prevalence was 43.18%, with most studies reporting bilateral localization as the most prevalent.

Keywords: Mental foramen, Anterior loop, Cone-beam computed tomography.

INTRODUCTION

Surgical procedures in the anterior segment of the mandible must be preceded by careful planning, taking into consideration important anatomical structures such as the mental foramen (MF), accessory mental foramen (AMF), anterior loop (AL) of the inferior alveolar nerve (IAN), and the mandibular incisive canal (MIC) to avoid functional damage[1]. Post-surgical complications resulting from injury to the IAN may occur as a consequence of failure of identification and recognition of the position, location, and size of the AL[2,3,4], MF, and MIC during pre-surgical planning[2,5]. However, the significant variability of anatomical landmarks between individuals and populations cannot be disregarded[2], which highlights the need to summarize relevant morphological aspects for the identification of clinically important structures such as the MF and the AL.

The MF represents the termination of the mental canal[6,7,8], whereas the AL constitutes the terminal portion of the IAN. Both anatomical structures must be considered during procedures that require local anesthesia, incisions, implant placement, osteotomies, and endodontic and periapical surgical interventions[9,10,11].

Although the determination of the precise clinical location of the MF can be challenging, as it varies in size, shape, and location[2], its identification is indispensable for performing diagnostic and dental procedures in the mandibular area[10].

Therefore, summarizing morphometric findings of important anatomical structures, such as MF and AL, from studies that used three-dimensional exams in different populations, can significantly contribute important information for the dental clinic [12].

The present study aimed to systematically review (SR) the literature, as well as to analyze epidemiological, morphological, and quantitative measures and topographic characteristics of the MF using cone-beam computed tomography (CBCT) images.

MATERIAL AND METHODS

Protocol and Registration

This SR was written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which establish the main considerations for transparent and thorough writing of an SR[13]. The research protocol was recorded in the International Prospective Register of Systematic Reviews (PROSPERO) under reference number CRD42018112991.

Search strategy and data collection

This SR was performed to answer the question "What are the main epidemiological aspects of the MF and AL when assessed by CBCT?" and elaborated using the PECOS strategy:

1. Population (P): human CBCT images
2. Exposure (E): MF.
3. Control (C): none.
4. Outcome (O): shape, quantitative measurements, prevalence of AL, and the relationship between MF and adjacent teeth.
5. Study design(S): cross-sectional and observational studies.

To identify the studies to be included in this review, an electronic search was performed in PubMed, Scopus, Web of Science, Cochrane, and Latin American and Health Sciences Information Center using the Faculty of Pharmacy, Dentistry and Nursing of the Federal University of Ceará system on December 12, 2018, and updated on January 21, 2021 (Appendix 1). A partial search of gray literature was performed using Google Scholar and Open Gray. The references of the selected articles were also searched individually. All references were manipulated in a reference management software (EndNote, Thomson Reuters, Philadelphia, PA, USA), and duplicate studies were removed. The search strategy was appropriately modified for each database to identify eligible studies.

Studies that evaluated MF or AMF on CBCT were included, regardless of the year of publication. The following articles were excluded: (1) literature reviews, clinical trials, editor's notes, pilot studies, and *in vitro* studies; (2) studies that evaluated MF or AL with panoramic radiographs or medical CT; and (3) studies not written in Latin (Roman) alphabet.

Selection of studies and data collection process

A two-phase SR was performed by two independent researchers (DAFB and DSM) who were previously trained to find available studies based on the adopted eligibility criteria. Phase 1 involved the analysis of titles and abstracts of all articles obtained from the databases to select studies to be fully read. For this screening, the Rayyan web-based tool and mobile app (Qatar Computing Research Institute, QCRI) for SR were used[14]. Phase 2 included the complete reading of the articles selected after finishing the first phase to provide an overview of the studies and sources for data acquisition. Moreover, phase 2 included an additional step: manual search of the references of the selected studies to find articles inadvertently omitted during the searches in the databases. In both phases, a third researcher (FWGC) resolved any disagreement between the two researchers.

The studies that met the inclusion criteria were carefully analyzed by two researchers (DAFB. and LMK) independently. A customized table that had been previously elaborated with variables of interest for this study was also used for data extraction. If there was any disagreement between the two researchers, the article was carefully discussed, and a third researcher (FWGC) was requested to obtain a final consensus. To obtain additional information (FOV and voxel sizes), the corresponding authors were contacted through the email addresses mentioned in the published article, and the waiting time for a reply was of two weeks.

Risk of bias (RoB) in individual studies

The included articles were classified according to the risk of bias (RoB) and methodological quality using the Meta-Analysis of Assessment and Review Instrument (MAStARI), a percentage system based on previous studies with similar methodologies ranging from "high" ("yes" response < 49%), to "moderate" (50% to 69% of "yes" responses), and "low" (when the study scored 70% or more) to assess the RoB[15]. A third reviewer made the final decision in the case of uncertainty. RevMan software (Review Manager, version 5.3, Cochrane Collaboration) was used to generate the RoB summary with adaptation for the eight questions of the MAStARI tool.

Data synthesis and meta-analysis

Initially, the results obtained from the selected studies were tabulated in Microsoft Excel using a customized checklist of the study variables. Then, they were analyzed with the Statistical Software for the Social Sciences software, version 20.0, for Windows, adopting a 95% level of significance. The dichotomous data were analyzed using Fisher's exact or Pearson's chi-square tests. Additionally, to perform a meta-analysis, data were exported to the MedCalc Statistical Software (version 16.4.3; MedCalc Software bv; https://www.medcalc.org; 2016), and a random-effects model was used to assess the prevalence of MF and AL. Heterogeneity among studies was measured using Cochran's Q and I^2 statistics, and publication biases were assessed by examining funnel plots for each meta-analysis.

RESULTS

Study selection

The search strategy resulted in 1545 articles. Of these studies, 744 were available in more than one database (duplicates). The authors independently read the titles and summaries of each article related to the topic of the SR. After this step, 669 articles were excluded because they were not related to the investigated topic. Additionally, 24 articles were excluded because they did not meet the eligibility criteria. Finally, 66 studies were included for data synthesis. The search results are presented in a search flowchart (Figure 1).

The 66 studies included in the SR evaluated a total population of 14233 patients. Some studies did not report the sex of the individuals, resulting in 12539 patients, of which 6655 were females and 5884 males. In most studies (n=44), the majority of the population was female, whereas in 12 studies, most participants were male. Four studies did not report the number of female participants, and in three studies, there was an equal number of men and women. Geographically, a total of 32 studies were of Asian origin[1,4,8,16-44], with one also encompassing a North American population[42], 16 were of European origin (7 with Turkish populations)[3,11,45-58], 12 were performed in South American populations (10 Brazilian and 2 Peruvian)[2,59-69], 4 were conducted in North America (United States of America)[70-73], and only two studies with African[74,75] populations were found. The age of the patients varied from 8 to 89 years, and the average age ranged from 21.9 to 53.55 years old (Table 1).

Mental Foramen

Circular shape was observed in 44.36% (95% CI = 30.57-58.59) of the cases, with no significant difference to the oval shape, which was observed in 48.72% (95% CI = 27.72-69.96) of cases. Significant heterogeneity ($p < 0.001$) was observed for both shapes (Figure 2). Regarding the MF position, the prevalence in the P1 (0.38%; 95% CI = 0.192-0.638) and P6 (1.44%; 95% CI = 0.27 %–0.27%) regions were significantly lower than in the other regions. P3 (43.66%, CI95% = 36.92-50.52) and P4 (43.12%; CI95% = 38.17-48.13) were the most prevalent locations, followed by P5 (10.39%; CI95% = 7.10-14.22). All regions demonstrated significant heterogeneity ($p < 0.001$).

Anterior Loop

The AL was analyzed in 31 studies, with a total population of 9245 patients. This variable showed significant heterogeneity ($p<0.001$), and the total prevalence (random effects) was 43.18% (95% CI = 32.00-54.72) (Figure 3).

Risk of Bias (RoB)

According to the risk of bias, three studies were at high risk (4.5%), 36 at moderate risk (54.5%), and 27 at low risk (40.9%) (Figure 4). The percentage of responses for each item is presented in Appendix 1.

DISCUSSION

The included studies were performed on five continents; however, there was a notable difference in their geographic distribution. Only two studies were conducted in Africa, whereas 32 studies were conducted in Asia, with Turkey being the country with the largest number of investigations (n=7), followed by the studies among Iranian and Arab populations (n=6). The distribution of the studies reveals geographic heterogeneity that may help explain the different methodologies used. This idea is reinforced by the fact that the morphology of the human mandible presents significant variations when different population groups are considered.

Regarding the CT scanners used in the studies, I-CAT was the most cited (n=16), followed by NewTom (n=9), CS 9300 (n=6), Promax 3D (n=4), Galileos Sirona, 3D scanner, and CS 9500 3D scanner (n=2). In addition, the scanners Accuitomo 170, Accuitomo 3D, CB Mercu-ray, ILUMA, OP300, Pointnix, CB-500, CB Mercu-ray, Kavo 3D, RayScan, Pax-Rev 3D, Picasso model, DCT Pro, Dranez 3D, Planmeca, Myray Hyperion X9, VEGA, CS 9000, and Ortophos (n=1/scanner). Four studies did not report the CT scanner used.

A wide variety of voxel sizes were observed, as depicted in Table 3. Thus, we were able to classify the studies according to the voxel size used as those with ≥0.3 mm (n=20) and <0.3 mm (n=25) voxel size. Eighteen articles did not report the voxel size.

Data related to the FOV were also observed and categorized as small (≤10 cm), medium (10–15 cm), and large (>15 cm). Eight articles had FOVs classified as small, 11 as medium, and 16 as large. Moreover, 24 articles did not report the FOV used, four used both small and medium FOVs, and two used both medium and large FOVs.

The age of the studied populations varied considerably (8-84 years)[14,67]. This age variation did not cause discrepancies among the studies, considering that the average age varied between 21.9[19] and 53.53[46] years; thus, the average age appears to be more associated with the number of patients evaluated, which consisted of a sample of 20 patients[19].

Mental Foramen

Although several aspects of MF have already been evaluated in previous investigations, only one study[68] reported cases of absence of MF, with a percentage of 2.5% in a Brazilian population sample of 202 patients. A prevalence of 100% of MF was reported by evaluating 96 CT scans in an Iranian population[12]. In 2011, Fernandes et al.[76] reported a case of hypoplasia and a case of absence of MF in Brazilian individuals, whereas de Freitas et al.,[77], who evaluated 1435 dry mandibles and observed the absence of MF on two occasions, once on the right side and another on the left side. These findings reinforce the rarity of the absence of MF as an anatomical variation, and most articles included in the present review did not assess the prevalence of MF.

Vertical and horizontal positions have been evaluated in some studies, categorizing them in relation to the apex of the nearest tooth, resulting in three possible positions: above (A), in line with the long axis of the second premolar (B), or below the root apex level (C)[26].

The horizontal position of the MF has already been classified and evaluated in different ways. Two investigations[20,32] used a classification system based on four possible positions: Type 1, in the line of the apex of the second premolar; Type 2, between the apex of the second and the first premolar; Type 3, between the apex of the second premolar and the first molar; and Type 4, distal to the apex of the molar. Other studies[1,75] proposed a classification system based on the position in the anteroposterior direction, with five possible outcomes: in the line of the first premolar, between the first and the second premolar, in the line of the second premolar, between the second premolar and first molar, and at the molar line. Recently, a more anterior position, in front of the first premolar, corresponding to P1, was added by several authors[18,25,26,37,57].

The most common horizontal and vertical positions of the mental foramen were in line with the long axis of the second premolar (41.3%) and below the root apex level (93.2%), respectively. These results highlight the need to conduct further investigations to assess the vertical position of the MF and its relationship with the roots of the adjacent teeth.

The horizontal position was assessed by our meta-analysis, demonstrating a low prevalence of position 1, which was statistically lower than that in the other locations. The locations in line with the long axis of the second premolar and between the premolars were the most prevalent, being found in 47.49% and 38.74% of cases, respectively. This fact is of great relevance to dental clinical practice, especially during mental nerve block anesthesia and other surgical procedures in this area. Therefore, it is suggested that during the blockade of the mental nerve, the needle should penetrate the mucosa in the region posterior to the second premolar and with an inclination towards the anterior region, thus reaching the vicinity of the MF and decreasing the possibility of damage to the mental nerve[78].

Additionally, linear measurements of the diameter of the distances from the MF to the alveolar cortex and the base of the mandible were reported in the included studies (Table 3). The mean of the vertical diameter varied from 2.2 mm to 4.44 mm[37]. Oliveira-Santos.,[59] found 4.13 mm on average; however, in this study, the voxel used was not informed, which might have influenced these findings. Of the studies that associated sex with vertical diameter, two investigations found that males presented larger vertical diameters than females. The horizontal diameter was measured in two studies: the only non-

Asian study, reported a mean of 2.92 mm[53], whereas Krishnan et al.,[30] reported 3.1 mm. Despite the different values, there were no significant geographical differences.

The mean distance from the MF to the alveolar cortex ranged from 9.12 mm[56] to 15.9 mm[18]. This distance has great surgical relevance, especially in dental implant placement procedures, because the length of the implants must not reach the MF. This finding suggests that the placement of dental implants in the MF region is not contraindicated, provided that correct planning is executed to establish the appropriate size for the case and that in a large part of the population there is sufficient bone height for the installation of implants in this area.

Anterior Loop

The meta-analysis demonstrated heterogeneity between the studies on the prevalence of the AL, which ranged from 2.47% in a study conducted in Brazil to 94% in a Malaysian population, and the total prevalence (random effects) was 43.1% (95% CI = 32.0 to 54.7) (Figure 3). A high prevalence was observed in different populations. The reported prevalence was 85.24%[71] in the United States, whereas in the Turkish and Chinese populations, it was 85.81%[50] and 93.93%[21], respectively. These findings suggest that a high prevalence of AL is not associated with a specific population. In contrast, in studies evaluating Brazilian populations, a low prevalence was observed in four studies: 2.47%[66], 7.77%[65], 10.83%[67],18.88%[2], whereas two other studies conducted in Brazil observed a prevalence of 29.78%[63] and 41.66%[64]. In fact, the presence of an AL in Brazilian individuals is significantly lower than that in other populations worldwide, and this information is of great clinical relevance, as individuals with an AL are more likely to suffer from sensorineural disorders and hemorrhagic complications during the trans-operative period of implant placement.

In addition to the presence of the AL, another important factor, especially in surgical procedures, is the length of AL. A maximum length of 8.41 mm was observed on the left side and 7.19 mm on the right side of the mandible[4] (Table 4). Other authors found similar values, such as 7.99 mm[27], 7.5 mm[21], 7 mm[60], and 6.67 mm[71]. With regard to sex, some authors reported no statistical difference in the AL length between women and men[3,27,34,46]; however, Yang et al.,[21] reported that the length of the AL was greater in men. Additionally, similar results were observed in a Taiwanese population, but this difference was not observed in Americans[4].

Currently, for surgical procedures such as implant placement, it has been established that a distance of 5 mm mesially to the MF must be considered because of the presence of AL. Nevertheless, two studies reported that in just about 4% of the cases, the AL length was greater than 4 mm and 4.1 mm[11,59]. Moreover, the age of the patients does not appear to influence the AL length, with other factors such as corticalization of the mandibular canal or decrease in bone trabeculation, displaying an apparently larger influence[59,64].

The mean length of the AL ranged from 0.89 mm[70] to 3.69 mm[27]. Some studies found a mean AL of greater than 3 mm[30,39,50]. This finding suggests that, for most individuals, a distance of 5 mm mesially to the MF renders invasive procedures less prone to complications that could result in AL damage.

Only a few studies have reported data regarding the laterality of AL. Bilateral occurrence appears to be more common than unilateral cases[1,3,39,46,64]. Some articles reported that the AL was more prevalent on the left side than on the right[3,34,67]; however, these data were not reported in a standardized way. Nascimento et al.[64], reported the greater prevalence of the AL on the left side in unilateral cases, whereas Vieira et al.[67], reported a higher prevalence on the left side among all cases with AL. There is a consensus among studies that this aspect requires further investigation to solidify this evidence.

CONCLUSION

In summary, the MF is preferentially between the premolars or near the second premolar, with a circular or oval shape, and its absence has rarely been reported. The AL was present with a high rate, in approximately 40% of the individuals; therefore, dental surgeons should consider this anatomical landmark during surgery planning and execution.

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Figures and legends

Figure 1. Flowchart of the selection process of the studies.

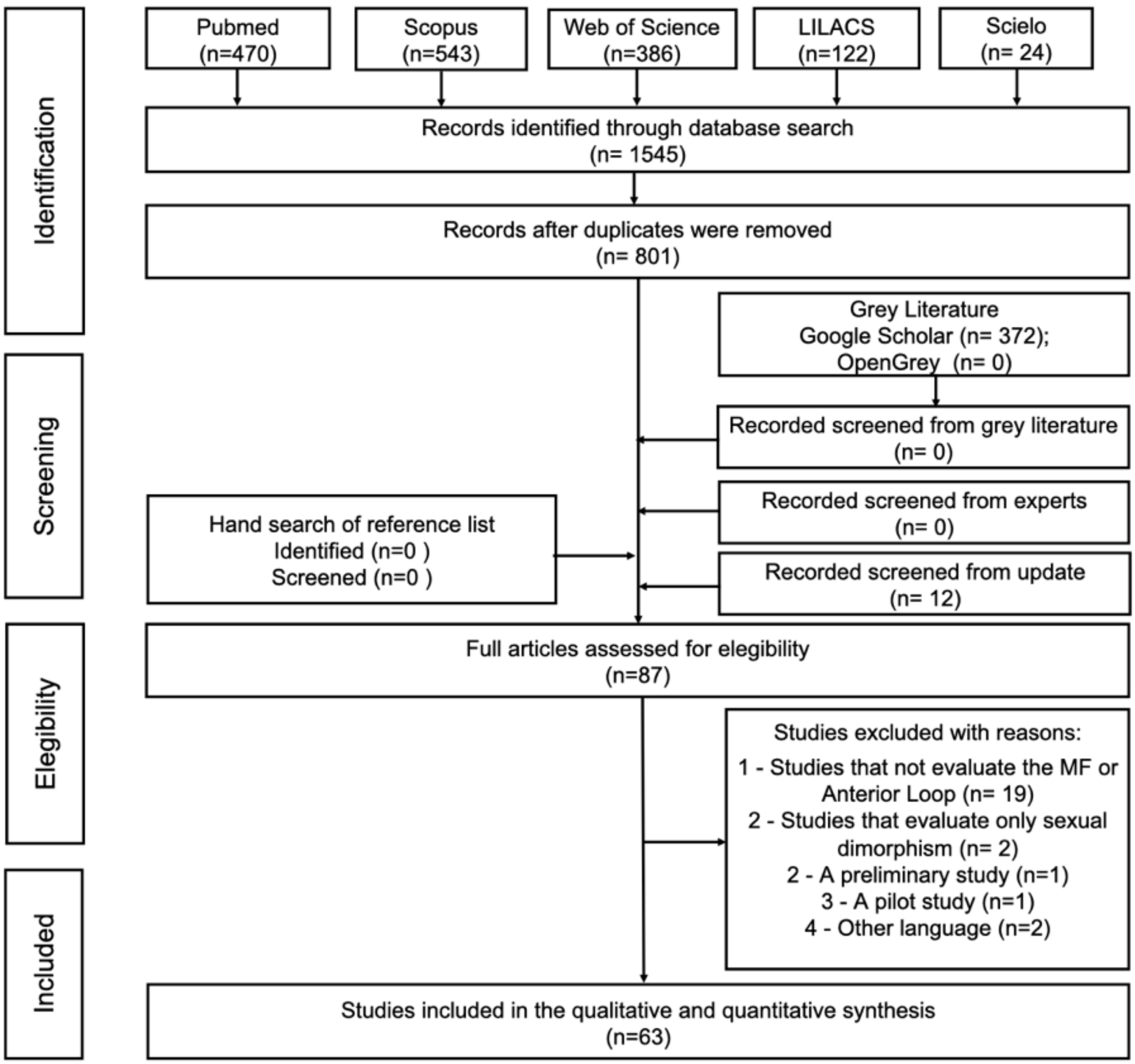

Figure 2. Meta-analyses of the mental foramen Shape.

Study	Sample size	Proportion (%)	95% CI	Weight (%)	Test for heterogeneity		Publication bias	
Circular format								
Chappidi et al	500	30.800	26.777 to 35.052	16.92	Q	2.195.773	Egger's test	25.393
Goyushov et al	663	42.534	38.736 to 46.399	16.98	DF	5	95% CI	-28.4295 to 33.5080
Krishnan et al	109	47.706	38.050 to 57.490	16.01	Significance level	P < 0.0001	Significance level	P = 0.8311
Alam et al	395	72.658	67.977 to 76.996	16.84	I^2 (inconsistency)	97.72%	Begg's test	
Muinelo-lorenzo et al	344	27.035	22.412 to 32.058	16.79	95% CI for I^2	96.56 to 98.49	Kendall's Tau	0.2000
Cabanillas Padilla et al	180	46.111	38.669 to 53.683	16.45			Significance level	P = 0.5730
Total (random effects)	**2191**	**44.369**	**30.597 to 58.599**	**100.00**				
Oval format								
Chappidi et al	500	69.200	64.948 to 73.223	16.77	Q	5.144.670	Egger's test	118.757
Goyushov et al	663	18.854	15.945 to 22.043	16.80	DF	5	95% CI	-32.8947 to 56.6462
Krishnan et al	109	52.294	42.510 to 61.950	16.38	Significance level	P < 0.0001	Significance level	P = 0.5023
Alam et al	395	27.342	23.004 to 32.023	16.74	I^2 (inconsistency)	99.03%	Begg's test	
Muinelo-lorenzo et al	344	72.965	67.942 to 77.588	16.72	95% CI for I^2	98.67 to 99.29	Kendall's Tau	0.06667
Cabanillas Padilla et al	180	53.889	46.317 to 61.331	16.58			Significance level	P = 0.8510
Total (random effects)	**2191**	**48.724**	**27.720 to 69.968**	**100.00**				

Figure 3 Meta-analyses of the prevalence of the anterior loop prevalence.

Study	**Sample Size**	**Proportion (%)**	**95% CI**	**Weight (%)**	**Test for heterogeneity**		**Publication bias**	
Small FOV								
Krishnan et al	109	46.789	37.168 to 56.589	19.85	**Q**	2.333.952	**Egger's test**	209.060
Vieira et al	240	10.833	7.200 to 15.469	20.13	**DF**	4	**95% CI**	-61.4596 to 103.2716
Genú et al	143	18.881	12.827 to 26.269	19.97	**Significance level**	P < 0.0001	**Significance level**	P = 0.4783
Von Arx et al	142	70.423	62.191 to 77.780	19.97	**I^2 (inconsistency)**	98.29%	**Begg's test**	
Panjnoush et al.,	200	60.000	52.854 to 66.845	20.08	**95% CI for I^2**	97.39 to 98.87	**Kendall's Tau**	0.4000
Total (random effects)	**834**	**39.959**	**16.864 to 65.731**	**100.00**			**Significance level**	P = 0.3272
Medium FOV								
Shalash et al	120	55.000	45.655 to 64.093	12.55	**Q**	3.768.736	**Egger's test**	-110.902
Eren et al	141	85.816	78.947 to 91.115	12.59	**DF**	7	**95% CI**	-31.0579 to 8.8774
Raju et al	124	25.000	17.661 to 33.570	12.56	**Significance level**	P < 0.0001	**Significance level**	P = 0.2230
Do Couto-Filho et al (CBCT)	47	29.787	17.339 to 44.894	12.14	**I^2 (inconsistency)**	98.14%	**Begg's test**	
Oliveira et al	202	23.762	18.070 to 30.242	12.66	**95% CI for I^2**	97.42 to 98.66	**Kendall's Tau**	-0.2546
Lu et al	366	85.246	81.192 to 88.718	12.74			**Significance level**	P = 0.3778
Kastala et al	180	56.667	49.091 to 64.020	12.64				
Total (random effects)	**1227**	**51.315**	**30.704 to 71.695**	**100.00**				
Large FOV								
Velasco-Torres et al	348	58.046	52.667 to 63.286	12.53				
Sinha et al	1000	9.700	7.936 to 11.705	12.56	**Q**	24.740.489	**Egger's test**	48.512
Shabam et al	71	35.211	24.241 to 47.458	12.34	**DF**	7	**95% CI**	-39.5839 to 49.2863
Brito et al	90	15.556	8.774 to 24.720	12.39	**Significance level**	P < 0.0001	**Significance level**	P = 0.7983
Rodricks, et al	200	57.500	50.330 to 64.444	12.49	**I^2 (inconsistency)**	99.72%	**Begg's test**	
Wei et al	612	67.810	63.948 to 71.500	12.55	**95% CI for I^2**	99.66 to 99.76	**Kendall's Tau**	-0.07143
Xie et al	1008	14.583	12.461 to 16.915	12.56			**Significance level**	P = 0.8046
Yang et al	824	93.568	91.671 to 95.145	12.56				
Total (random effects)	**4153**	**43.585**	**16.933 to 72.435**	**100.00**				
Non indentified FOV								
Filo et al	694	69.741	66.172 to 73.140	9.26				
Moghdamm et al	234	23.504	18.225 to 29.468	9.15	**Q**	6.420.834	**Egger's test**	-50.349
Genç et al	72	11.111	4.921 to 20.725	8.81	**DF**	10	**95% CI**	-21.5861 to 11.5162
Angel et al	165	47.879	40.053 to 55.782	9.09	**Significance level**	P < 0.0001	**Significance level**	P = 0.5087
Sahman and Sisman	494	28.543	24.597 to 32.747	9.24	**I^2 (inconsistency)**	98.44%	**Begg's test**	
Chappidi et al	500	40.000	35.676 to 44.443	9.24	**95% CI for I^2**	97.98 to 98.80	**Kendall's Tau**	-0.01818
Sridhar et al	146	17.808	11.975 to 24.994	9.06			**Significance level**	P = 0.9379
Wong et al	100	94.000	87.397 to 97.767	8.94				
Kajan et al	84	36.905	26.628 to 48.134	8.88				
Nascimento et al	240	41.667	35.359 to 48.183	9.16				
Al-Mahalawy et al	302	15.232	11.372 to 19.789	9.19				
Total (random effects)	**3031**	**38.566**	**24.982 to 53.126**	**100.00**				
All FOV	**9245**	**43.181**	**32.004 to 54.720**					

Houve heterogeneidade significativa ($p<0.001$, $I^2 = 99.2\%$, CI95% = 99.10-99.29%), porém não houve risco de viés significativo (Egger's tets, p=0.966; Begg's test, p=0.987).

Figure 4 – Risk of bias as assessed by the critical appraisal tools of the Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI). The risk of bias was categorized as High when the study scored up to 49% of "yes" responses, Moderate when the study scored from 50% to 69% of "yes" responses, and Low when the study scored more than 70% of "yes" response.

Table 1. Specific Search Terms for Each Database and Truncations

Electronic Database	Search strategy
PubMed	**#1** "chin"[MeSH Terms] OR "chin"[All Fields] OR "chin"[All Fields] OR "mentum"[All Fields]) OR "mental foramen"[All Fields] O OR "accessory mental foramen"[All Fields] OR "mental canal"[All Fields] OR "anterior loop"[All Fields] OR "mental nerve loop"[All **#2** "cone-beam computed tomography"[MeSH Terms] OR "cone-beam computed"[All Fields] OR "cone-beam computed tomography CT Scan"[All Fields] OR "Cone-Beam CT Scans"[All Fields] OR "Cone Beam Computed Tomography"[All Fields] OR "Cone-Beam C Fields] OR "Cone Beam Computerized Tomography"[All Fields] OR "Cone-Beam CT"[All Fields] OR "Cone Beam CT"[All Fields] **Algoritm** ("chin"[MeSH Terms] OR "chin"[All Fields] OR "mentum"[All Fields]) OR "mental foramen"[All Fields] OR "alveolar ner mental foramen"[All Fields] OR "mental canal"[All Fields] OR "anterior loop"[All Fields] OR "mental nerve loop"[All Fields] tomography"[MeSH Terms] OR "cone-beam computed"[All Fields] OR "cone-beam computed tomography"[All Fields] OR "Cone-B "Cone-Beam CT Scans"[All Fields] OR "Cone Beam Computed Tomography"[All Fields] OR "Cone-Beam Computerized Tomography Computerized Tomography"[All Fields] OR "Cone-Beam CT"[All Fields] OR "Cone Beam CT"[All Fields])
Scopus	**#1** "chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "accessory mental foramen" OR "mental canal" OR "anterior l **#2** "cone-beam computed tomography" OR "cone-beam computed" OR "cone-beam computed tomography" OR "Cone-Beam CT Scan OR "Cone Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomograp "Cone Beam CT" **Algoritm** (TITLE-ABS-KEY ("chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "accessory mental foram "anterior loop" OR "mental nerve loop") AND TITLE-ABS-KEY ("cone-beam computed tomography" OR "cone-beam compute tomography" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Cone Beam Computed Tomography" OR "Cone-Bear OR "Cone Beam Computerized Tomography") OR TITLE-ABS-KEY ("Cone-Beam CT" OR "Cone Beam CT"))
Web of Science	**#1** ("chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "accessory mental foramen" OR "mental canal" OR "anterior l

	#2 ("cone-beam computed tomography" OR "cone-beam computed" OR "cone-beam computed tomography" OR "Cone-Beam CT Scan" OR "Con Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT
	Algorithm ("chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "accessory mental foramen" OR "mental canal" OR "anterior lo AND TÓPICO: ("cone-beam computed tomography" OR "cone-beam computed" OR "cone-beam computed tomography" OR "Cone-Beam CT Scans" OR "Cone Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR Beam CT")
Scielo	**#1** "chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "accessory mental foramen" OR "mental canal" OR "anterior loop" OR "r
	#2 "cone-beam computed tomography" OR "cone-beam computed" OR "cone-beam computed tomography" OR "Cone-Beam CT Scan" OR "Con Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT
	Algorithm ("chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "accessory mental foramen" OR "mental canal" OR "anterior lo AND ("cone-beam computed tomography" OR "cone-beam computed" OR "cone-beam computed tomography" OR "Cone-Beam CT Scan" OR "Cone Beam Computed Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Bea
LILACS	**#1** "chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "acessory mental foramen" OR "mental canal" OR "anterior loop" OR "m mentoniano" OR "mandibula" OR "mandíbula" OR "mandible" [Palavras]
	#2 "tomografia computadorizada por raios x" OR "tomografia computadorizada por rayos x" OR "tomographt, x-ray computed" [Palavras]
	Algoritm "chin" OR "mentum" OR "mental foramen" OR "alveolar nerve" OR "acessory mental foramen" OR "mental canal" OR "anterior loop" "forame mentoniano" OR "mandibula" OR "mandíbula" OR "mandible" [Palavras] and "tomografia computadorizada por raios x" OR "tomograf x" OR "tomography, x-ray computed" [Palavras]
Grey literature	
Google Scholar	Busca #1 "mental foramen"AND "cone-beam computed tomography"
OpenGrey	mental foramen or mental nerve loop or anterior loop

Table 2: Characteristics of the included studies

Study	**Continent**	**Country**	**Tomograph**	**FOV (cm)**	**Voxel (mm)**
Srivastava et al 2021	Asia	Saudi Arabia	Scanora 3Dx	NI	NI
Wei et al 2020	Asia	China	DCTPRO	2	0.2 - 0.3
Shalash et al 2020	Africa	Egypt	Cranex 3DX	1	0.2
Alyami et al 2020	Asia	Saudi Arabia	CS 9500 3D	NI	0.2
Alfaleh et al 2020	Asia	Saudi Arabia	Iluma	2	0.29
Zmyslowska-Polakowska et al 2019	Europe	Poland	GX CB-500	NI	0.125-0.5
Xie et al 2019	Asia	China	NewTom VG	2	0.3
Sinha et al 2019	Asia	India	Myray Hyperion X9	2	N.I.
Raju et al 2019	North America	USA	CS 9500 3D	1	0.2
Rodricks, et al 2018	Asia	India	CS 9300	2	0.3
Kastala et al 2019	Asia	India	CS 9300	1/2	0.09 - 0.5
Chappidi et al 2018	Asia	Saudi Arabia	CS 9000 3D	NI	NI
Alsoleihat et al. 2018	Asia	Jordan	CS 9300	NI	NI
Avila et al. 2018	South America	Peru	Pointnix	2	0.5
Genç et al. 2018	Europe	Turkey	NI	NI	NI
Goyushov et al. 2018	Europe	Turkey	I-CAT	1	0.2
Krishnan et al. 2018	Asia	India	CS 9300	0	0.076
Oliveira et al. 2018	South America	Brazil	I-CAT	1	0.25
Prakash et al. 2018	Asia	India	Newtom	1	NI
Vieira et al. 2018	South America	Brazil	I-CAT	0	0.2
Oliveira et al. 2018	South America	Brazil	OP300	1	0.2
Wong et al. 2018	Asia	Malaysia	KaVo 3D eXam	1	0.25
Sridhar et al. 2018	Asia	India	GALILEOS	NI	0.3
Pradeep et al. 2018	Asia	India	NI	NI	NI
Al-Mahalawy et al. 2017	Asia	Saudi Arabia	I-CAT	NI	0.3
Alam et al. 2017	Asia	Saudi Arabia	NI	0	NI
Aoun et al. 2017	Asia	Lebanon	CS 9300	NI	NI
Elkerdawy et al. 2017	Africa	Egypt	I-CAT	NI	NI
Gungor et al .2017	Europe	Turkey	I-CAT	1	0.3
Kung et al. 2017	Asia	Taiwan	NI	NI	NI
Moghdamm et al. 2017	Asia	Iran	Newtom VGI	NI	NI
Muinelo-Lorenzo et al. 2017	Europe	Spain	I-CAT	NI	0.25-0.3
Velasco-Torres et al. 2017	Europe	Spain	I-CAT	2	0.3

Shabam et al. 2017	Asia	Iran	Planmeca Oy	2	0.2
Yang et al. 2017	Asia	China	NewTom VG	2	0.15
Kheir et al. 2017	Asia	Iran	Orthophos	0/1	0.3
Brito et al. 2016	South America	Brazil	I-CAT Classic	2	0.25
Chong et al. 2016	Europa	England	PaX-Reve 3D, Vatech	0	0.08
Eren et al. 2016	Europa	Turkey	ProMax 3D	1	0.15-0.4
Nascimento et al. 2016	South America	Brazil	I-CAT	NI	0.25
Panjnoush et al. 2016	Asia	Iran	ProMax 3D	0	0,16
Sahman and Sisman. 2016	Europa	Turkey	Accuitomo 170	1/2	0.125-0.25
Carruth et al. 2015	North America	USA	CS 9300	NI	0.076
Chen et al. 2015	Asia	China	GALILEOS	2	0.15-0.3
Do Couto-Filho et al. 2015	South America	Brazil	I-CAT	1	0.25
Khojastepour et al. 2015	Asia	Iran	NewTom VGI	0/1	0.3
Lee et al. 2015	Asia	South Korea	VEGA	2	0.39
Lu et al. 2015	North America	USA	I-CAT	0/1	0.4
Demir et al. 2015	Europe	Turkey	ProMax 3D	2	NI
Muinelo-lorenzo et al. 2015	Europe	Spain	I-CAT	NI	max 0.3
Niyas et al. 2015	Asia	India	NI	NI	NI
Saito et al. 2015	South America	Brazil	I-CAT	NI	NI
Cabanillas Padilla et al. 2014	South America	Peru	Picasso Model, Vatech	2	NI
Çaglayan et al. 2014	Europe	Turkey	NewTom 3G	2	0.16
Filo et al. 2014	Europe	Switzerland	KaVo 3D exam	2	0.25-0.4
Genú et al. 2014	South America	Brazil	I-CAT	0	0.25
Rosa et al. 2013	South America	Brazil	I-CAT	NI	NI
Von Arx et al. 2013	Europe	Switzerland	Accuitomo 3D	0	0.08
Neves et al. 2013	South America	Brazil	I-CAT Classic	1	0.25
Chen et al. 2013	Asia/North America	Taiwan + USA	I-CAT	0	0.3-0.4
Kajan et al. 2012	Asia	Iran	Newton VG	NI	NI
Parnia et al. 2012	Asia	Iran	ProMax 3D	NI	NI
Angel et al. 2011	North America	USA	CB Mercu- Ray	NI	NI
Apostolakis et al. 2011	Europe	Greece	Newtom VG	0/1	0.1-0.3
De Oliveira-Santos et al. 2012	South America	Brazil	Scanora 3D	NI	0.2
Kalender et al. 2011	Europe	Turkey	NewTom 3G	9 i	0.3

NI: not informed. FOV, field of view. FOV type: 0 = small ≤ 10 cm; 1 = medium 10-15 cm; 2 = large > 15 cm

Table 3: Characterization of the included studies by sample, age, methods and observers' parameters.

Study	Sample			Age		Methods		
	Total	Male	Female	Range	Mean	In situ	Pan	CBCT
Srivastava et al 2021	240	127	113	18-66	NI	N	N	Y
Wei et al 2020	306	134	172	12-76	41	N	N	Y
Shalash et al 2020	120	NI	NI	NI	NI	N	N	Y
Alyami et al 2020	149	86	63	30-60	NI	N	N	Y
Alfaleh et al 2020	200	88	112	NI	32.5	N	N	Y
Zmyslowska-Polakowska et al 2019	487	NI	NI	NI	NI	N	N	Y
Xie et al 2019	1008	521	487	NI	41.1	N	N	Y
Sinha et al 2019	1000	NI	NI	18-58	NI	N	N	Y
Raju et al 2019	124	56	68	16-83	NI	N	N	Y
Rodricks, et al 2018	200	111	89	8-79	31.27	N	N	Y
Kastala et al 2019	90	45	45	NI	NI	N	Y	Y
Chappidi et al 2018	500	264	236	NI	NI	N	N	Y
Alsoleihat et al. 2018	139	50	89	23-69	43.5	N	N	Y
Avila et al. 2018	100	48	52	NI	36.6	N	N	Y
Genç et al. 2018	72	30	42	NI	52.9	N	N	Y
Goyushov et al. 2018	663	272	391	>18	NI	N	N	Y
Krishnan et al. 2018	109	52	57	24-69	40.5	N	N	Y
Oliveira et al. 2018	104	32	72	18-80	49.2	N	N	Y
Prakash et al. 2018	90	40	50	NI	36.15	N	N	Y
Vieira et al. 2018	240	77	163	12-94	46.6	N	N	Y
Oliveira et al. 2018	202	61	141	15-89	NI	N	N	Y

Wong et al. 2018	100	50	50	NI	NI	N	N	Y
Sridhar et al. 2018	146	63	83	21-70	38.89	N	N	Y
Pradeep et al. 2018	85	NI	NI	20-35	NI	N	N	Y
Al-Mahalawy et al. 2017	302	196	106	16-68	34.9	N	N	Y
Alam et al. 2017	395	268	127	NI	NI	N	N	Y
Aoun et al. 2017	50	23	27	18-34	23.46	N	N	Y
Elkerdawy et al. 2017	40	15	25	42-68	NI	N	N	Y
Gungor et al .2017	210	107	103	10-70	NI	N	N	Y
Kung et al. 2017	215	105	110	21-80	57	N	N	Y
Moghdamm et al. 2017	234	113	121	18-84	50.1	N	N	Y
Muinelo-Lorenzo et al. 2017	344	139	205	13-86	47.44	N	N	Y
Velasco-Torres et al. 2017	348	172	176	NI	NI	N	N	Y
Shabam et al. 2017	71	36	35	20-68	43.54	N	N	Y
Yang et al. 2017	412	166	246	11-81	NI	N	N	Y
Kheir et al. 2017	180	84	96	NI	48.6	N	N	Y
Eren et al. 2016	141	62	79	23-79	41.2	N	N	Y
Nascimento et al. 2016	240	94	156	13-87	51.4	N	N	Y
Panjnoush et al. 2016	200	90	110	NI	F: 48.78 M: 51.71	N	N	Y
Sahman and Sisman. 2016	494	254	240	20-84	41.2	N	N	Y
Carruth et al. 2015	206	30	76	>18	NI	N	N	Y
Chen et al. 2015	60	30	30	20 - >60	NI	N	N	Y

Do Couto-Filho et al. 2015	47	NI	NI	18-52	35	N	Y	Y
Khojastepour et al. 2015	156	69	87	NI	36.99	N	N	Y
Lee et al. 2015	20	9	11	NI	21.9	N	N	Y
Lu et al. 2015	366	183	183	21-80	NI	N	N	Y
Muinelo-lorenzo et al. 2015	344	139	205	13-86	47.44	N	Y	Y
Niyas et al. 2015	21	8	13	20-64	NI	N	N	Y
Saito et al. 2015	100	34	66	19-79	44.7	N	N	Y
Demir et al. 2015	279	141	138	20-69	32.68	N	N	Y
Cabanillas Padilla et al. 2014	180	74	106	20-50	NI	N	N	Y
Çaglayan et al. 2014	192	86	106	18-55	32.5	N	N	Y
Filo et al. 2014	694	341	353	8-89	29.89	N	N	Y
Genú et al. 2014	143	62	81	21-79	49.84	N	N	Y
Rosa et al. 2013	326	129	197	NI	NI	N	N	Y
Von Arx et al. 2013	142	62	80	NI	39.7	N	N	Y
Neves et al. 2013	127	55	72	18-61	41.9	N	Y	Y
Chen et al. 2013	200	53+55	47+45	20-82	53.55	N	N	Y
Kajan et al. 2012	84	41	43	13-77	49	N	N	Y
Parnia et al. 2012	96	50	46	20-77	46.6	N	N	Y
Angel et al. 2011	165	55	110	18-80	NI	N	N	Y
Apostolakis et al. 2011	93	42	51	21-89	53.53	N	N	Y
De Oliveira-Santos et al. 2012	100	41	59	NI	NI	N	N	Y
Kalender et al. 2011	193	92	101	20-83	38.6	N	N	Y
Total	14233	5884	6655	8-89	21.9-53.53			

Legends: PR panoramic radiograph; CBCT, cone beam computed tomography; Y, yes; N, no; U, unclear; M, male; F, female; NI, not inform
correlation coefficient; IR, intra-examiner reliability.

Table 4: Sample characterization by FOV, voxel, tomography, vertical and horizontal diameters, and the distances from MF to alveolar cortex and border of the mandible.

Author	Fov	Voxel (mm)	Diameter (mean)		Distances (mm)	
			Vertical (mm)	Horizontal (mm)	Alveolar cortex	Border of the mandible
Raju et al 2019	1	0.2	NI	NI	12.92	N.I.
Alsoleihat et al. 2018	NI	NI	M 3.08 F 2.46	NI	NI	NI
Avila et al. 2018	2	0.5	NI	NI	12.75	14
Genç et al. 2018	NI	NI	M 3.27 F 2.87	NI	9.12	11.4
Krishnan et al. 2018	0	0.076	2.84	3.1	NI	NI
Oliveira et al. 2018	NI	0.25	NI	NI	11.21	*12.31
Al-Mahalawy et al. 2017	NI	0.3	NI	NI	14.3	*13.8
Aoun et al. 2017	NI	NI	NI	NI	NI	*13.04
Gungor et al .2017	1	0.3	NI	NI	13.29	*12.7
Muinelo-Lorenzo et al. 2017	NI	NI	NI	NI	11.42	*13.55
Zmyslowska-Polakowska et al. 2017	NI	0.125-0.25	3.26	NI	NI	NI
Panjnoush et al. 2016	0	0,16	NI	NI	NI	*8.8
Sheikhi et al. 2016	NI	0.3	NI	NI	NI	**13.31
Chen et al. 2015	2	0.15 to 0.3	2.95	NI	NI	*14.61
Muinelo-lorenzo et al. 2015	NI	max 0.3	4.44	2.92	11.42	13,55 M1
Niyas et al. 2015	NI	NI	N	N	15.9	10,4
Saito et al. 2015	NI	NI	NI	NI	NI	*7.25
Cabanillas Padilla et al. 2014	2	NI	2-2.99 (42.5%)	NI	15	*13.8
Çaglayan et al. 2014	2	0.16	NI	NI	12.01	*13.08
Goregen et al. 2013	NI	NI	4.5	NI	NI	NI
Von Arx et al. 2013	0	0.08	NI	NI	12.6	*13.2
Chen et al. 2013	0	0.3 or 0.4	NI	NI	NI	*G1:9.84 *G2:10.13
Oliveira-Santos et al. 2012	NI	NI	4.13	NI	NI	NI
Kalender et al. 2011	9’	0.3	NI	NI	NI	*12.5

NI: Not informed. M: male; F: female; ’: inches.
FOV type: 0 = small ≤ 10 cm; 1 = medium 10-15 cm; 2 = large > 15 cm.
*Method 1: Distance from MF up to lower point of border of the mandible; **Method 2: Distance from MF to superior region of the border of the mandible.

Table 5: Sample characterization by FOV, voxel, tomography, prevalence, length, and angulation of the anterior loop.

Author	FOV (cm)	Voxel (mm)	Prevalence (%)	Length (mm)		Angulation
				Average	SD	
Wei et al	2	0.2 - 0.3	67.8	3.3	1.2	NI
Shalash et al	1	0.2	55	N.I.	NI	NI
Xie et al	2	0.3	14.6	N.I.	NI	NI
Sinha et al	2	N.I.	9.7	NI	NI	NI
Raju et al	1	0.2	25	N.I.	NI	NI
Rodricks, et al	2	0.3	57.5	N.I.	NI	NI
Kastala et al	1/2	0.09 - 0.5	56.67	N.I.	NI	NI
Chappidi et al	NI	NI	40	N.I.	NI	NI
Genç et al. 2018	NI	NI	11.11	NI	NI	NI
Krishnan et al. 2018	0	0.076	47.2	3.38	0.96	NI
Vieira et al. 2018	0	0.2	10.9	NI	NI	NI
Oliveira et al. 2018	1	0.2	2.47	2.12	NI	NI
Wong et al. 2018	1	0.25	94	3.69 (0.73– 7.99)	1.75	NI
Sridhar et al. 2018	NI	0.3	17.8	R 1.75 / L 1.46	R 0.79 / L 0.32	NI
Pradeep et al. 2018	NI	NI	11.76	2.79	NI	NI
Rodricks et al. 2018	2	0.3	57.5	R 0.5 / L 0.37	NI	NI
Al-Mahalawy et al. 2017	NI	0.3	15.2	NI	NI	NI
Kung et al. 2017	NI	NI	NI	R 2.6 (0-5.46) L 2.61 (0-5.57)	R 1.25 / L 1.27	NI
Moghdamm et al. 2017	NI	NI	23.5	2.77(0.1-7.1)	1.56	NI
Velasco-Torres et al. 2017	2	0.3	58.09	R 2.0 / L 1.92	R 0.98/ L 0.99	NI
Shabam et al. 2017	2	0.2	35.2	NI	NI	NI
Yang et al. 2017	2	0.15	93.97	2.53 (0.5-7.5)	1.27	NI
Kheir et al. 2017	0/1	0.3	32.8	R 2.69 / L 2.36	R 1.56 / L 1.16	NI
Brito et al. 2016	2	0.25	7.7	NI	NI	NI
Eren et al. 2016	1	0.15-0.4	86	3.15(2.9 – 3.3)	NI	NI
Nascimento et al. 2016	NI	0.25	41.6	1.1(0.25-4.00)	0.8	NI
Panjnoush et al. 2016	0	0.16	59.9	NI	NI	NI

Sahman and Sisman. 2016	1/2	0.125-0.25	28.5	2.19 /2.08 (0.6-6)	1 / 0.89	NI
Chen et al. 2015	2	0.15-0.3	NI	R 1.22 (0 – 7.19) L 1.10 (0-8.41)	R 1.74 / L 1.73	19.13º 0º-81.79º
Do Couto-Filho et al. 2015	1	0.25	29.8	NI	NI	NI
Lee et al. 2015	2	0.39	NI	1.9 (0- 3.3)	0.8	NI
Lu et al. 2015	0/1	0.4	85.2	1.46 (2.87 -6.67)	1.25	NI
Demir et al. 2015	2	NI	40.5	NI	NI	NI
Filo et al. 2014	NI	0.25-0.4	69.74	1.16 (0.3 – 5.60)	1.01	NI
Genú et al. 2014	0	0.25	18.9	3.14	1.24	NI
Rosa et al. 2013	NI	NI	NI	2.4 (max. 7)	NI	NI
Von Arx et al. 2013	0	0.08	70.1	2.4 R 2.26 / L 2.55	NI R 0.96 / L 0.97	46.8º
Chen et al. 2013	0	0.3-0.4	NI	USA: 6.22 Taiwan: 7.61	USA: 168 Taiwan: 1.81	NI
Kajan et al. 2012	NI	NI	36.9	NI	NI	NI
Parnia et al. 2012	NI	NI	NI	3.54 R 3.6 / L 3.2	1 R 1 / L 1.5	NI
Angel et al. 2011	NI	NI	48	NI	NI	NI
Apostolakis et al. 2011	NI	NI	48 sides	NI	NI	NI

NI, not informed. R, right; L, left. FOV type: 0 = small ≤ 10 cm; 1 = medium 10-15 cm; 2 = large > 15 cm.

Capítulo 4

5.4 CAPÍTULO 4

Cover page

Surgical-related morphometric aspects and proposal of a new classification of genial tubercles in cone-beam computed tomography

Daniel Almeida Ferreira Barbosa[a*], Lucca Reis Mesquita[a], Lúcio Mitsuo Kurita[a], Paulo Goberlânio Barros Silva[b], Filipe Nobre Chaves[c], Renata Cordeiro Teixeira[d], Fábio Wildson Gurgel Costa[a]

[a]Departament of Oral and Maxillofacial Radiology, Federal University of Ceará, Ceará, Fortaleza, Brasil.
[b]Departament of Oral Pathology, School of dentistry, Unichristus University Center, Ceará, Fortaleza, Brasil.
[c]Post-graduated Program in Science Health, Federal University of Ceará *Campus Sobral*, Ceará, Sobral, Brasil.
[d]Departament of Oral and Maxillofacial Radiology, School of Dentistry, Unifor Univsersity Ceará, Fortaleza, Brasil.

Correspondence author:

Daniel Almeida Ferreira Barbosa,

Federal University of Ceará, Ceará, Fortaleza, Brasil.

Rua Monsenhor Furtado, 1273, Rodolfo Teófilo, Fortaleza-CE, Brazil. CEP: 60430-355. Fone: +55 85 33668232.

E-mail: danielodontologia@gmail.com

Authors contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by LRM, DAFB, PGBS and LMK. The first draft of the manuscript was written by RCT, FNC and FWGC and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethical approval This research was approved by the Research Ethics Committee of the Federal University of Ceará (approval number 1.757.620)

Abstract

Objective: This study evaluated epidemiological and morphological aspects of genial tubercles (GTs) using cone-beam computed tomography (CBCT).

Methods: This retrospective, observational and cross-sectional study evaluated 276 tomographs of adults dentate individuals (18-69 years). The presence and absence of GTs was evaluated, and in cases in which this structure was observed, linear measurements (length, height, and width), anatomical distances. In addition, a GT classification was proposed based on the presence, number and location of the tubercles.

Results: Of the 276 CT scans, 28 (10.14%) had absence of GTs and in 248 CT scans GTs were present, of which 42 (57.5%) were from females and 106 (42.5%) from males. Regarding the number of GTS, the most prevalent variant was the two-tubercle-variant (143, 57.7%), followed by the presence of a single tubercle (n=62, 25.0%), 3 tubercles (n=40, 16.1%) and 4 tubercles (n=3, 1.2%). The most prevalent classification was IIIA (n=96, 38.7%), followed by IIIB (n=60, 36.3%), IIA (n=53, 21.4%) and IIB (n=9, 3.6%).

Conclusion: A prevalence of GT of approximately 90% was observed, with two GTs exam being the most frequent finding. Men had a longer mean GT length compared to women. Female individuals exhibited a shorter distance from the base of the GT to the base of the mandible.

Keywords: Genial tubercle, cone-beam computed tomography; Mandible; Anatomy.

1. Introduction

Genial tubercles (GTs) are small bone eminences found close to the midline, in the lingual region of the mandible. These anatomical protuberances serve as insertion of the geniohyoid muscles in its lower portion and the genioglossus muscle in its upper portion. These muscles are related to tongue mobility and swallowing function and are essential for speaking and eating. [1,2]

Although classically described as four eminences distributed in an upper and a lower pair, GTs demonstrate different anatomical patterns regarding shape and position, such as two upper and one lower eminences, two upper eminences and a single elongated median eminence.[3,4] Cone-beam computed tomography (CBCT) is considered an accurate method for assessing the morphology, size, and position of the GTs.[5]

GTs are located in a region that until recently was considered a safety zone in invasive procedures, such as the insertion of implants in the interforaminal region of the mandible.[4] In addition, the GT position has been used in surgical planning for maxillomandibular repositioning, especially in mandibular advancement for the treatment of obstructive sleep apnea syndrome (OSAS).[6] There are reports of GT fractures, ranging from spontaneous fractures to cases of GT fractures associated with trauma as etiological factors.[7]

In this context, imaging examinations are an important tool for studying the morphology of GTs and their relationship with the mandible and the adjacent lower anterior teeth.[5] Although the position and imaging aspects of GTs have been already described,[8] to the best of our knowledge, no topographic classification has been established to characterize GTs. Thus, the aim of the present study was to evaluate radiomorphometric and epidemiological aspects of GTs in a Brazilian population using CBCT and to propose a topographic classification of GTs.

2. Materials and methods

2.1 Study design and ethical considerations

This cross-sectional, multicenter, and retrospective study was conducted using CBCT. This research was approved by the Research Ethics Committee of the [redacted] (approval number 1.757.620) and this study is in line with Declaration of Helsinki. This study followed the guidelines proposed by the STROBE Initiative (*Strengthening the reporting of observational studies in epidemiology*).[9]

Context

This study included CBCTs obtained between January 2015 and August 2017 from two dental imaging centers located in [redacted] These two private clinics were chosen because they are well-recognized reference centers in dental imaging.

2.2 Eligibility criteria

Initially, a preliminary analysis of all tomographic examinations of the image bank of the participating centers was performed. The imaging exams had been requested for various reasons, such as preoperative planning for implants oral, localization of impacted teeth, maxillomandibular fractures, etc. CT scans of dentate patients (considering the region between the lower premolars) of both sexes, aged between 18 and 69 years, as well as CT scans in which it was possible to clearly observe the bilateral anterior region of the mandible, lower edge of the mandible and alveolar cortex were included. The exclusion criteria were: (1) CT scans of individuals who underwent more than one CT scan during the study period to avoid duplicate entries; (2) tomographic exams exhibiting images suggestive of pathological processes, as well as fractures and / or malformations that could alter the bone architecture of the mandibular anterior region; (3) metallic artifacts affecting the image quality, such as dental implants, plates and fixation screws; (4) images with low diagnostic quality.

2.3 Variables

The variables analyzed in the present study were: (1) sex, (2) age, (3) presence or absence of GTs, (4) GT classification based on the number and position of eminences, (5) linear measurements related to GTs.

2.4 Data source / Evaluation criteria

The CT scanners used in the present study were I-CAT Next Generation (Imaging International Sciences, Hatfield, Pennsylvania, USA) and i-CAT classic (Imaging International Sciences, Hatfield, Pennsylvania, USA) (Table 1). *Digital Imaging and Communications in Medicine* (DICOM) files from TCFC images were stored on a portable hard disk for further evaluation by a single observer in an appropriate environment.

All images were analyzed using the CDIS 3D Software (Caresetream LLC, Atlanta GA, USA). Initially, a panoramic reconstruction was performed using the lower edge of the mandible as a reference point and the GTs were identified using 1 mm cross-sections.

GTs were initially classified according to the amount found in 3-D reconstructions through the observation of the mandible in different planes, considering that the occurrence of up to four tubercles have been reported. Then, oblique MPR images were used to manipulate the sagittal reconstructions to locate the GTs. After each tubercle was located, the largest GT in size was selected, considering the anteroposterior direction, as well as the slice where the largest dimension of that same GT was observed. The following measures were obtained from parasagittal reconstructions based on the study by LOPES et al., (2016) [10] using the length measurement function: (1) distance from the uppermost point of the base of the GT to the cement-enamel junction (CEJ) of the lower incisor; (2) distance from the uppermost point of the base of the GT to the apex of the lower incisor. (Figure 1a) These two measurements were performed only when the lower incisor was visible in the slice. When the incisor was not clearly visible, the distance from the uppermost point of the GT base to the alveolar crest was measured (Figure 1b); mandibular bone thickness in the GT region (Figure 1c); distance from the lowest point of the GT base to the base of the mandible (Figure 1d); length of the base of the GTs (Figure 1e); distance between the base and the apex of the GTs (Figure 1f). Additionally, in an axial reconstruction, the distance from the base of the GT to the apex of the GT was measured in a latero-lateral view according to the study by Wang et al., (2013)[5] (Figure 1).

Additionally, a classification based on the absence or presence of GT was proposed: type I = non-visible. (Figure 3a); type II = presence of a single GT (Figure 3b); type III = presence of two or more GTs (Figure 3c).

This classification also included a complementary information to types II and III, with IIA for cases of a single GT centralized in relation to the midline and IIB for those lateralized in relation to the midline. Type III was divided into IIIA for multiple GTs with different dimensions and IIIB for multiple GTs with similar dimensions.

2.5 Evaluation of method error

To avoid potential sources of bias, an observer was trained and calibrated by a gold-standard researcher with vast experience in dental radiology to identify the absence / presence of GTs and to perform the linear measurements adopted in the present study. Initially, the observer verified the absence / presence of GTs in 30 CBCT images and then performed all the proposed linear measurements. After an interval of 15 days, a researcher who did not participate in the data collection randomly coded the images, and each parameter was analyzed again by the first observer. The data were exported to Microsoft Excel spreadsheets (Microsoft Corporation, Redmond, WA) and analyzed using the *Statistical Package for the Social Sciences* (SPSS®) version 20.0 for Windows (*IBM Corporation, Sommers*, NY).

To assess reproducibility errors, the following analyses were performed: (1) Cohen's kappa statistic for categorical data (presence / absence of GT); (2) to assess systematic errors regarding numerical data (linear measurements in relation to the GT); (3) Dahlberg's formula for the calculation of the random error. The kappa coefficient was interpreted according to the Lands & Koch classification (0.00, poor; 0.00–0.20, slight; 0.21–0.40,fair; 0.41–0.60, moderate; 0.61–0.80, substantial and 0.81–1.00, almost perfect). In relation to the CCI, a bidirectional random factors model with a 95% confidence interval was used, considering $p < 0.05$ values to be satisfactory. To evaluate the possible technical errors, Dahlberg's formula was used, [11] which is represented by the following equation = $\sqrt{\frac{\sum d^2}{2n}}$. Therefore, the error value represents the square root of the sum of the squared values of the differences ($\sum d^2$) between the measurements (value of the second measurement subtracted from the value of the first measurement) divided by the number of measurements (n) multiplied by two.

2.6 Sample size

Considering a prevalence of 96.6% of GTs [12] and a three-year collection period, the evaluation of 143 CT scans from a total of 1,380 were deemed necessary CT scans to obtain a sample with 5% accuracy and 99% confidence to represent the images from the imaging centers (n = [Np (1-p)] / [(d2 / Z21-α / 2 * (N-1) + p * (1-p)]). Additionally, we included further 12 CTs (approximately 10%), totaling 155 tomographs.

A simple randomization mechanism was then designed as a sampling process for selecting the images based on the registration numbers of the exams. After random draws, the CT scans were selected. If the selected image did not meet the inclusion and exclusion criteria, the immediately subsequent image would be selected or the immediately previous one in case it had also not met the inclusion and exclusion criteria of the study.

2.7 Statistical analysis

GT measurements were expressed as means and standard deviations, submitted to the Kolmogorov-Smirnov normality test and compared between sexes, classifications and age groups using Student's t and ANOVA / Bonferroni tests (parametric data). The measurements were also correlated with age through Pearson's correlation.

All analyses were performed using 95% confidence intervals (95% CI) in the *Statistical Package for the Social Sciences* (SPSS®) version 20.0 for Windows (*IBM Corporation, Sommers*, NY).

3. Results

The sample was initially consisted of 300 CT scans. Twenty-four CTs were excluded from the study because they met the eligibility criteria, with 20 exams showing the absence of at least one of the lower central incisors, 2 exams with extensive periapical lesions in the anterior region of the mandible and 2 exams with low diagnostic quality (Figure 4). Of the 276 remaining exams, 28 (10.14%) showed absence of GT and were, therefore, classified as type I.

GTs were present in 248 CT scans, of which 142 (57.5%) were found in female and 106 (42.5%) male patients. The mean age was 47.4 ± 12.77 (range: 21 to 69) years, with 28 (11.4%) patients between 21 and 30 years, 50 (20.4%) between 31 and 40 years, 56 (22.9%) between 41 and 50 years, 62 (25.3%) between 51 and 60 years, and 59 (20.0%) between 61 and 69 years. Most patients (143, 57.7%) had 2 GTs, followed by patients who had only 1 GT (n = 62, 25.0%), patients who had 3 GTs (n = 40, 16.1%), and patients who had 4 GTs (n = 3, 1.2%). The most prevalent classification was IIIA (n = 96, 38.7%), followed by IIIB (n = 60, 36.3%), IIA (n = 53, 21.4%) and IIB (n = 9, 3.6%).

The means of the measurements are shown in Table 2. The male sex showed significantly higher values than the female sex in the measurements of the distance from the highest point of the GT to the alveolar bone cortex - D1 ($p = 0.005$), distance from the highest point of the GT to the CEJ of the adjacent tooth - D2 ($p < 0.001$), distance from the highest point of the GT to the apex of the adjacent tooth - D3 ($p < 0.001$), mandible thickness - D4 ($p < 0.001$), distance from the lowest point of the GT to the MB - D5 ($p = 0.005$), measured from the base of the GT (cross-sectional slice) - D6 ($p = 0.083$), distance from the base of the GT to the apex of the GT (cross-sectional slice) - D7 ($p = 0.003$), measurement from the base of the GT (axial slice) - D8 ($p < 0.001$) and the distance from the base of the GT to the apex of GT (axial section) - D9 ($p < 0.001$) (table 1). The age ranges did not significantly influence the GT means (Table 3), but the GT classified as IIA presented mandible thickness - D4 ($p = 0.003$), the smallest distance from the lowest point of the GT to the MB - D5 ($p = 0.002$), greater measure of the base of the GT (cross-sectional slice) - D6 ($p < 0.001$), greater distance from the base of the GT to the apex of the GT (cross-sectional slice) - D7 ($p = 0.001$), greater measure of the base of the GT (axial slice) - D8 ($p < 0.001$) and the distance from the base of the GT to the apex of the GT (axial section) - D9 showed lower values in group IIB (Table 4).

The measurement of the base of the GT (cross-sectional slice) - D6 ($p = 0.003$) and the measurement of the base of the GT (axial slice) - D8 ($p = 0.012$) were inversely correlated with age in the entire sample and in females ($p = 0.001$ and $p = 0.022$, respectively) (Table 5). In IIB, there was a significant inverse correlation between age and the distance from the uppermost point of the GT to the alveolar bone cortex - D1 ($p < 0.001$) and the thickness of the mandible - D4 ($p = 0.006$). In the IIIA, the distance from the uppermost point of the GT to the alveolar bone cortex - D1 ($p = 0.013$) and the measurement from the base of the GT (parasagittal section) - D6 ($p = 0.033$) were inversely correlated with age. In IIA and IIIB, there were no significant correlations between the measurements of the GT and age (Table 6).

4. Discussion

GTs can be viewed on conventional radiographs, especially in occlusal radiographs; however, it is not possible to evaluate them with linear measurements. CBCTs enable the visualization and evaluation of the GT morphology, size and position based on the best assessment in three dimensions of this anatomical structure.[5,12] Classically described as four equidistant elevations found between the upper and lower edges of the mandible and arranged in pairs surrounding the lingual foramen, the morphological type of GTs is controversial and debated, as several osteological and radiological studies have shown that there is great variation in their morphology.

Regarding the GT distribution pattern, studies have demonstrated an acceptable precision of linear measurements of the alveolar bone and mandibular anatomy in CBCTs. The results of a study by Hueman et al.[13] demonstrated the accuracy of CBCTs in identifying the anatomical location of the GTs. Therefore, we used CBCTs to explore the morphological pattern, dimensions, and position of this important anatomical landmark. Moreover, another important factor in epidemiological studies is sexual dimorphism. Several anatomical features present clear differences between males and females, while others remain similar regardless of this factor. Sexual dimorphism is an important tool in human identification, especially in events involving explosions and carbonization of individuals.[14]

This research carried out an important anatomic and epidemiological analysis of GTs using an appropriate and reproducible methodology, which included a significant sample of 248 CBCTs from two different dental imaging reference centers, justified by the fact that these results are more representative of the studied population, contributing to its external validity.[15]

The sample in this study was predominantly female (57.5%), different from other studies, such as by Kolsuz et al. [16] and Wang et al. [5] in which this prevalence was closer to 50%. Additionally, Araby et al. [12] observed GTs in a sample consisting 69.4% of men, which differs diametrically from the sample of the present study. Regarding the age variable, the age group with the highest prevalence was between 51 and 60 years, but it did exhibit significant differences compared to the other age groups. All studies that evaluated the age variable only mentioned the total age range, and in one investigation the mean age was informed. In our study, the mean age was 47.4 years, ranging from 21 to 69 years. Similar age ranges have also been reported by Araby et al. (17 to 63 years), [12] Nejaim et al. (21 to 80 years old), [17] and Kolsuz et al (20 to 76 years), [16] which also demonstrated a mean age of 40.3 years, being considerably lower than the mean age of the present study.

The present study proposed a classification system for GTs evaluating their disposition in the mandible, thus being different from the study by Araby et al. [12] which was the only investigation to date that had developed classification system for GTs in five categories according to their number. When comparing the similarities between the two classification systems, we can correlate pattern V with type I, as they both indicate absence of GTs, which was found in 6.40% of the sample in the study by Araby et al. [12] and 10.14% in our study. Standard IV can also be compared with the IIA classification, as they both indicate the presence of a single centralized tubercle. In this comparison, the results were similar, with 20% and 21.4%, respectively. The other standards and classifications cannot be compared to each other. However, based on the number of tubercles, we were able to estimate the results of certain patterns: Pattern I had a considerable difference, appearing in 14.2% of cases, whereas in our study it appeared in only 1.2% of the sample. For pattern II, the results would be 22.6% and 16.1%, respectively.

Regarding sex, the sample in this study was predominantly female (57.5%). This finding was different from other works, such as the investigations by Kolsuz et al. [16] and Wang et al. [5] in which the prevalence was closer to 50%.

In relation to linear measurements, this is the first study that evaluated the distances from the upper part of the base of GT to the alveolar crest or the CEJ of the adjacent incisor. In both measurements, male patients exhibited significantly greater distances than female patients. Furthermore, in the IIIA and IIB groups, there was a significant inverse correlation between the distance to the alveolar crest and age.

In relation to the measurement from the upper point of the base to the apex of the adjacent incisor, the value 6.26 ± 3.26mm was considerably smaller than the one found by Araby et al. (8.26 ± 2.7mm) [12] and by Nejaim et al. [17] and Wang et al. [5] who obtained the same average of 7.1 - 9.1mm. However, the present study was the only one that found significant differences between groups. This distance was greater in men (7.87mm), compared to women (5.12mm), and greater in tubercles with IIA classification (a single centralized tubercle) (7.69 ± 3.33mm).

The measurement from the upper point of the base to the apex of the adjacent incisor is important especially when we take into account mandibular advancement surgery in the treatment of OSAS. Park et al. [6] demonstrated in an investigation on mandibular advancement surgery for treating OSAS that, when the osteotomy is performed at a distance of 5mm or less from the apex of the lower central incisors (LCI), in about 20% of the cases the musculature will not be properly captured, whereas Pommer et al. [18] observed that a distance of at least 9 mm to the apex of the ICI must be respected because of the presence of the mandibular incisive canal and the possible risk of injury to this structure.

In the present study, the measurement of the thickness of the mandible was assessed separately, differently from the studies by Kolsuz et al (14.0 - 16.2mm) [16] and Wang et al (12.7 - 14.6mm), [5] which used a different methodology to perform this measurement, calculating the mandible thickness including the anteroposterior dimension of the GT. Thus, the measurement of 12.20 ± 2.05mm found in the present study was smaller than the values found in those studies.

The study by Nejaim et al. [17] also evaluated sexual dimorphism, however they found no significant difference between males (15.3 ± 2.39mm) and females (14.4 ± 2.15mm). In the present study, these values were statistically higher in males (12.77 ± 2.11) than females (11.78 ± 1.90);

however, it is not possible to establish a definitive difference between males and females because of an intersection area common to both sexes. In addition, samples categorized as IIA also had significantly greater thicknesses, whereas in IIB there an inverse correlation between the thickness of the mandible and age was observed. The studies by Hadia et al (CBCT: 14mm / Caliper: 14.2mm) [19] and Hueman et al (CBCT: 14.4 ± 2.8mm / Caliper: 14.3 ± 2.2mm) [13] performed measurements on cadavers through dissection using calipers and compared those measurements with ones obtained from CBCTs. Other studies that also reported higher values were the ones by Kolsuz et al. (14.0 - 16.2mm) [16] and Wang et al. (12.7 - 14.6mm). [5]

The distance from the lowest point of the GT base to the mandible base has also been assessed by multiple other studies. The mean value obtained of the present study of 9.48 ± 2.55mm was similar to that found by Kolsuz et al. (8.3 - 10.1mm).[16] However, it was higher than the measurements found in other studies such as by Araby et al. (8.13 ± 3.07mm)[16] and Wang et al (6.4 - 8.4mm).[5] Similar to the measurements of the thickness of the mandible, two studies also performed this measurement with calipers on cadavers compared to CBCT (Hadia et al. CBCT: 12.9mm / Caliper: 10.9mm; and Hueman et al. CBCT: 11.2 ± 3.6mm / Caliper: 13.3 ± 2.9mm).[13,19] Probably, larger GT are associated with a higher risk of fracture, which can provoke muscle retraction and traction of the tongue in a posterior direction and consequent obstruction of the upper airways.[20] In the present study, this distance was found to be significantly greater in males than females and lower in IIA GTs.

The length of GT base in the parasagittal view can be measured through two different methodologies. Given the possibility of two tubercles being present in the same slice in an upper and lower position, the GT base length can be obtained through the larger GT only, which we adopted in this study, or through the entire dimension from the beginning of the upper tubercle to the end of the lower one, which was the methodology used in the study by Araby et al (6.67 ± 3.04mm).[12] This may be a factor that caused the result of the present study to be statistically lower (4.68 ± 1.81mm). The studies carried out only with CBCTs, obtained much higher values, such as in the investigations by Kolsuz et al (7.3 - 8.7mm) [16] and Wang et al (6.5 - 7.9mm). [5] In studies using cadavers, the results were similar to the present study, such as demonstrated by Hadia et al (CBCT: 4.5mm / Caliper: 5.0mm) [19] and Hueman et al (CBCT: 5.1 ± 1.6mm / Caliper: 4.7 ± 1.5mm). [13] This measurement was significantly higher in GT categorized as IIA. In addition, it was inversely correlated with age in females and in IIIA GTs.

The base of the GT was also evaluated in the axial section, this time evaluating the lateral measurement of the GT. The same methodological difference of the measurement in the sagittal section happens in this measure, but in this case it is the bias of the cases in which two or more tubers are side by side, a reality even more common than an upper and lower one. Only three studies reported the measurement analysis methodology, without similarities. [5,12,16] All of them found averages much higher than the present study (3.05 ± 1.18), which measured only the largest tubercle in the anteroposterior direction. Studies on cadavers had closer results, but still significantly higher, as in Hadia et al. (CBCT: 4.9mm / Caliper: 5.2mm) [19] and Hueman et al (CBCT: 5.3 ± 1.2mm / Caliper: 4.9 ± 0.9mm). [13] Nejaim et al. [17] also evaluated this measurement and compared it with sexual dimorphism but found no statistical differences between men (8.18 ± 2.53mm) and women (7.38 ± 2.58mm). This result differs from that found in the present study, in which men (3.37 ± 1.30mm) obtained a statistically higher mean than women (2.82 ± 1.03mm). In addition, in tubercles classified as IIA, the measurement of the length base of GT was significantly greater. This measurement was also inversely correlated with age in women.

The distance from the base to the apex of the GT, which is equivalent to the anteroposterior distance of the GT, was evaluated both in parasagittal and in axial cuts. Apparently, none of the consulted studies performed this measurement in the parasagittal section, whereas the present study found a mean value of 2.01 ± 0.88mm. Nejaim et al.[17] evaluated the differences between men (1.89 ± 0.82mm) and women (1.37 ± 0.64mm) in axial cuts, finding this measurement to be statistically superior in men. This result reinforces what was found in the present study, in which the measurement in men (2.20 ± 0.97mm) was also significantly higher than that found in women (1.81 ± 0.72mm). With regard to statistical differences between groups, this measurement in parasagittal cuts was also statistically greater in males. In GTs classified as IIA, the measurement in parasagittal cuts was significantly higher, whereas in GTs classified as IIB, the measurement in axial slice obtained lower values.

Limitations

The sample used in this investigation can not be generalized to the Brazilian population. Although linear measurements related to GT were higher in men, there was no sexual dimorphism. Therefore, further studies in different populations are suggested.

5. Conclusion

In summary, a prevalence of GT of approximately 90% was observed, with the two-tubercle-variant being the most frequent. According to the classification proposed in this study, the most prevalent were IIIA and IIIB. Male patients exhibited a longer mean GT length compared to female patients. Female individuals showed a shorter distance from the base of the GTs to the base of the mandible.

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Declaration of competing interest

The authors report no conflict of interest.

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Figures legends

Figure 1. 1a) Cross-sectional slice on CBCT: distance from the apex of the central incisor adjacent to the GT; 1b) Distance from GT to the cortex of the alveolar crest; 1c) thickness of the mandible in the GT region; 1d) distance from the lower edge of the mandible to the lowest point of the base of the GT; 1e) measurement of the base of the GT; 1f) measurement from the base to the apex of the GT.

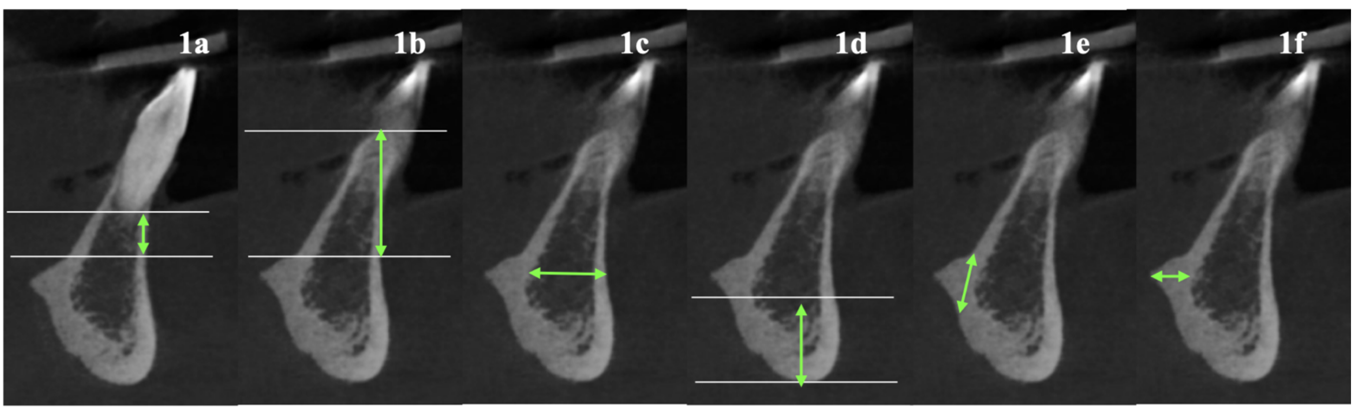

Figure 2: 2a) Axial slice on CBCT: measurement from the base to the apex of the GT. 2b) Axial slice on CBCT: measurement of the base of the GT.

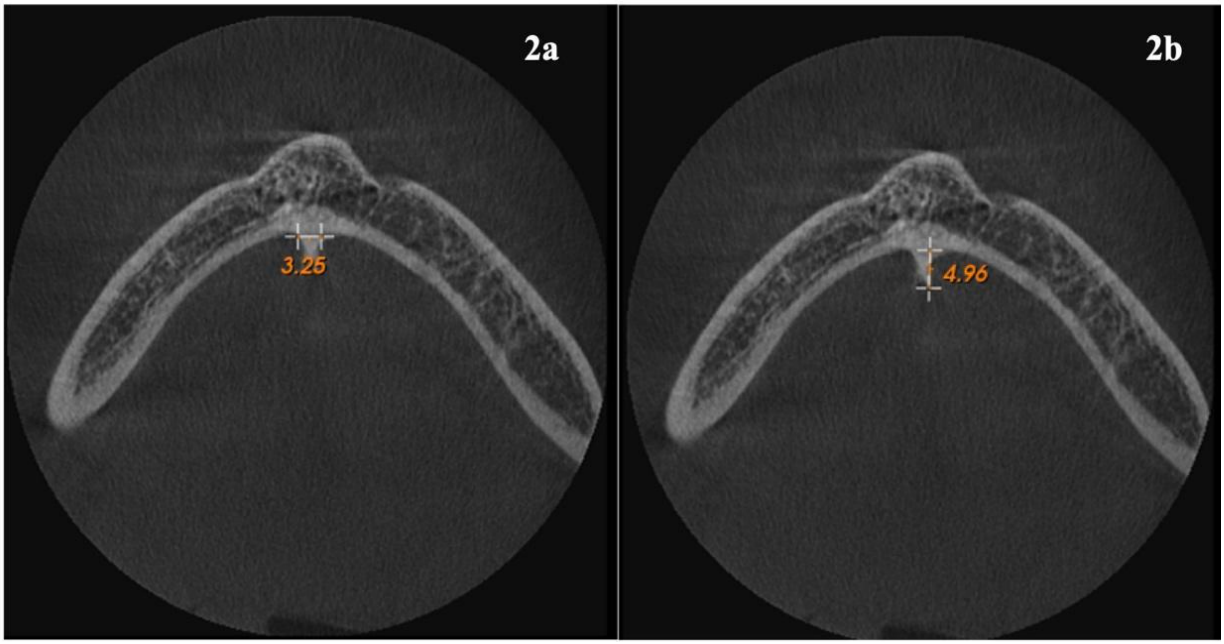

Figure 3. 3a) Type I GT (non-visible). 3b); Type II (single GT). 3c) ;Type III (multiple GT).

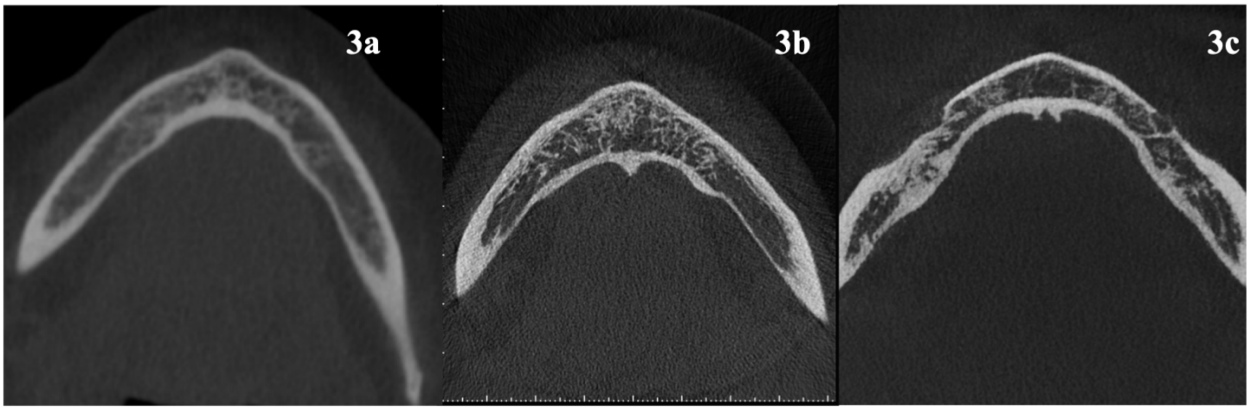

Figure 4. CBCT methodology selection flow chart.

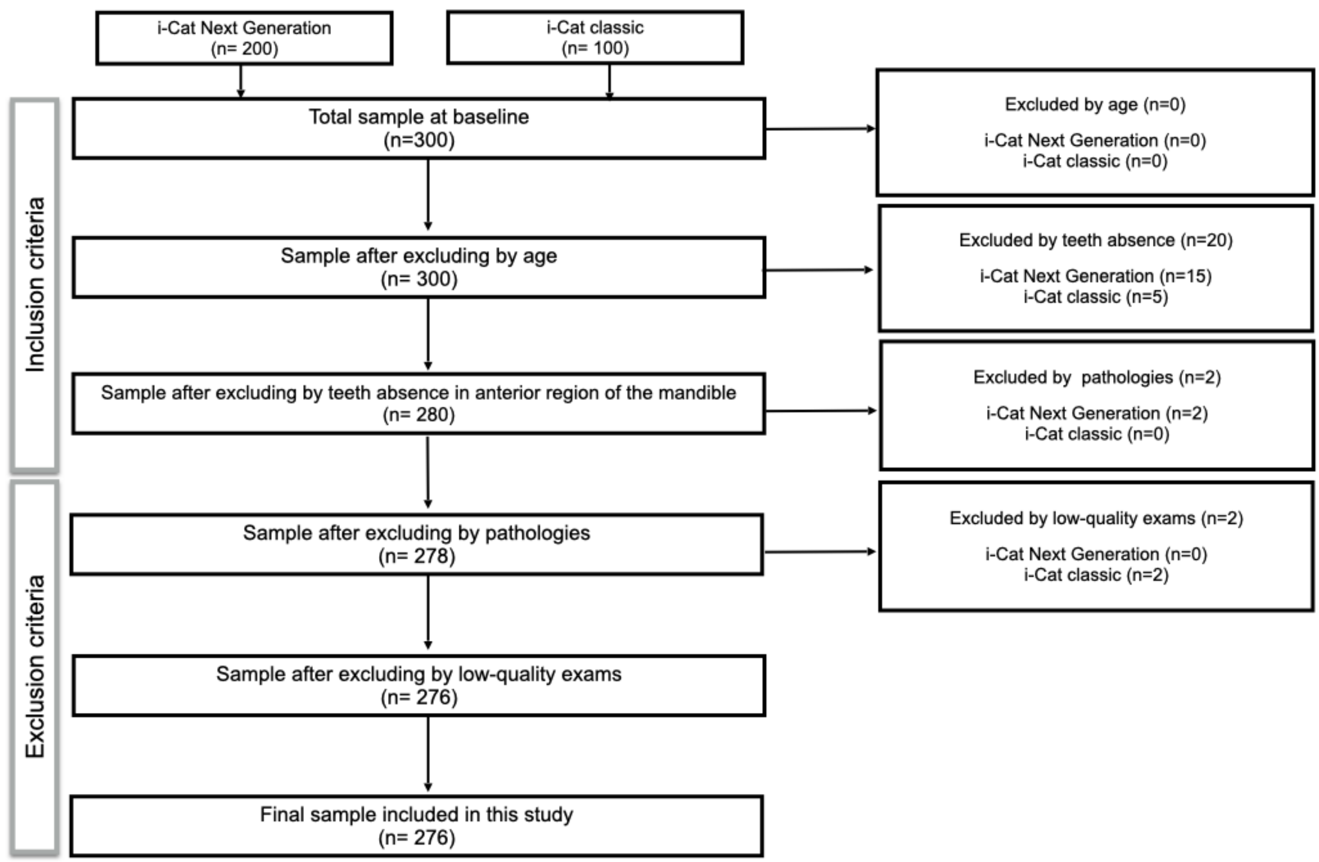

Table 1: Characterization of cone-beam computed tomographs according to image acquisition parameters.

	i-CAT Next Generation	i-CAT classic
kVp	90-140kVp	90-140kVp
mA	5mA	8mA
FOV	8x8cm to 16x8cm	8x8cm to 16x8cm
Voxel	0.3mm	0.2mm
	0.25mm	0.25mm

FOV, field of view.

Table 2: Comparison of the dimensions of mean values (mm) and standard deviation of GT between males and females.

	Total	Sex		p-value
		Male	Female	
Distance from the uppermost point of the GT base to the alveolar crest (CC)	17.24±3.45	18.23±3.47	16.46±3.26	*0.005*
Distance from the uppermost point of the BGT to (CEJ) (CC)	18.81±3.64	21.05±3.54	17.31±2.87	*<0.001*
Distance from the uppermost point of the BGT to the apex of the lower incisor (CC)	6.26±3.26	7.87±3.36	5.12±2.68	*<0.001*
Mandibular bone thickness in the GT region (CC)	12.20±2.05	12.77±2.11	11.78±1.90	*<0.001*
Distance from the lowest point of BGT to the BM (CC)	9.48±2.55	10.01±2.38	9.09±2.62	*0.005*
Length of the BGT (CC)	4.68±1.81	4.91±1.78	4.51±1.81	0.083
Distance between the base and the apex of the GT (CC)	2.01±0.88	2.20±1.00	1.86±0.76	*0.003*
Length of the BGT (AC)	3.05±1.18	3.37±1.30	2.82±1.03	*<0.001*
Distance between the base and the apex of the GT (AC)	1.98±0.85	2.20±0.97	1.81±0.72	*<0.001*

*p<0.05, test t Student (mean ± SD). AC: axial cut; CC cross-sectional cut; BM, base of the mandible; BGT, base of the genial tubercle; CEJ, cement-enamel junction; GT, genial tubercle.

Table 3: Comparison of the dimensions of mean values (mm) and standard deviation of GT between age groups.

	Age (years)					
	20-30	31-40	41-50	51-60	61-70	p-value
Distance from the uppermost point of the BGT to the alveolar crest (CC)	18.31±3.77	17.27±4.08	17.62±2.70	17.17±3.68	16.24±3.43	0.438
Distance from the uppermost point of the BGT to (CEJ) (CC)	18.45±4.28	18.30±3.39	19.64±3.55	19.21±3.67	18.16±3.60	0.441
Distance from the uppermost point of the BGT to the apex of the lower incisor (CC)	5.65±3.70	5.93±2.55	6.96±3.71	6.94±3.54	5.34±2.71	0.248
Mandibular bone thickness in the GT region (CC)	12.43±1.82	12.23±2.22	12.42±2.07	11.79±2.09	12.21±1.90	0.474
Distance from the lowest point of BGT to the BM (CC)	9.39±2.69	9.20±2.61	9.43±2.52	9.25±2.76	10.22±2.17	0.276
Length of the BGT (CC)	4.92±1.83	5.16±2.07	4.82±1.84	4.39±1.59	4.23±1.64	0.059
Distance between the base and the apex of the GT (CC)	2.15±0.81	1.99±0.95	2.01±0.98	1.92±0.69	2.00±0.92	0.859
Length of the BGT (AC)	3.19±1.29	3.31±1.31	3.23±1.40	2.72±0.92	2.94±0.92	0.054
Distance between the base and the apex of the GT (AC)	2.08±0.71	1.91±0.82	1.87±0.78	2.01±0.77	2.09±1.09	0.636

*$p<0.05$ versus other age groups, ANOVA/Bonferroni test (mean ± SD). AC: axial cut; CC cross-sectional cut; BM, base of the mandible; BGT, base of the genial tubercle; CEJ, cement-enamel junction; GT, genial tubercle.

Table 4: Comparison of the dimensions of the mean values and standard deviation of the GT between according to the type of GT based on the new proposal classification.

	Classification				p-value
	IIA	IIB	IIIA	IIIB	
Distance from the uppermost point of the GT base to the alveolar crest (CC)	18.23±4.04	13.80±0.99	16.90±3.36	17.02±3.04	0.165
Distance from the uppermost point of the BGT to (CEJ) (CC)	19.96±3.90	17.53±1.71	19.02±3.53	18.13±3.70	0.138
Distance from the uppermost point of the BGT to the apex of the lower incisor (CC)	7.69±3.33	5.86±1.82	6.40±3.08	5.46±3.44	0.077
Mandibular bone thickness in the GT region (CC)	13.00±2.32 *	11.49±2.22	12.23±1.82	11.76±1.95	0.003
Distance from the lowest point of BGT to the BM (CC)	8.30±2.94*	9.57±2.33	9.77±2.26	9.87±2.44	0.002
Length of the BGT (CC)	5.80±2.42*	4.38±1.20	4.27±1.27	4.51±1.67	0.000
Distance between the base and the apex of the GT (CC)	2.27±1.18*	1.59±0.66	2.13±0.81	1.77±0.69	0.001
Length of the BGT (AC)	4.02±1.65*	2.48±1.08	2.84±0.91	2.75±0.74	0.000
Distance between the base and the apex of the GT (AC)	2.21±0.97	1.53±0.60*	2.17±0.90	1.70±0.64	0.000

*p<0.05 versus other types, ANOVA/Bonferroni test (mean ± SD). AC: axial cut; CC cross-sectional cut; BM, base of the mandible; BGT, base of the genial tubercle; CEJ, cement-enamel junction; GT, genial tubercl

Table 5: Comparison of the correlation of the dimensions of GT between male and female.

		Age (years) *vs.*	
	Total sample	Female	Male
Distance from the uppermost point of the GT base to the alveolar crest (CC)	p=0.112 (r=-0.148)	p=0.853 (r=-0.023)	**p=0.013 (r=-0.346)*
Distance from the uppermost point of the BGT to (CEJ) (CC)	p=0.967 (r=0.003)	p=0.165 (r=0.149)	p=0.278 (r=-0.145)
Distance from the uppermost point of the BGT to the apex of the lower incisor (CC)	p=0.999 (r=0.000)	p=0.404 (r=0.098)	p=0.343 (r=-0.135)
Mandibular bone thickness in the GT region (CC)	p=0.182 (r=-0.086)	p=0.925 (r=-0.008)	p=0.064 (r=-0.183)
Distance from the lowest point of BGT to the BM (CC)	p=0.189 (r=0.084)	p=0.180 (r=0.114)	p=0.617 (r=0.050)
Length of the BGT (CC)	**p=0.003 (r=-0.190)*	**p=0.001 (r=-0.270)*	p=0.416 (r=-0.081)
Distance between the base and the apex of the GT (CC)	p=0.446 (r=-0.049)	p=0.144 (r=-0.124)	p=0.805 (r=0.025)
Length of the BGT (AC)	**p=0.012 (r=-0.159)*	**p=0.022 (r=-0.192)*	p=0.172 (r=-0.136)
Distance between the base and the apex of the GT (AC)	p=0.498 (r=0.044)	p=0.723 (r=0.030)	p=0.496 (r=0.068)

*p<0.05, Pearson's correlation. AC: axial cut; CC cross-sectional cut; BM, base of the mandible; BGT, base of the genial tubercle; CEJ, cement-enamel junction; GT, genial tubercle.

Table 6: Comparison of the correlation of GT dimensions between types based on the new proposel classification.

	Age (years) vs.			
	IIA	**IIB**	**IIIA**	**IIIB**
Distance from the uppermost point of the GT base to the alveolar crest (CC)	p=0.397(r=-0.164)	**p<0.001(r=-1.000)*	**p=0.013(r=-0.396)*	p=0.334(r=0.146)
Distance from the uppermost point of the BGT to (CEJ) (CC)	p=0.184(r=-0.269)	p=0.695(r=-0.183)	p=0.711(r=0.048)	p=0.760(r=0.043)
Distance from the uppermost point of the BGT to the apex of the lower incisor (CC)	p=0.062(r=-0.425)	p=0.538(r=0.284)	p=0.782(r=-0.039)	p=0.444(r=0.117)
Mandibular bone thickness in the GT region (CC)	p=0.646(r=-0.066)	**p=0.006(r=-0.829)*	p=0.533(r=-0.065)	p=0.394(r=-0.091)
Distance from the lowest point of BGT to the BM (CC)	p=0.331(r=0.139)	p=0.197(r=-0.474)	p=0.208(r=0.130)	p=0.905(r=0.013)
Length of the BGT (CC)	p=0.390(r=-0.123)	p=0.335(r=-0.365)	**p=0.033(r=-0.219)*	p=0.058(r=-0.200)
Distance between the base and the apex of the GT (CC)	p=0.790(r=-0.038)	p=0.813(r=-0.092)	p=0.562(r=-0.060)	p=0.235(r=-0.126)
Length of the BGT (AC)	p=0.075(r=-0.251)	p=0.093(r=-0.592)	p=0.420(r=-0.084)	p=0.129(r=-0.161)
Distance between the base and the apex of the GT (AC)	p=0.787(r=-0.039)	p=0.193(r=-0.478)	p=0.614(r=0.052)	p=0.786(r=0.029)

*p<0.05, Pearson's correlation. AC: axial cut; CC cross-sectional cut; BM, base of the mandible; BGT, base of the genial tubercle; CEJ, cement-enamel junction; GT, genial tubercle.

Capítulo 5

5.5 CAPÍTULO 5

Página título

Aspectos tomográficos do forame mentual e *loop anterior,* forame mentual acessório e foramina lingual em TCFC e estimativa de risco de injúria a essas estruturas relacionada a procedimentos cirúrgicos orais

Daniel Almeida Ferreira Barbosa[a*], Renata Cordeiro Teixeira[b], Lúcio Mitsuo Kurita[a], Paulo Goberlânio Barros Silva[c], Alynne Vieira de Menezes Pimenta[d], Filipe Nobre Chaves[d], Fábio Wildson Gurgel Costa[d]

[a]Aluno de Pós-graduação, Divisão de Radiologia Oral, Universidade Federal do Ceará, Fortaleza, Ceará, Brasil.
[b]Professsora, Divisão de Estomatologia, Universidade de Fortaleza (UNIFOR), Fortaleza, Brasil.
[c]Professor, Divisão de Patologia Oral, Centro Universitário Unichristus, Fortaleza, Ceará, Brasil.
[d]Professor, Divisão de Radiologia Oral, Universidade Federal do Ceará, Fortaleza, Ceará, Brasil.
[e]Professor, Divisão de Diagnóstico Oral, Universidade Federal do Ceará, *Campus Sobral,* Sobral, Ceará, Brasil.

Autor de Correspondência:
Daniel Almeida Ferreira Barbosa,
Universidade Federal do Ceará, Fortaleza, Ceará, Brasil.
Rua Monsenhor Furtado, 1273, Rodolfo Teófilo, Fortaleza-CE, Brazil. CEP: 60430-355. Fone: +55 85 33668232.
E-mail: danielodontologia@gmail.com

Aspectos éticos: Esta pesquisa foi aprovada pelo Comitê de Ética em Pesquisa da Universidade Federal do Ceará em Seres Humanos da UFC (número 1.757.620).

Conflito de interesse: Nenhum

RESUMO

Objetivo: Avaliar aspectos epidemiológicos e radiomorfométricos do forame mentual (FM), *loop anterior* (LA), forame mentual acessório (FMA) e foramina lingual (FL) por meio de tomografias computadorizadas de feixe cônico (TCFC), além de estimar o risco relativo a procedimentos cirúrgicos orais em região anterior mandibular.

Métodos: Foi realizado um estudo retrospectivo com 250 TCFC de indivíduos dentados na região anterior de mandíbula, com idade entre 18 e 69 anos. Foi avaliado presença/ausência, medidas lineares (comprimento, altura e largura), distâncias anatômicas (para as corticais ósseas vestibular, lingual, alveolar, base da mandíbula e ao ápice do dente adjacente), relativos ao FM, FMA e FL, bem como risco estimado de injúria a essas estruturas em procedimentos cirúrgicos mandibulares.

Resultados: Dos 250 exames, a idade média dos pacientes foi 47,44±12,57 anos e 150 indivíduos eram do sexo feminino e 100 do sexo masculino. A posição horizontal mais prevalente do FM foi próximo ao segundo pré-molar (50,2%) e abaixo do ápice dentário (91,2%). O LA foi observado em 45,8% das hemimandíbulas, sendo os casos bilaterais (72%) mais frequentes que os casos unilaterais (28%). A prevalência total do FMA foi de 7,2% (n=18) dos casos, sendo 5,2% (n=13) indivíduos do sexo feminino e 2% (n=5) masculino. Em um caso foi observada a presença do FMA bilateralmente (0,4%). Com relação à FL, observou-se uma prevalência de pelo menos uma em 94,4% dos casos (n=235) e uma segunda foramina estava presente em 77 (31,0%) indivíduos. A estimativa de risco evidenciou que as osteotomias para genioplastia devem ser realizadas abaixo do FM em pelo menos 5mm, independentemente da técnica adotada, bem como deve-se respeitar uma distância de 4mm a frente do FM para procedimentos invasivos como colocação de implantes. Em relação à profundidade de coleta de enxerto, esta deve se limitar a 4mm com um risco de cerca de 30,8% de injuriar a FLI quando esta se faz presente.

Conclusão: Em quase metade dos casos o LA estava presente, sendo o comprimento menor que 4mm, em 100% dos casos, portanto neste estudo evidenciou-se segurança na colocação de implantes a partir de 4mm anteriormente ao FM.

Palavras-chave: Forame mentual, Loop anterior, Forame mentual acessório, Foramina lingual, tomografia computadorizada de feixe cônico.

INTRODUÇÃO

Clinicamente a região entre os forames mentuais mandibulares tem sido considerada segura para a realização de procedimentos cirúrgicos. Entretanto, embora incomuns, deve-se considerar o risco de injúria a determinadas estruturas neurovasculares existentes nessa região[1,2]. Em relação a reparos anatômicos da região mandibular anterior (foramina lingual (FL), forame mentual (FM) e forame mentual acessório (FMA), diversos autores têm proposto, por meio de estudos tomográficos e/ou cadavéricos, margens cirúrgicas de segurança mínimas frente a procedimentos tais como técnicas de genioplastia *mini wing*[3], *chin wing*[4], genioplastia estética[5], *sliding genioplasty*[6] e *Wedge osteotomy*[7], remoção de enxerto ósseo livre de mento[1,8] e inserção de implantes dentários adjacentes ao FM[9]. Nesse cenário, ressalta-se a importância de estudos com tomografias computadorizadas de feixe cônico (TCFC) que se proponham a obter dados tanto de prevalência e demográficos de reparos anatômicos mandibulares, como medidas lineares relacionadas a tais estruturas.

A FL é uma importante estrutura que se localiza na região anterior da mandíbula, próxima à linha média, por onde passam vasos oriundos, provavelmente, de vasos maiores como as artérias e veias sublinguais. Pela localização da FL, a cirurgia para colocação de implantes osseointegráveis ou coleta de enxerto ósseo autógeno em região mentual pode eventualmente provocar ruptura destes vasos e, consequentemente, hemorragias. Tem sido relatado a formação de grandes hematomas acompanhados de edema em soalho de boca, quando há colocação de implantes na região anterior em que a cortical lingual é perfurada[10-12].

Por sua vez, o FM representa um dos mais importantes reparos anatômicos mandibulares sob o ponto de vista clínico, apresentando notória variabilidade em um mesmo indivíduo e entre indivíduos[13]. Injúrias relacionadas à região onde se encontra o FM podem levar a alterações de sensibilidade, tais como parestesia ou anestesia em lábio inferior, mucosa adjacente, mento e dentes associados[14]. Nesse contexto, após a inserção de implantes dentários na região adjacente ao FM, distúrbios neurossensoriais (permanentes ou temporários), têm sido reportados[15-17]. De fato, procedimentos cirúrgicos para colocação de implantes osseointegráveis em região de pré-molares inferiores devem considerar a presença do FM, visto que quando esse reparo anatômico não é apropriadamente identificado através de exames por imagem, bem como protegido no transoperatório, podem ocorrer alterações neurossensoriais pós-operatórias importantes para o paciente[13]. Além disso, variações anatômicas relacionadas ao FM como a presença de um loop anterior (LA) emergindo deste e o FMA, apresentam grande relevância clínica frente a procedimentos cirúrgicos periodontais, periapicais e de inserção de implantes dentários[18].

A tomografia computadorizada de feixe cônico (TCFC) surge como uma ferramenta de avaliação com significante acurácia por se tratar de um exame tridimensional com precisão de medidas lineares[2]. Posto isto, o objetivo deste trabalho foi avaliar aspectos morfométricos e topográficos do FM e seu LA, FMA e FL em TCFC de indivíduos brasileiros, bem como estimar o risco relativo de injúria a tais estruturas quando da realização de procedimento cirúrgicos na região anterior de mandíbula.

MATERIAL E MÉTODOS

Desenho do estudo e aspectos éticos

Trata-se de um estudo transversal, quantitativo e descritivo com TCFC obtidas da rotina de diferentes centros de imagem odontológicos, aprovado no Comitê de Ética em Pesquisa em Seres Humanos da Universidade Federal do Ceará (número 1.757.620) e condizente com a Declaração de Helsinki. Este artigo foi conduzido de acordo com as recomendações do *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) para estudos observacionais[19].

Amostra

Tendo em vista uma prevalência de 100% do FM[20] e um período de coleta de três anos, estimou-se necessário dentro de uma população de 1380 tomografias avaliar 173 tomografias a fim de obter uma amostra que represente com uma precisão de 5% e uma confiança de 95% as imagens do serviço n=Z2 .P.(1−P).N α2 /Z2 .P.(1−P)+(N−1).e2. Acresceu-se 10% sobre esta, totalizando um mínimo 191 tomografias. A partir de uma base de dados com 300 tomografias, traçou-se um mecanismo de aleatorização simples para seleção das imagens. Caso alguma imagem não atendesse aos critérios de elegibilidade, a imagem de registro imediatamente posterior seria selecionada.

Critérios de elegibilidade

Foram incluídas TCFC de indivíduos de ambos os sexos, com idade entre 18 e 69 anos, que envolvessem a região anterior da mandíbula e que apresentassem todos os dentes na região interforaminal. Por outro lado, foram excluídos exames tomográficos que evidenciassem: imagens sugestivas de alterações patológicas (ex., cistos e tumores), fraturas e síndromes que alterassem a arquitetura óssea local; perda óssea severa que impossibilitasse o estudo adequado de qualquer um dos reparos anatômicos avaliados no presente estudo; artefatos de imagem que afetassem a qualidade diagnóstica, tais como implantes dentários e placas e parafusos de fixação de fraturas.

Obtenção e avaliação das imagens

Foram avaliadas imagens de TCFC obtidas de dois centros de imagem que seguiram os critérios de elegibilidade adotados na presente investigação, tendo sido codificadas por números para manter o anonimato. Os exames tomográficos foram adquiridos através dos aparelhos I-Cat e I-Cat Next Generation (*Imaging International Sciences*, Hatfield, Pennsylvania, USA), e os pacientes permaneceram em posição estática (em pé ou sentados) seguindo as recomendações dos fabricantes desses tomógrafos e com protocolos adequados para as indicações clínicas (Material Suplementar 1). As tomografias foram analisadas por um único observador especialista em Radiologia Odontológica e previamente treinado para a realização da coleta de dados. As avaliações foram realizadas em um mesmo computador (Apple Inc., modelo MacBook Pro, processador Intel Core i7, 2,3 ghz) utilizando o *software Imaging Studio* versão 3.4 (Anne Solutions, Brasil)[21] em condições de pouca iluminação.

Coleta e análise de dados

Forame mentual

Inicialmente, os arquivos em formato *Digital Imaging and Communications in Medicine* (DICOM) foram importados no programa para análise das imagens. Foram selecionados cortes parassagitais com distância de 1mm e reconstruções panorâmicas com espessura de 20mm, as quais tiveram a base da mandíbula (BM) como referência anatômica.

Posteriormente, foi realizada uma reconstrução em 3D e o FM foi classificado horizontalmente em seis posições[22]: posição 1 - anterior ao primeiro pré-molar; posição 2 - em linha com o primeiro pré-molar; posição 3 - entre o primeiro e segundo pré-molares; posição 4 - em linha com o segundo pré-molar; posição 6 – entre a raiz do dente 45 e a raiz mesial do dente 46; posição 6 – na linha da raiz mesial do dente 46. Ademais, a posição vertical do FM foi classificada em relação à raiz do dente mais adjacente de acordo com ALAM et al., (2017)[23] como: posição 1 – acima do ápice radicular; posição 2 - no ápice radicular; posição 3 – abaixo do ápice radicular. Além disso, a forma do FM foi classificada de acordo com Goyushov et al., (2018)[24] em oval, redondo ou irregular.

Em seguida foram obtidas três distâncias em reconstruções transversais (1- limite inferior do FM à BM; 2- limite superior do FM à crista alveolar [CA]; 3 - FM à cortical externa lingual de acordo com Çaglayan et al., [2014][25]) como ilustrado na Figura 1A. Por fim, o ângulo de emergência do FM foi aferido em reconstruções parassagitais segundo Von Arx et al., em 2013[26], sendo calculado entre uma linha simulando a continuidade da parede superior do FM e outra que tangenciava a cortical externa vestibular (Figura 1B-D).

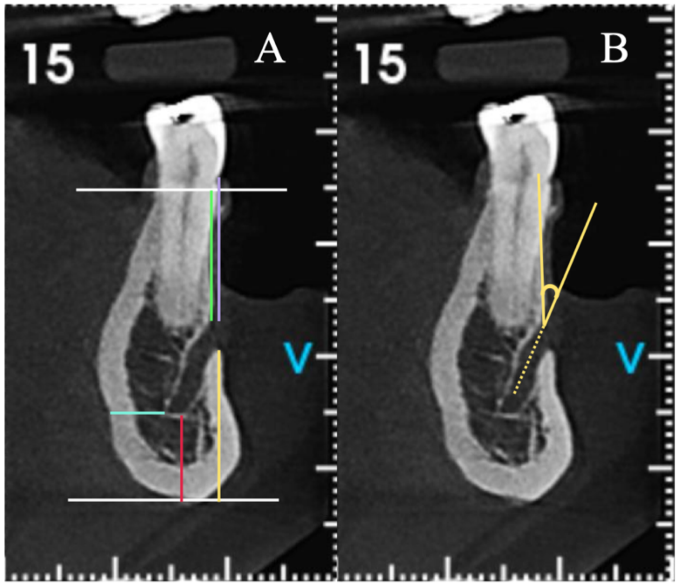

Figura 1. A) Reconstrução transversal evidenciando linhas: brancas (tangenciando a BM e a CA); verde (distância do ponto mais superior da abertura do FM à CA); azul (distância do ponto mais interno do FM à cortical óssea vestibular externa); amarelo (distância do ponto mais inferior da abertura do FM à BM); vermelho (distância do ponto mais inferior do FM à BM); roxo (distância do ponto mais superior da abertura do FM à JAC); B) medida do ângulo de emergência de acordo proposto por Von Arx et al., 2013.

Em cortes oblíquos do FM com distância de 1mm foram aferidos os diâmetros verticais e horizontais e a distância do FM ao ápice radicular do dente mais próximo. Foram marcados dois pontos tangenciando perpendicularmente o centro do FM identificado no corte axial e, desta forma, os cortes oblíquos de 10 mm de espessura foram obtidos. Em seguida, foi selecionado o corte em que o FM estivesse mais evidente para que as medidas lineares fossem realizadas (Figura 2 A-J).

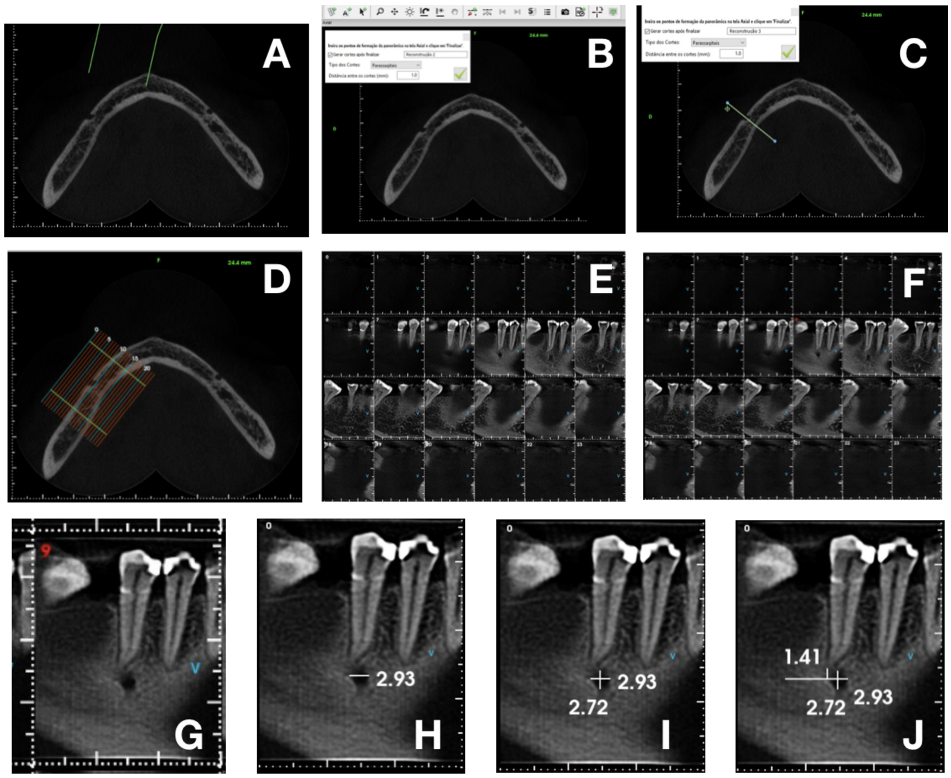

Figura 2. A – G: evidenciando a sequência de passos para a reconstrução e seleção do corte oblíquo do FM. H: medida linear do diâmetro horizontal. I: medida linear do diâmetro vertical. J: medida linear da distância do FM ao ápice do dente mais adjacente.

Loop anterior

O LA do FM foi avaliado segundo Von arx et al., (2013)[26]. O FM era identificado no plano axial e uma linha referência do plano sagital era posicionada adjacente à cortical vestibular, tangenciando o FM. Em seguida, no plano coronal, as linhas de referências eram posicionadas na base do FM e então era rotacionado o plano sagital paralelamente ao ângulo de abertura do FM para se investigar a presença ou não do LA (Figuras 3 A-C).

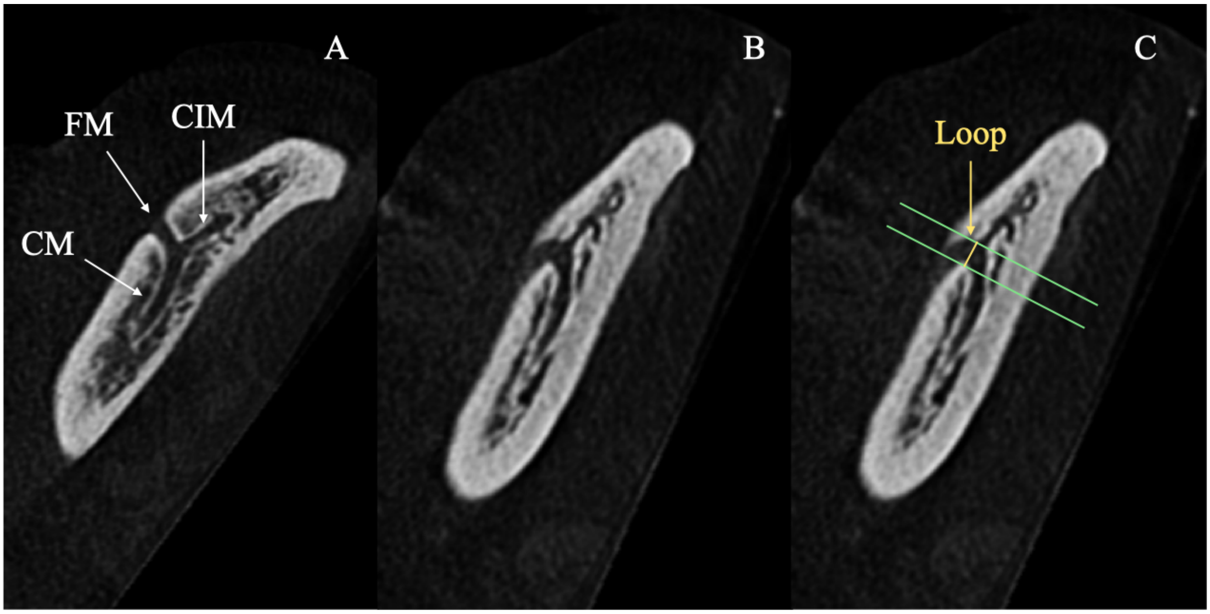

Figura 3. A – Ausência de LA com as estruturas anatômicas. B – Tomografia evidenciando a presença do LA. C – Metodologia adotada para a medição do comprimento do LA.

Caso fosse observada a presença do LA, uma linha tangenciando perpendicularmente o ponto mais anterior do FM era tracejada e, em seguida, foi inserida uma linha tangenciando o ponto mais anterior do LA (início do CIM). Posteriormente, era medida a distância entre essas duas linhas que corresponde ao comprimento do LA (Figura 3D).

Forame mentual acessório

Os volumes tridimensionais foram percorridos através das reconstruções nos três diferentes planos, com o objetivo de identificar eventuais forames acessórios. Os FMA foram classificados quanto à ausência/presença, diâmetro e distância do FMA ao FM. O FMA foi classificado quanto ao número, como 0 – ausente; 1 - presente; e quando presentes, o número de FMA encontrados de 1 a 4, de acordo com o estudo de do Carmo Oliveira et al., (2018)[27]. Após a identificação do forame acessório, foi medida a menor distância entre FMA e o FM em uma metodologia desenvolvida pelo autor.

Uma vez que o FMA foi visualizado (Figura 4A), aferiu-se a menor distância entre o FMA e o FM (Figura 4B). Para tanto, foi marcado o ponto mais anterior do FMA e mais próximo ao FM (Figura 4C), e o ponto mais posterior do FM e mais próximo à FMA (Figura 4D). Com isto, a medida era visualizada na reconstrução em 3D (Figura 4E).

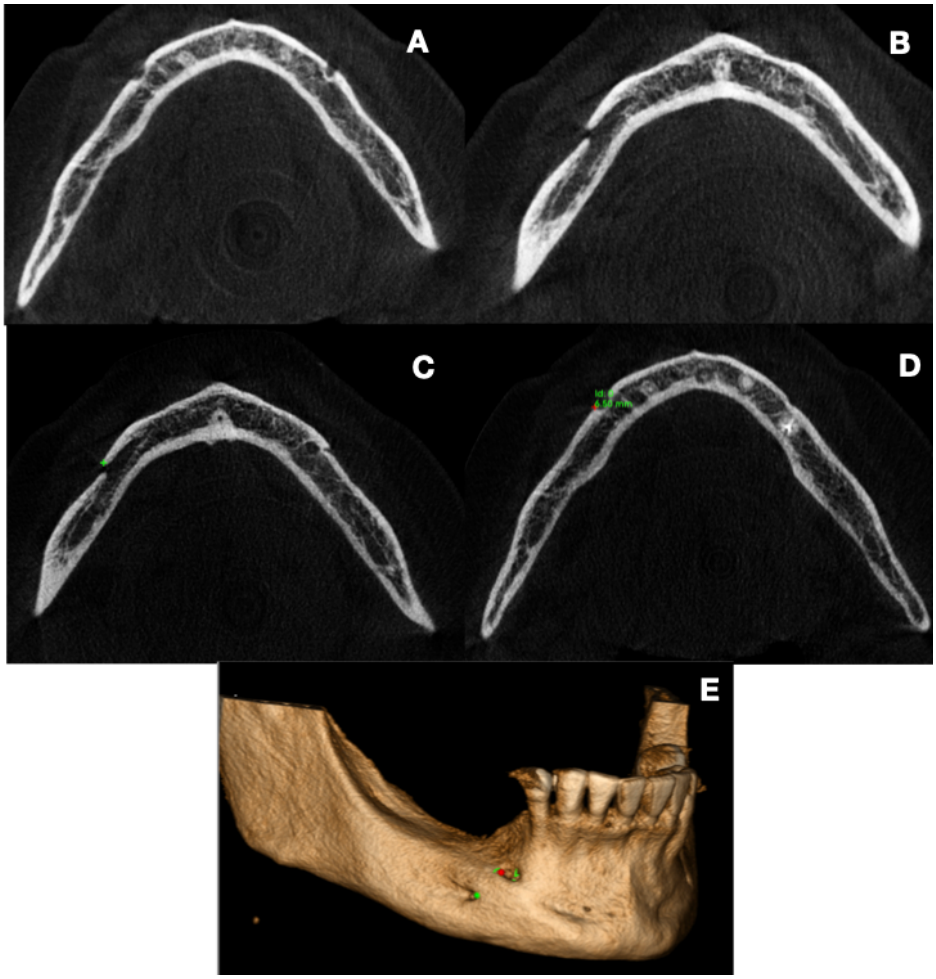

Figura 4. A - Presença do FM. B – Presença do FMA posterior ao FM. C - Marcação do ponto mais anterior do FMA. D - Marcação do ponto mais posterior do FM. E – Reconstrução em 3D mostrando os pontos marcados, em verde no FMA, em vermelho no FM.

A posição do FMA em relação ao FM foi classificada em de acordo com estudo de Yovchev et al., (2017)[28] em quatro possíveis situações: 1) disto-inferior (DI); 2) disto-superior (DS); 3) mésio-inferior (MI); 4) mésio-superior (MS). Ademais, foi registrada a lateralidade quanto à presença de forames adicionais, sendo classificada como unilateral ou bilateral.

Foramina Lingual

A FL foi identificada nos cortes parassagitais e após visualizada, era classificada quanto à presença ou ausência de FL superior (FLS) e FL inferior (FLI). Em seguida, as seguintes distâncias eram aferidas utilizando a função "medir comprimento 2D": 1) FLS à BM; 2) FLS à JAC; 3) FL superior à CA; 4) comprimento das FLS e FLI (Figura 5 A-D)[22].

Também foi aferida a distância do ponto terminal da FL até a cortical óssea vestibular de acordo com o estudo Sheikhi et al., (2012)[29] (Figura 5E). O diâmetro da FL foi obtido na região vestibular e lingual conforme Bernardi et al., 2014 (Figura 5 F-G) Em adição, foi aferida a distância da FL ao ápice do dente mais adjacente à estrutura (Figura 5H).

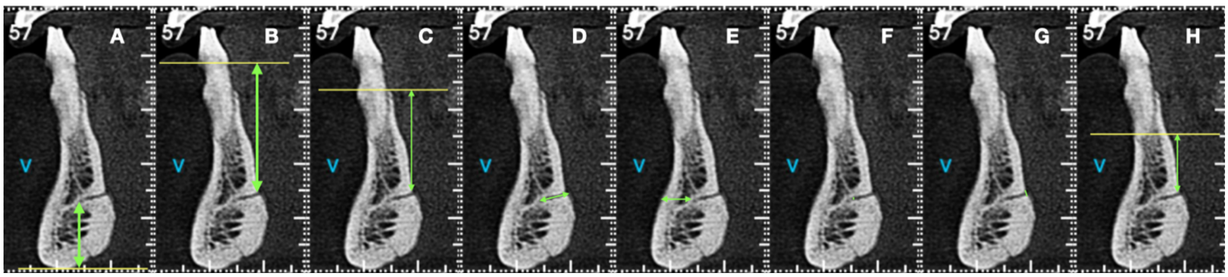

Figura 5. A) medida entre a FL e a borda inferior da mandíbula; B) medida entre a FLS e a JAC; C) medida entre a FLS e a CA que será considerada para este estudo; D) mensuração do comprimento do canal lingual; E) mensuração do ponto terminal da FL até a cortical óssea vestibular. F) diâmetro da FL na região vestibular; G) diâmetro da FL na região lingual; H) distância da FL ao ápice do dente adjacente.

Calibração e erro do estudo

O examinador foi submetido, previamente ao início de coletas de dados, a teste de calibração intra-examinador através de avaliação de 30 imagens com um intervalo de 15 dias no qual foram selecionadas aleatoriamente os exames tomográficos. Para avaliar erros de reprodutibilidade, foram realizadas as seguintes análises: (1) coeficiente de correlação intraclasse (CCI) para avaliar erros sistemáticos referentes aos dados numéricos sendo considerados valores até 0,5, como pobre discordância, entre 0,5 e 0,75 moderada, entre 0,75 e 0,9 boa e acima 0,9 é considerado excelente[24]; (2) fórmula de Dahlberg para avaliar erros casuais das medições realizadas. Em relação ao CCI, foi utilizado o modelo CCI, de efeitos aleatórios bidirecionais e com intervalo de confiança de 95%, considerando-se satisfatórios os valores com $p<0,05$. Para avaliar os possíveis erros técnicos de método, foi utilizada a fórmula de Dahlberg[30].

Estimativa de risco

Além disso, foi calculado o risco estimado de injúria às estruturas anatômicas avaliadas no presente trabalho em relação a margens de segurança na região interforaminal para procedimentos cirúrgicos orais de acordo com as seguintes técnicas:

1 - Remoção de enxerto livre na região da sínfise mandibular: A) distância anterior ao forame mentual: 5mm[1,8]; B) profundidade do enxerto ósseo: 5mm[8] e 4mm[1]; C) distância abaixo dos ápices dentários adjacentes: 5mm[8] e 8mm[1].

2 – Técnicas de osteotomias horizontais para genioplastia: A) Mini *Wing*: 3mm abaixo do FM[3]; B) *Chin Wing* :1cm anterior ao FM[4]; C) Genioplastia estética: 6mm abaixo do FM[5]; D) Genioplastia por deslizamento: 5mm abaixo do FM e 5mm abaixo dos ápices dos incisivos inferiores[6]; *Wedge osteotomy*: 5mm abaixo do FM[7].

3 – Inserção de implantes dentários em região próxima ao FM: A) distância da porção mais distal do implante até a porção mais anterior do LA do FM: 5mm[31] e 6mm[9].

Análise estatística

Os dados foram tabulados no Microsoft Excel e exportados para o *software Statistical Package for the Social Sciences* (SPSS) versão 20,0 para Windows adotando uma confiança de 95%. As características dos FM, FMA, LA e FL foram expressos em forma de frequência absoluta e percentual e analisados pelo teste qui-quadrado de Pearson. As medidas quantitativas foram expressas em forma de média e desvio padrão, submetidas ao teste de normalidade de Kolmogorov-Smirnov e analisadas pelos testes de Mann-Whitney, Wilcoxon e correlação de Spearman (dados não paramétricos).

RESULTADOS

Um total de 250 imagens foram avaliadas sendo 150 do sexo feminino e 100 do sexo masculino. A idade média dos pacientes foi 47,44±12,57 anos, sem diferença entre os sexos (p=0,434) e a maioria dos pacientes apresentando menos de 50 anos em ambos os grupos (p=0,408). Do lado direito a posição horizontal do FM mais prevalente foi a 4 (n=124, 49,6%) e a vertical a posição 3 (n=229, 91,6%). O formato mais prevalente foi o oval (n=155, 62,0%) e o dente associado foi o segundo pré-molar (n=166, 66,4%). Do lado esquerdo, FM estava localizado na posição horizontal 4 em 50,8% dos casos (n=127) e quanto à posição vertical, a mais prevalente foi a 3 (n=227, 90,8%). O formato mais prevalente foi o oval (n=165, 66,0%) e o dente mais próximo ao FM foi o segundo pré-molar (n=164, 65,6%) (Tabela 1).

Forame Mentual

Foi observada uma prevalência de 100% do FM nas tomografias avaliadas. A distâncias média do FM à CA foi de 11,66±2,40mm e para a BM de 9,39±1,14mm. O ápice do dente mais próximo ao

FM estava a uma distância média de 4,76±1,48mm, sendo o segundo pré-molar o dente mais frequentemente associado (67,2%) (Tabela 2). Os homens apresentaram maior distância média do FM à JAC (p=0,035), abertura do FM até a base da mandíbula (p=0,039) e ângulo de emergência (p=0,037).

Forame Mentual Acessório

A prevalência total do FMA foi de 7,2% (n=18) dos casos, sendo 13 (n=5,2%) indivíduos do sexo feminino e 5 (n=2%) masculino. Em um caso foi observada a presença do FMA bilateralmente e não houve nenhum caso de dois FMA em um mesmo lado. Quanto à lateralidade foi observado a presença de FMA em 10 casos (4,0%) no lado direito e 8 (n=3,2%) do lado esquerdo. Em relação à posição dos FMA observados, as posições mais prevalentes no lado direito foram MI, MS e DI (n=3, 33,3%) e no lado esquerdo a MS (n=37,5%) (Tabela 1). A distância média do FMA para o FM foi de 4,68mm, do diâmetro horizontal foi de 1,15mm e do diâmetro vertical de 1,0mm no lado direito, enquanto do lado esquerdo essas médias foram de 4,67mm, 0,97mm e 0,9mm, respectivamente.

Loop Anterior do FM

A prevalência do LA foi de 45,8% (n=229) em pelo menos um dos lados, sendo em observado o LA em 45,2% das tomografias no lado direito e 46,4% no lado esquerdo. Quanto à lateralidade, os casos bilaterais foram mais prevalentes que os unilaterais, sendo observados em 72% (n=96) dos indivíduos que apresentaram LA. O lado esquerdo foi mais prevalente (15,7%, n=21) que o lado direito (12,0%, n=16) nos casos unilaterais. O comprimento do LA variou de 0,4 a 3,72mm, sendo o comprimento médio 2,18±0,49mm e não houve diferença estatisticamente significante entre os lados direito e esquerdo, bem como entre os sexos.

Foramina Lingual

Com relação à FL (Tabela 1), foi observada uma prevalência de pelo menos uma em 94,4% dos casos (n=235) e uma segunda foramina estava presente em 77 (31,0%) indivíduos. A distância média da FLS ao ápice do dente adjacente foi de 6,83mm, sendo nos homens de 7,00mm e nas mulheres 6,72mm. A distância média da FLS à cortical óssea vestibular foi de 5,85mm, sendo ligeiramente maior nos homens (6,00mm) quando comparado com as mulheres (5,75mm) (Tabela 3).

As medidas lineares da FLS foram todas maiores nos homens quando comparado às mulheres, entretanto houve diferença estatisticamente significativa apenas na distância da FLS à JAC (p=0,042), no diâmetro inicial ($p<0,001$) e no diâmetro final (p=0,001) (Tabela 4). A distância média da FLI à CA foi de 25,28±8,67mm e até a BM foi de 4,31±1,96mm, sendo que nenhuma medida da FLI mostrou diferença entre os sexos (Tabela 3).

Reprodutibilidade do método

Em relação às medições lineares, observou-se uma reprodutibilidade e confiabilidade do método significante para todas as medidas, variando de satisfatório (r=0,772) a muito satisfatório (r=0,998). Em adição, a avalição quanto ao erro técnico de medição para as distâncias lineares foram aceitáveis e não excederam 0,5 mm para quaisquer dessas variáveis.

Estimativa de risco cirúrgico

O risco estimado para acometimento do FM durante técnica de genioplastia foi consideravelmente baixo. A maior parte dos pacientes (n=151, 30,2%) apresentaram uma distância de 8mm entre a BM e o FM, e apenas 7 pacientes tinham distância até 5mm (1,4%). Quando considerado a técnica *aesthetic genioplasty*[5] apenas 7 pacientes tinham distância abaixo do FM até 6mm (Tabela 4).

Para a profundidade de enxerto ósseo de mento a maior parte dos pacientes apresentou a distância da cortical vestibular à FL de 6mm (n=51, 20,4%). Considerando risco de cometimento de estruturas anatômicas adotado por Hunt and Jovanovic[8] de 5mm, 138 (55,2%) pacientes tinham essa medida dentro da faixa de risco, mas adotando a faixa de risco de Pommer[1] de 4mm, apenas 72 (34,6%) estavam dentro do risco de acometimento dessas estruturas (Tabela 4).

Considerando a distância do ápice dental adjacente à FL, a maior parte dos pacientes (n=50, 24,0%) apresentaram uma distância de 7mm. Considerando o ponto de risco adotado por Hunt and Jovanovic[8] de 5mm, 72 (28,1%) pacientes tinham essa medida dentro da faixa de risco, mas adotando a faixa de risco de Pommer[1] de 8mm, apenas 178 (85,6%) estavam dentro do risco de acometimento dessas estruturas (Tabela 4).

Já a distância entre a porção mais distal estimada de um implante dentário até a porção mais anterior do LA mostrou três distâncias possíveis, das quais a distância de 2mm foi a mais prevalente (n=86, 64,2%), tanto considerando a média dos lados direito e esquerdo como considerando os forames independentemente (n=138, 55,9%) (Tabela 4).

Nenhum desses riscos mostrou diferença entre sexo (material suplementar 2) ou idade (material suplementar 3).

DISCUSSÃO

Forame mentual

A prevalência de FM neste estudo foi de 100%, embora alguns estudos que utilizaram a TCFC para avaliar esta estrutura encontrem a ausência em alguns indivíduos[32]. Em relação à posição horizontal o FM estava localizado mais frequentemente na linha do segundo pré-molar tanto do lado direito (49,6%) quanto do lado esquerdo (50,8%). Este achado corrobora com Khojastepour et al., (2015)[13] que encontrou 48,7% e 51,9% dos casos do FM na posição 4 nos lados direito e esquerdo, respectivamente. Krishnan et al., (2018)[33] encontrou 34,3% dos casos na posição 4 e 43,5% na posição 3 e do Carmo Oliveira et al., (2018)[26] reportou 44,4% dos casos na posição 3 e 40,8% na posição 4.

O FM localizado a frente do primeiro pré-molar e na linha do primeiro molar inferior pode ser considerado um achado incomum, visto que a maior porcentagem de P6 já relatada foi por Cabanillas Padilla et al (2014)[34] de 9,4% e na posição 1 foi de 0,5%[23,35]. Neste estudo a posição 1 do FM foi encontrada em 0,4% dos casos.

Em relação à posição horizontal, o FM estava localizado abaixo do ápice do dente adjacente em 91,2% dos casos, corroborando com o estudo de Alam et al., (2017)[23] que encontrou 93,3% de FM na posição 3, 5,2% na posição 2 e 0,9% na posição 1. A proximidade do FM com o ápice dos dentes deve sempre ser identificada pelo fato de mimetizarem em muitas situações lesões periapicais, sobretudo em exame bidimensionais e esta relação foi encontrada em 8,8% dos casos neste estudo. De acordo com Von Arx et al., (2013)[26] a distância média entre o FM e o ápice radicular de foi 5mm (0,3-9,8mm), e neste estudo foi de 4,67±2,10mm do lado esquerdo e 4,83±1,89mm do lado direito.

O formato do FM mais prevalente foi o oval com 64% dos casos, seguido do redondo com 35% e o formato irregular foi observado em apenas 5 lados (1%). Este achado se assemelha ao reportado por Muinelo-lorenzo et al., (2015)[36] com 73,1% de FM oval e 26,9% redondos, em contraste com o estudo de Alam et al., (2018)[23] que reportou 72,6% dos indivíduos com formato redondo. Krishnan et al., (2018)[33] reportou os formatos oval e redondo com 52,3% e 47,7%, respectivamente.

Neste estudo, o diâmetro horizontal foi maior que o diâmetro horizontal com médias de 3,98mm e 3,33mm, o que explica o formato oval ter sido mais prevalente neste estudo, e corrobora com Krishnan et al., (2018)[32] que encontrou uma média de 3,1mm de diâmetro horizontal e 2,84mm do vertical e com Von Arx et al., (2013)[25] com 3,2mm e 3,0mm, respectivamente.

A TCFC é a modalidade imaginológica indicada para avaliar a distância entre o FM e a cortical óssea alveolar para seleção do comprimento do implante e, neste estudo foi encontrada uma distância média de 11,66mm, semelhante ao reportado por Muinelo-lorenzo et al., (2015)[36] que relatou 11,42mm na média, Çaglayan et al., (2014)[25] encontrou 12,01mm e Von Arx et al., (2013)[26] 12,6mm. As maiores médias foram registradas por Gungor et al., (2017)[37] de 14,03mm nos homens, com diferença estatística quando comparado com as mulheres 12,53mm, e Cabanillas-Padillas et al., (2014)[34] de 15,1mm no lado direito e 14,9mm no lado esquerdo. Tal fato reforça a necessidade de se realizar a TCFC no planejamento de colocação de implantes, ao passo que demonstra que há uma tendência de uma maior distância entre o FM e a CA nos homens, o que consequentemente favorece a utilização de implantes mais compridos nos homens.

Em casos de indivíduos com reabsorções ósseas severas ou mandíbulas atróficas, pode-se lançar mão da técnica de colocação implantes dentários com inclinação para lingual na região do FM, e assim ficando posicionado entre o FM e a cortical óssea lingual, neste estudo foi encontrada a distância FM-CL de 0,91mm, o que evidencia que esta técnica deve ser aplicada a partir de planejamento individual. Soma-se a isto, que na região do FM, na face interna da mandíbula comumente está alojada a glândula submandibular na fossa submandibular e que foi observado no estudo de Parnia et al., (2010)[38] no qual foi avaliado a profundidade da fóvea que 28% dos indivíduos apresentam uma concavidade do tipo 3, ou seja, maior que 3mm, provocando uma constricção da espessura da mandíbula.

Do ponto de vista anestésico, a inserção da agulha para o bloqueio do nervo mentoniano deve ser realizado de cima para baixo[39], portanto o ângulo de emergência do FM maior que 45º facilita a anestesia. Von arx et al., (2013)[26] avaliaram o ângulo de emergência do FM tendo encontrado uma média de 46,8º, o que indica que o FM emerge mais comumente com uma inclinação ínfero-superior. Este estudo encontrou uma média de 54,4º no lado direito e 56,75º no lado esquerdo. Ambos os estudos reportaram uma angulação menor que 90º em todos os indivíduos, portanto o FM emerge de baixo para cima.

As cirurgias endodônticas envolvendo os pré-molares inferiores devem ser planejadas considerando a distância do FM ao ápice do dente, pois são procedimentos invasivos e existe um risco dano neurovascular[40] relatou uma distância média de 5±1,4mm e neste estudo foi encontrada uma distância média de 4,83mm no lado direito e 4,67mm no lado esquerdo, semelhante ao reportado por Von Arx., et al (2013)[26] que mostrou uma distância média de 5mm, sendo que em 47% dos casos, o FM estava distante do ápice mais de 5mm. Entretanto 2 FM neste estudo estava localizados criticamente próximos ao ápice dentário numa distância menor que 1mm, tal fato foi reportado por Von Arx et al.,[25] em 3 casos.

Loop Anterior

O LA trata-se de uma curva do canal mandibular antes de emergir para o FM por onde irá sair o nervo mentoniano, responsável pela inervação sensorial dos dentes e tecidos moles na região anterior da mandíbula. Esta estrutura pode ser observada em radiografias panorâmicas, entretanto a sua visualização é significativamente menor quando comparada às tomografias computadorizadas[44]. Eskenazi e colaboradores em 2014[41] comparam a prevalência do LA em radiografias panorâmicas e TCFC, e o LA foi visualizado em 36,6% das RP e em 48,8% das tomografias avaliadas.

O presente estudo visualizou o LA em 45,8% dos casos em pelo menos um lado mandíbula utilizando a metodologia adotada por Von Arx., et al[26] que reportou em sua pesquisa uma prevalência de 70,1%. Do Couto et.,[42] reportou em uma população brasileira uma prevalência de 29,8% em TCFC, enquanto Brito et al.,[43] encontrou o LA em 7,7% de uma amostra com 90 tomografias. Portanto devido a esta variabilidade da visualização do LA, ressalta-se a importância clínica em identificar esta variação no planejamento de intervenções cirúrgicas na região do FM, em especial na colocação de implantes.

Tal fato está diretamente associado ao comprimento LA, uma vez que a área imediatamente a frente do FM passa a não ser segura para procedimentos invasivos quando o LA está presente. Este estudo reportou um comprimento médio de 2,18mm, sendo este valor semelhante ao reportado por Von Arx et al.,[26] de 2,3mm utilizando a mesma metodologia de medição. Recentemente, Wei e colaboradores[44] avaliando uma população chinesa reportaram uma média do comprimento do LA de 3,1mm no lado esquerdo e 3,4mm no lado direito, com um comprimento máximo de 7,3mm. Von Arx et al.,[26] por sua vez afirmou que o LA maior do que 4mm é uma condição rara, tendo reportado este achado em apenas 7 casos de um total de 117 tomografias que apresentaram o LA. O comprimento máximo encontrado neste estudo foi de 3,72mm, sendo este valor semelhante ao reportado por Eren at al.,[45] de 3,3mm em uma população turca e por Nascimento et al.,[46] que avaliou 250 tomografias de indivíduos brasileiros e encontrou um comprimento máximo de 4,0mm com média de 1,1mm.

Forame mentual acessório

A prevalência de FMA é muito variada a depender da população estudada, tendo sido reportada variando de 2,53%[23] até 39,44%[34]. Foi encontrada uma prevalência de 7,2% neste estudo, corroborando com outras populações brasileiras investigadas de acordo com Neves et al., (2013)[47] que encontrou 7,0%

e Vieira et al., (2018)[48] 7,9%, em contraste com os estudos de Imada et al., (2012)[49] que encontrou 3,0% e Leite et al., (2013)[50] com 3,2%. Estes achados sugerem a localização geográfica dentro de um mesmo país pode influenciar a prevalência do AMF.

Em relação à discrepância observada no estudo de Cabanillas-Padilha et al., (2014)[34] que encontrou 39,44% de FMA em uma amostra com 180 indivíduos, devem ter sido consideradas foraminas presentes em áreas sem comunicação com o CM, ou sem continuidade com o CIM que é uma continuidade intraóssea do CM na região anterior da mandíbula o que de acordo com do Carmo Oliveira et al (2018)[27] e Aytugar et al., (2019)[51] não são descritos como FMA, e este critério também foi adotado neste estudo. Yoon et al., (2019)[52] no Peru, Aytugar et al., (2019)[51] na Turquia, Krishnan et al., (2018)[33] na Índia, Muinelo-Lorenzo et al., (2015)[36] na Espanha, Kakatami et al., (2008)[53] no Japão, Wei et al.,[44] (2019) na China encontraram o FMA entre 10,45% e 13,08%. Com isto, quando comparado com outras populações mundiais, os brasileiros aparentemente, possuem uma menor prevalência do FMA.

Alguns estudos sugerem que o sexo tenha influência na prevalência do FMA como demonstrado por Han et al., (2016)[54] e Li et al., (2017)[55] que encontraram diferença estatisticamente significante entre os sexos, sendo mais frequente nos homens. No presente estudo houve uma maior prevalência de FMA em mulheres quando comparado aos homens sem diferença estatisticamente significante, este dado é conflitante com o estudo de Aytugar et al., (2019)[51] e Lam et al., (2019)[56] que reportaram maior ocorrência nos homens mas também sem diferença estatisticamente significante.

Os FMA podem estar presentes em um lado apenas ou em ambos, neste estudo foi observado uma maioria ampla de casos unilaterais com a presença de apenas um caso bilateral, representando um caso (6,25%) em 16 indivíduos, sendo 0,4% da amostra total. Um achado semelhante foi observado por Lam et al (2019)[56] no qual foi observado o FMA em 0,4% dos indivíduos. Alguns estudos não evidenciaram a ocorrência de FMA bilateralmente[36,50,52,57].

O FMA apresenta uma comunicação com o CM e, portanto, dele emergem vasos e nervos acessórios que vascularizam e inervam os dentes adjacentes. Clinicamente, deve-se ter atenção para a visualização do FMA, especialmente quando está presente mais de um FMA, de acordo com Cabanillas-Padilha et al., (2014)[34] pode-se encontrar até 4 FMA, tendo sido observado em seu estudo em 0,3% dos indivíduos. Aytugar et al., (2019)[51] observou a presença de 3 FMA em 0,6% dos indivíduos e Cabanillas-Padilha et., (2014)[34] em 2,2%, portanto a ocorrência de três ou mais FMA pode ser considerado raro.

Outro aspecto importante referente ao FMA além do número é a sua localização, pois dependendo da sua posição há um risco maior ou menor de ser injuriado em procedimentos invasivos. A classificação da posição do FMA proposta Goregen et al.,[58] e Zmyslowska-Polakowska et al. (2017)[57] descreveu em duas situações possíveis, sendo estas anterior e posterior, no qual reportaram 54,6% e 28,6% dos casos localizados anteriormente ao FM e 45,5% e 71,4% posteriormente ao FM, respectivamente.

Atualmente, a maioria dos estudos que classifica a posição do AMF na direção ântero-posterior, bem como ínfero-superior a qual foi adotada neste estudo. De acordo com Kalender et al., (2011)[40] a posição mais prevalente foi a ântero-inferior (33%) seguido de inferior, superior e póstero-superior (16,6%) e Aytugar et al., (2019)[51] reportou a posição póstero-inferior com maior prevalência em 35% dos casos. Estudando uma população da Bulgária, Youvchev et al., (2017)[28] encontrou a posição DI mais prevalente (62,9%), seguido da posição DS (22,6%), MS (12,9%) e MI (1,6%).

Este estudo mostrou o FMA presente mésio-superiormente ao FM em 33,3% dos casos corroborando com os achados Imada et al., (2012)[49] também em uma população brasileira que reportou dois (n=50%) casos logo acima do FM e os outros dois (n=50%) casos anteriores ao FM. Han et al., (2016)[54] encontrou o FMA na posição mésio-superior em 39,2% dos casos, sendo um achado semelhante ao presente estudo. Krishnan et al., (2018)[33] reportou as posições mésio-superior e mésio-inferior em 21,4% dos casos.

As localizações anteriores do FMA apresentam grande importância clínica em virtude de a região entre os FM ser uma área de colocação de implantes dentários bastante utilizada, e por ser considerada uma excelente zona doadora de enxerto ósseo[14,50]. Injúrias provocadas no FMA podem provocar hemorragias trans- e pós-operatórias, bem como distúrbios neurossensoriais[14]. Em 2008 Pommer[1] descreveu que, cerca de 57% dos casos em que a técnica clássica de coleta de enxerto óssea na região interforaminal tenham provocado injúria no canal incisivo mandibular, entretanto a possibilidade da existência de FMA localizados anteriormente ao FM deve ser sempre considerada[50].

O bloqueio anestésico do nervo mentoniano tem como ponto de referência o FM, por onde emerge o nervo mentoniano para inervar a região anterior da mandíbula através dos seus três ramos: dentais, gengivais e labiais. A presença do FMA por onde emergem nervos acessórios supre neurovascularmente a região adjacente, portanto tem influência no bloqueio anestésico nesta área caso a solução anestésica não atinja o FM[59].

Aytugar et al., (2019)[51] mostraram em seu estudo uma distância do FMA até o FM de 3,22mm nos homens e 3,05mm nas mulheres. Este estudo encontrou do lado direito uma média de 4,68mm e no lado esquerdo de 4,53mm sem diferença estatisticamente significante entre os lados, bem como não houve diferença entre os sexos. Wei et al., (2019)[44] e Li et al. (2017)[55] reportaram em seu estudos a distância do FMA-FA de 5,1 ±1,4 mm e 5,32±1,55mm, respectivamente, em populações chinesas, Zmyslowska-Polakowska et al., (2017)[57] observou em indivíduos poloneses esta distância sendo de 2,86 ±1,34mm. Kalender et al., (2011)[40] avaliando uma população turca encontrou uma distância FM-FMA maior que os outros citados anteriormente sendo de 6,6±4,2mm. Estes achados sugerem que a etnia pode ter alguma influência na distância do FMA-FM.

Os diâmetros do FMA foram menores que os diâmetros do FM, sendo a média o vertical do lado direito 1,00±0,42mm e do lado esquerdo 0,90±0,40. Aytugar et al., 2019[51] reportou esta medida com média de 1,36±0,54 mm e Li et al.,[55] 1,23±0,37mm. Em relação ao diâmetro horizontal no lado esquerdo foi menor (0.97±0.41) quando comparada ao lado direito (1,15±0,44) sem diferença estatisticamente significante. Li et al.,[55] mostrou no seu estudo uma média de diâmetro horizontal 1,38±0,47mm. Portanto, tem sido demonstrado que o FMA apresenta menores dimensões quando comparado ao FM em vários estudos.

Foramina Lingual

A FL abriga no interior do seu canal ramificações de vasos oriundos das artérias sublinguais e submentuais e tem sido descrito na literatura casos relacionados a eventos hemorrágicos após a injúria da FL durante procedimentos cirúrgicos invasivos na região anterior da mandíbula, como colocação de implantes dentários[60].

A prevalência da FL pode ser considerada alta em diferentes populações mundiais observadas em estudos que avaliaram essa estrutura utilizando TCFC. Aoun et al.,[22] avaliou indivíduos libaneses e encontrou a prevalência de pelo menos uma FL em 93,3% dos casos, Gillis et al.,[61] na Bélgica e Laçin et al.,[62] na Turquia reportaram pelo menos uma FL em 100% dos exames avaliados. Oliveira et al., (2018)[63] mostrou uma prevalência em uma população brasileira de 97% e este encontrou pelo menos uma FL em 94,4% das tomografias. Xie et al., (2019)[64] na China, Wang et al., (2015)[67] no Taiwan e Serkerci et al.,[66] na Turquia 90,9%, 97% e 98,2%, respectivamente. Palma et al., (2016)[67] estudando uma população brasileira reportou 100% de prevalência de canais, entretanto foram considerados canais linguais que não estavam localizados na linha média, o que não caracteriza a foramina lingual medial e adotada neste estudo definida por Aoun et al., (2017)[22].

Neste estudo foi encontrada apenas uma foramina, também chamada de FLS em 63,6% (n=159) dos indivíduos e em 30,8% (n=77) dos casos foram encontradas 2 FL. Clinicamente indivíduos que apresentam duas FLs podem apresentar sangramentos mais abundantes caso haja uma injúria dessas estruturas, sobretudo caso os implantes necessitem de uma inclinação mais para lingual aumentando o risco de injuriar tanto a FL presente com provocar perfuração da cortical óssea lingual e gerar hemorragias cujos danos podem causas comprometimento das vias aéreas com risco de vida para o indivíduo, principalmente porque a maioria desses procedimentos é realizada em ambiente ambulatorial (Mason et al., 1990)[68].

Os nossos resultados mostram que o trajeto do canal lingual superior apresenta um trajeto em direção superior conforme se direciona para a cortical óssea lingual onde desemboca na FL e possui a menor distância para a CA (15,63±3,11) e a maior distância para a cortical CA na porção intraóssea (25,28±8,67). Em situações clínicas de pacientes classe III, cujo planejamento inclui realizar compensação da inclinação dos implantes para vestibular, o risco de injuriar a FL aumenta, bem como de perfuração da cortical lingual. Além disso, mesmo em casos de cirurgias guiadas para a colocação de implantes, o controle da variação de angulação é dificultada sobretudo no sentido vestíbulo-lingual, este fato evidencia a importância de uma expertise técnica nestes procedimentos sobretudo em casos de guias parciais[69].

E embora um guia cirúrgico não possa ser usado, para os implantes únicos na região anterior em que o espaço edêntulo entre os dentes adjacentes é muito estreito para colocar um guia cirúrgico adequado, ou em uma área edêntula posterior onde, a abertura da boca é limitada, um protocolo de broca parcialmente guiada ou o uso de navegação dinâmica pode fornecer mais precisão do que a colocação de implante à mão livre ou um guia convencional, o que reduziria os riscos de inclinações para lingual e rompimento da cortical óssea lingual[70-72].

A prevalência de um ou dois canais é bastante variada nos estudos, Laçin et al.,[62] reportou achados semelhantes a este estudo com 66,28% dos indivíduos com apenas uma FL e 30,85% com duas, Xie et al., (2019)[64] encontrou uma FL em 66,8% dos casos e 21,9% com diferença estatisticamente significativa, e Denny et al., (2016)[73] mostrou que das FLs mediais em 69,2% dos casos havia apenas uma e em 28,4% foram encontradas duas.

Contrapondo esses achados Gilis et al.,[61] reportou 66% dos casos com duas FLs e uma FL em 26% dos indivíduos, e Zhang et al., (2018)[74] encontrou duas FLs em 46,5% das mandíbulas avaliadas. Não houve diferença estatisticamente significativa entre sexos neste estudo em relação à prevalência de uma ou duas FLs, corroborando com os achados de Aoun et al., (2017)[22] e Xie et al., (2019)[64]. O estudo de Laçin et al., (2016)[62] reportou que as mulheres apresentaram uma FL em 72,04% dos casos e os homens 59,75%, com diferença estatisticamente significativa entre os grupos.

A região anterior da mandíbula por ser uma área doadora de enxerto é submetida a procedimentos cirúrgicos que envolvem a face externa da mandíbula[14]. Pommer et al., descreveu em 2008[1] que deve-se respeitar uma profundidade de 4mm na região anterior durante a coleta de enxertos para diminuir o risco de injúria ao CIM. A presença da FL na região da linha média pode ser um fator a ser considerado dependendo da distância entre a FL e a cortical óssea vestibular. Neste estudo a distância média da FLS até a cortical vestibular foi de 5,85mm. Sheiki et al., (2012)[29] encontrou uma distância média de 4,91mm e Sanchez-perez et al., (2018)[75] de 4,73mm. Tais achados evidenciam que o proposto por Pommer et al., (2008)[1] também pode ser aplicado em relação ao risco de injúria da FL.

Algumas técnicas de reabilitação oral envolvendo as colocações de implantes sugerem em seus protocolos a inserção de implantes na região da linha média da mandíbula. De fato, a presença da FL, em especial da FLS, deve ser levada em consideração no planejamento da inserção de implantes nessa região em relação ao comprimento do implante selecionado. Foi observado neste estudo que a distância média foi de 15,63mm, não havendo diferença entre os sexos. Sekerci et al., (2014)[66] encontraram uma média de 12,04mm e Sanches-perez et al., (2015)[75] reportaram 11,04mm. Babiuc et al.,[76] Sheiki et al.,[29] Aoun et al.,[22] e He et al.,[77] mostraram em seus estudos 14,2mm, 14,39mm, 16,24mm e 16,82mm, respectivamente. A metodologia descrita por Sekerci et al.,[66] não foi clara de em quais pontos foram realizadas as medidas, o que talvez justifique essa diferença quando comparado aos outros estudos.

Estimativa de risco

Em virtude de a região anterior da mandíbula ser uma área frequentemente associada a procedimentos cirúrgicos invasivos, o presente trabalho realizou uma estimativa de risco de injúria das estruturas anatômicas avaliadas relacionadas a técnicas cirúrgicas nesta área (Tabela 4).

Jovanovic et al., 1999[8], preconizaram que para procedimentos de coleta de enxerto na região anterior da mandíbula fosse adotada a regra dos 5, ou seja, as distâncias consideradas seguras para esta técnica deveria manter uma distância de 5mm anterior ao FM, 5mm ao ápice dos dentes anteriores e uma profundidade de coleta de no máximo 5 mm para evitar lesar a FL. Posteriormente, Pommer em 2008 estabeleceu novas distâncias consideradas seguras, mantendo pelo menos 5mm até o FM, e diminuindo a profundidade do enxerto na região anterior para 4mm e aumentando a distância ao ápice dos dentes anteriores para 8 mm[1]. Baseado em nossos achados, a coleta de enxerto sendo limitada a uma distância mínima de 4mm até o FM sendo a média de 2,18, pode ser considerada suficientemente segura, uma vez que nenhum LA apresentou um comprimento maior que 4mm, e deve-se evitar aproximar-se do FM a uma distância inferior a esta (Tabela 4).

O planejamento de inserção de implantes dentários requer uma avaliação da espessura, altura e qualidade óssea, além da visualização de estruturas anatômicas importantes que possam estar presentes[77]. De fato, as reconstruções parassagitais são as imagens mais utilizadas pelos implantodontistas para esses planejamentos, embora em relação ao LA não sejam as melhores reconstruções para a avaliação da presença ou ausência do LA. Posto isto, uma visualização dinâmica do volume da TCFC deve ser realizada com o objetivo de identificar e mensurar o comprimento do LA durante o planejamento de reabilitação com implantes na região interforaminal.

O presente estudo encontrou uma prevalência de 45,8%, sendo o comprimento máximo de 3,72mm e portanto, recomenda-se evitar a inserção de implantes a uma distância de pelo menos 4mm do FM. Além disso, os protocolos de cirurgias guiadas mostram que há uma diminuição de desvio da colocação dos implantes no sentido ântero-posterior, variando de 5 a 6mm nos casos de guias totais e 3mm nos protocolos de guias parciais. Isto reforça a importância de se realizarem as cirurgias guiadas que podem ser consideradas como uma medida de diminuição de risco porque torna o procedimento mais previsível[69].

Ademais, estabelecimento da distância de 4mm para o FM recomendado pelo presente trabalho, leva em consideração os resultados reportados por Bencharit et al., (2018)[69] que mostrou que a experiência e treinamento do cirurgião são fatores importantes nas cirurgias guiadas, pois especialmente nos guias parciais a variação de inclinação dos implantes durante a colocação pode exceder 10º e nas guias parciais chegar a 5º. Além disso, a colocação de implantes com inclinação mesial não resulta em aumento de estresse e, portanto, é uma alternativa em áreas que tenham reabsorções ósseas e que a enxertia óssea leve a um aumento de risco cirúrgico, maior tempo de tratamento e desconforto para o paciente[78]. Nestes casos, a inclinação para mesial de implantes à frente do LA refletem em um maior risco de injúria desta estrutura.

Em relação à profundidade da coleta do enxerto, o maior risco na região interforaminal é o risco de injúria à FL, para tanto a distância da FL à cortical vestibular foi avaliada e profundidades maiores que 5mm aumentam sensivelmente as chances de atingir a FL, em contrapartida o presente estudo mostra que quando se limita a no 4mm de profundidade o risco gira em torno de 30,8%, desta forma evita-se intercorrências trans e pós-operatórias como hemorragias oriundas de danos a veias e artérias que percorrem os canais linguais. A morbidade mais comum envolvendo a coleta de enxerto autógeno na região sinfisária é a parestesia[79] variando de 30%[80] a 50%[81] imediatamente após o procedimento cirúrgico, e há uma redução da parestesia após um ano em parte dos indivíduos sendo reportados entre 7,4%[82] e 20%[81] permanecem com esse distúrbio neurossensorial.

A distância a ser preservada entre a coleta de enxerto e o ápice dos dentes adjacentes proposta por Pommer et al., (2008)[1] de até 8mm é considerada segura, apresentando um risco maior quando esta distância é inferior a 7mm, e os resultados encontrados no presente estudo demonstram um risco elevado a partir de 5mm. A hipersensibilidade pode ocorrer caso ostetotomias e coletas de enxertos sejam realizadas a uma distância mínima de 5mm do ápice dos dentes, embora esta morbidade costuma desaparecer até um ano do procedimento cirúrgico[83].

Outro procedimento bastante realizado na região sinfisária são as genioplastias. Existem diferentes técnicas descritas na literatura, em que basicamente o desenho da osteotomia pode apresentar variação, visto que o objetivo final é o mesmo. As técnicas apresentam em comum a recomendação de distâncias mínimas da osteotomia em relação ao FM. Seinfeldin et al., (2014)[6] e Costa et al., (2018)[7] descrevem que a osteotomia deve ser realizada 5mm abaixo do FM, Japatti et al., (2020)[5] descreve que deve ser 6mm abaixo do FM e Cordier et al., (2019)[3] com uma técnica chamada *"mini wing"* relata uma distância de 3mm. De acordo com os dados de estimativa de risco cirúrgico obtidos na presente pesquisa, recomenda-se preservar uma distância maior ou igual a 5mm é considerada segura para estas osteotomias, sendo que o desenho não apresenta relevância com relação ao risco de injuriar o FM. Esta mesma recomendação pode ser aplicada às técnicas de osteotomia para aumento de dimensão vertical da sínfise mandibular propostas por Lee et al., (2014)[84].

Limitações

A amostra utilizada é uma subpopulação de uma população do nordeste brasileiro, portanto não pode ser representativo da população brasileira. Além disso, não foi observado dimorfismo sexual nos reparos anatômicos avaliados. Portanto, sugere-se a realização de outros estudos em diferentes populações acerca dos reparos anatômicos avaliados no presente trabalho.

Conclusão

Em sumário, observou uma prevalência 7,2% do FMA, sendo observados em 5,2% de mulheres e 2% de homens. O LA anterior foi observado em 45,8% das tomografias, não havendo diferença entre os lados, e a FL estava presente em 94,4% dos casos, sendo que em 31% dos indivíduos apresentaram duas FL. A estimativa de risco cirúrgico na região anterior mostrou uma distância de 4mm anterior ao FM, uma profundidade de 4mm para coleta de enxertos e osteotomias para genioplastia com uma distância de pelo menos 5mm para o FM como referências relativamente seguras para procedimentos invasivos nesta área.

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Tabelas.

Tabela 1: Características da amostra e prevalência das estruturas anatômicas quanto aos lados direito e esquerdo.

	Lado		
	Direito	**Esquerdo**	**p-Valor**
FM - Posição Horizontal			
1	0	1 (0,4%)	0,407[b]
2	4 (1,6%)	6 (2,4%)	
3	78 (31,2%)	85 (34,0%)	
4	124 (49,6%)	127 (50,8%)	
5	44 (17,6%)	31 (12,4%)	
FM - posição vertical			
1	2 (0,8%)	4 (1,6%)	0,713[b]
2	19 (7,6%)	19 (7,6%)	
3	229 (91,6%)	227 (90,8%)	
FM - Formato			
Oval	155 (62,0%)	165 (66,0%)	0,065[b]
Redondo	90 (36,0%)	85 (34,0%)	
Irregular	5 (2,0%)	0	
FM – Distância ao dente			
43/33	3 (1,2%)	1 (0,4%)	0,6602[b]
44/34	72 (28,8%)	81 (32,4%)	
45/35	172 (68,8%)	164 (65,6%)	
46/36	3 (1,2%)	3 (1,2%)	
FMA - Prevalência			
0	240 (96,0%)	242 (96,8%)	0,518 [b]
1	10 (4,0%)	8 (3,2%)	
2	0 (0,0%)	0 (0,0%)	
FMA - Localização			
DS	1 (10,0%)	2 (25,0%)	0,785[b]
MI	3 (30,0%)	1 (12,5%)	
MS	3 (30,0%)	3 (37,5%)	
DI	3 (30,0%)	2 (25,0%)	
Loop Anterior			
Prevalência	113 (45,2%)	116 (46,4%)	0,132[b]

*p<0,05, [a]Teste de Mann-Whitney (média±DP); [b]Teste qui-quadrado de Pearson (n, %).

Legenda: FM: forame mentual; MS: mésio-superior; MI: mésio-inferior; DS: disto-superior; DI:disto-inferior; FMA: forame mentual acessório.

Tabela 2: Análise geral e entre os lados e a média±DP das medidas lineares em milímetros e angulares em graus do FM, FMA e LA.

	Medida média				Coeficiente de variação		
	Total	**Feminino**	**Masculino**	**p-Valor[a]**	**Feminino**	**Masculino**	**p-Valor[b]**
Média							
Distância do FM-CA	11,66±2,40	11,44±2,36	11,97±2,44	0,061	20,6%	20,4%	0,769
Distância do FM-JAC	14,71±2,68	14,47±2,77	15,06±2,50	***0,035***	19,1%	16,6%	0,510
Distância do FM-CL	4,18±1,28	4,12±1,22	4,27±1,36	0,439	29,7%	31,9%	0,601
Distância do FM-BM	9,39±1,14	9,34±1,12	9,47±1,17	0,434	12,0%	12,4%	0,374
Distância abertura do FM-BM	12,67±1,18	12,53±1,11	12,88±1,26	***0,039***	8,9%	9,8%	0,192
Ângulo emergência	55,61±9,01	56,54±9,03	54,21±8,84	***0,037***	16,0%	16,3%	0,541
Diâmetro vertical	3,33±0,68	3,32±0,69	3,36±0,66	0,652	20,7%	19,6%	0,417
Diâmetro horizontal	3,98±0,94	4,00±0,98	3,96±0,89	0,932	24,5%	22,4%	0,491
Distância do FM-ADA	4,76±1,48	4,71±1,36	4,83±1,65	0,860	29,0%	34,1%	0,059
FMA: distância FM-FMA	4,67±3,00	4,61±3,16	4,90±2,82	0,827	35,9%	33,2%	0,179
FMA: diâmetro vertical	0,95±0,40	0,95±0,43	0,94±0,36	0,615	45,5%	38,1%	0,163
FMA: diâmetro horizontal	1,06±0,43	1,05±0,41	1,07±0,46	0,708	39,3%	42,8%	0,158
Loop anterior	2,18±0,49	2,14±0,52	2,24±0,43	0,198	24,4%	19,3%	0,164

*$p<0,05$, [a]Teste de Mann-Whitney; [b]Teste de Levene (média ± DP)

Legenda: FM: forame mentual; JAC: junção amelo-cementária; CA: crista alveolar; CL: cortical lingual; BM: base da mandíbula; FMA: forame mentual acessório; ADA: Ápice do dente adjacente.

Tabela 3: Análise entre os lados e a média±DP das medidas lineares em milímetros ds FLS e FLI

	Medida média				Coeficiente de variação		
	Total	Feminino	Masculino	p-Valor[a]	Feminino	Masculino	p-Valor[b]
FL Superior							
Distância da FLS à CA	15,63±3,11	15,44±2,87	15,91±3,42	0,282	18,6%	21,5%	0,096
Distância da FLS à JAC	18,67±3,10	18,24±2,94	19,26±3,23	**0,042**	16,1%	16,8%	0,458
Distância da FLS à BM	11,61±2,36	11,49±2,50	11,78±2,16	0,444	21,7%	18,3%	0,224
Comprimento FL	6,35±2,46	6,27±2,46	6,47±2,48	0,448	39,2%	38,4%	0,787
Distância da FLS à CV	5,85±2,03	5,75±1,90	6,00±2,22	0,476	33,1%	36,9%	0,209
Distância da FLS ao ADA	6,83±2,79	6,72±2,84	7,00±2,73	0,616	42,3%	39,0%	0,530
Diâmetro inicial	0,76±0,30	0,71±0,30	0,85±0,29	**<0,001**	43,0%	33,5%	0,420
Diâmetro final	0,64±0,28	0,67±0,27	0,60±0,28	**0,011**	40,8%	46,3%	0,792
FL Inferior							
Distância da FLI à CA	25,28±8,67	25,81±11,04	24,71±5,08	0,720	42,8%	20,6%	0,588
Distância da FLI à JAC	27,41±3,84	26,87±3,53	28,03±4,15	0,330	13,1%	14,8%	0,069
Distância da FLI à BM	4,31±1,96	4,36±1,90	4,26±2,06	0,744	43,6%	48,4%	0,757
Comprimento FLI	5,67±1,75	5,79±1,50	5,54±2,03	0,925	25,9%	36,6%	0,014
Distância da FLI à CV	6,00±1,95	5,79±1,96	6,26±1,94	0,263	33,9%	31,0%	0,954
Distância da FLI ao ADA	15,12±2,84	14,76±2,38	15,55±3,32	0,240	16,1%	21,4%	0,016
Diâmetro inicial	0,53±0,14	0,51±0,13	0,56±0,15	0,130	25,5%	26,8%	0,603
Diâmetro final	0,59±0,18	0,56±0,13	0,62±0,22	0,214	23,2%	35,5%	0,002

*p<0,05, [a]Teste de Mann-Whitney; [b]Teste de Levene (média ± DP)

Legenda: FLS: foramina lingual superior; JAC: junção amelo-cementária; CA: crista alveolar; CV: cortical vestibular; BM: base da mandíbula; ADA: Ápice do dente adjacente.

Tabela 4: Risco estimado de injúria ao FM e FL em procedimentos cirúrgicos na região interforaminal

	n (%)	IC95%	
Técnicas de genioplastia *vs*, distância do FM-BM (5-13 mm)			
5	7 (1,4%)	0,4	2,4%
6	12 (2,4%)	1,1	3,7%
7	60 (12,0%)	9,2	14,8%
8	151 (30,2%)	26,2	34,2%
9	114 (22,8%)	19,1	26,5%
10	91 (18,2%)	14,8	21,6%
11	26 (5,2%)	3,3	7,1%
12	27 (5,4%)	3,4	7,4%
13	12 (2,4%)	1,1	3,7%
Técnicas de genioplastia			
Até 5	7 (1,4%)	0,4%	2,4%
5-6	10 (2,0%)	0,8%	3,2%
> 6	483 (96,6%)	95,0%	98,2%
Esthetic genioplasty (6 mm abaixo do FM)			
Até 6	7 (1,4%)	0,4%	2,4%
> 6	493 (98,6%)	97,6%	99,6%
Profundidade de enxerto ósseo de mento (1-13 mm) *vs*, distância da FL-CV			
1	5 (2,0%)	0,3	3,7%
2	22 (8,8%)	5,3	12,3%
3	38 (15,2%)	10,7	19,7%
4	27 (10,8%)	7,0	14,6%
5	46 (18,4%)	13,6	23,2%
6	51 (20,4%)	15,4	25,4%
7	40 (16,0%)	11,5	20,5%
8	10 (4,0%)	1,6	6,4%
9	1 (0,4%)	0,0	1,2%
10	5 (2,0%)	0,3	3,7%
11	5 (2,0%)	0,3	3,7%
Hunt, Jovanovic 1999 (5 mm)			

Até 5	138 (55,2%)	49,0	61,4%
> 5	112 (44,8%)	38,6	51,0%
Pommer et al,, 2008 (4 mm)			
Até 4	92 (36,8%)	30,8	42,8%
> 4	158 (63,2%)	57,2	69,2%
Limite inferior de enxerto ósseo de mento *vs*, distância da FL-BM			
Até 5 (Hunt, Jovanovic 1999)	72 (34,6%)	28,1%	41,1%
> 5 (Hunt, Jovanovic 1999)	136 (65,4%)	58,9%	71,9%
Distância da FL-ADA (1-12 mm)			
1	2 (1,0%)	0,0	2,3%
2	20 (9,6%)	5,6	13,6%
3	8 (3,8%)	1,2	6,5%
4	37 (17,8%)	12,6	23,0%
5	5 (2,4%)	0,3	4,5%
6	27 (13,0%)	8,4	17,5%
7	50 (24,0%)	18,2	29,8%
8	29 (13,9%)	9,2	18,6%
9	9 (4,3%)	1,6	7,1%
11	10 (4,8%)	1,9	7,7%
12	11 (5,3%)	2,2	8,3%
Hunt, Jovanovic 1999 (5 mm)			
Até 5	72 (34,6%)	28,1	41,1%
> 5	136 (65,4%)	58,9	71,9%
Pommer et al., 2008 (8 mm)			
Até 8	178 (85,6%)	80,8	90,4%
> 8	30 (14,4%)	9,6	19,2%
Porção mais distal do implante dentário até a porção mais anterior do loop (comprimento do loop anterior do FM –média dos lados)			
1	43 (32,1%)	24,2%	40,0%
2	86 (64,2%)	56,1%	72,3%
3	5 (3,7%)	0,5%	6,9%
Porção mais distal do implante dentário até a proção mais anterior do loop (comprimento do loop anterior do FM – por LOOP)			

1	96 (38,9%)	32,8%	44,9%
2	138 (55,9%)	49,7%	62,1%
3	13 (5,3%)	2,5%	8,0%

Legenda: CA: crista alveolar; CV: cortical vestibular; BM: base da mandíbula; ADA: Ápice do dente adjacente; FM:Forame mentual; FL: foramina lingual.

Material suplementar 1: Caracterização dos tomógrafos computadorizados de feixe cônico de acordo com os parâmetros de aquisição da imagem.

	i-CAT Next Generation	**i-CAT classic**
kVp	90-140kVp	90-140kVp
mA	5mA	8mA
FOV	8x8cm a 16x8cm	8x8cm a 16x8cm
Voxel	0,3mm 0,25mm	0,2mm 0,25mm

Material suplementar 2: Estimativa de risco de acordo com o sexo.

	Sexo						p-Valor
	Feminino	**IC95%**		**Masculino**	**IC95%**		
FM - distância do FM-BM							
5 mm	5 (1,7%)	0,2	3,1%	2 (1,0%)	0,0	2,4%	0,333
6 mm	7 (2,3%)	0,6	4,0%	5 (2,5%)	0,3	4,7%	
7 mm	36 (12,0%)	8,3	15,7%	24 (12,0%)	7,5	16,5%	
8 mm	97 (32,3%)	27,0	37,6%	54 (27,0%)	20,8	33,2%	
9 mm	67 (22,3%)	17,6	27,0%	47 (23,5%)	17,6	29,4%	
10 mm	56 (18,7%)	14,3	23,1%	35 (17,5%)	12,2	22,8%	
11 mm	9 (3,0%)	1,1	4,9%	17 (8,5%)	4,6	12,4%	
12 mm	15 (5,0%)	2,5	7,5%	12 (6,0%)	2,7	9,3%	
13 mm	8 (2,7%)	0,8	4,5%	4 (2,0%)	0,1	3,9%	
FL - distância FL-CV							
1 mm	4 (2,7%)	0,1	5,2%	1 (1,0%)	0,0	3,0%	0,100
2 mm	12 (8,0%)	3,7	12,3%	10 (10,0%)	4,1	15,9%	
3 mm	25 (16,7%)	10,7	22,6%	13 (13,0%)	6,4	19,6%	
4 mm	15 (10,0%)	5,2	14,8%	12 (12,0%)	5,6	18,4%	
5 mm	28 (18,7%)	12,4	24,9%	18 (18,0%)	10,5	25,5%	
6 mm	34 (22,7%)	16,0	29,4%	17 (17,0%)	9,6	24,4%	
7 mm	20 (13,3%)	7,9	18,8%	20 (20,0%)	12,2	27,8%	
8 mm	6 (4,0%)	0,9	7,1%	4 (4,0%)	0,2	7,8%	
9 mm	1 (0,7%)	0,0	2,0%	0 (0,0%)	0,0	0,0%	
10 mm	5 (3,3%)	0,5	6,2%	0 (0,0%)	0,0	0,0%	
11 mm	0 (0,0%)	0,0	0,0%	5 (5,0%)	0,7	9,3%	
5mm							
Até 5 mm	84 (56,0%)	48,1	63,9%	54 (54,0%)	44,2	63,8%	0,755
>5 mm	66 (44,0%)	36,1	51,9%	46 (46,0%)	36,2	55,8%	
4mm							
Até 4 mm	56 (37,3%)	29,6	45,1%	36 (36,0%)	26,6	45,4%	0,830
>4 mm	94 (62,7%)	54,9	70,4%	64 (64,0%)	54,6	73,4%	
FL - distância FL-ADA							
1 mm	2 (1,6%)	0,0	3,8%	0 (0,0%)	0,0	0,0%	0,238
2 mm	15 (12,0%)	6,3	17,7%	5 (6,0%)	0,9	11,1%	
3 mm	2 (1,6%)	0,0	3,8%	6 (7,2%)	1,7	12,8%	

4 mm	23 (18,4%)	11,6	25,2%	14 (16,9%)	8,8	24,9%	
5 mm	4 (3,2%)	0,1	6,3%	1 (1,2%)	0,0	3,6%	
6 mm	17 (13,6%)	7,6	19,6%	10 (12,0%)	5,0	19,1%	
7 mm	30 (24,0%)	16,5	31,5%	20 (24,1%)	14,9	33,3%	
8 mm	13 (10,4%)	5,0	15,8%	16 (19,3%)	10,8	27,8%	
9 mm	7 (5,6%)	1,6	9,6%	2 (2,4%)	0,0	5,7%	
11 mm	5 (4,0%)	0,6	7,4%	5 (6,0%)	0,9	11,1%	
12 mm	7 (5,6%)	1,6	9,6%	4 (4,8%)	0,2	9,4%	
5mm							
Até 5 mm	46 (36,8%)	28,3	45,3%	26 (31,3%)	21,3	41,3%	0,416
>5 mm	79 (63,2%)	54,7	71,7%	57 (68,7%)	58,7	78,7%	
8mm							
Até 8 mm	106 (84,8%)	78,5	91,1%	72 (86,7%)	79,5	94,0%	
>8 mm	19 (15,2%)	8,9	21,5%	11 (13,3%)	6,0	20,5%	
FL – distância FL-BM							
Até 5 mm	46 (36,8%)	28,3%	45,3%	26 (31,3%)	21,3%	41,3%	0,416
> 5 mm	79 (63,2%)	54,7%	71,7%	57 (68,7%)	58,7%	78,7%	
Comprimento do LA – Média dos lados							
1	27 (35,1%)	24,4%	45,7%	16 (28,1%)	16,4%	39,7%	0,673
2	47 (61,0%)	50,1%	71,9%	39 (68,4%)	56,4%	80,5%	
3	3 (3,9%)	0,0%	8,2%	2 (3,5%)	0,0%	8,3%	
Comprimento do LA– Por loop							
1	63 (45,3%)	37,0%	53,6%	33 (30,6%)	21,9%	39,2%	0,053
2	68 (48,9%)	40,6%	57,2%	70 (64,8%)	55,8%	73,8%	
3	8 (5,8%)	1,9%	9,6%	5 (4,6%)	0,7%	8,6%	

*p<0.05, teste qui-quadrado de Pearson.

Legenda: CA: crista alveolar; CV: cortical vestibular; BM: base da mandíbula; ADA: Ápice do dente adjacente; FM:Forame mentual; FL: foramina lingual.

Material suplementar 2:Estimativa de risco de acordo com grupos etários.

	Idade										
	20-30	**IC95%**		**31-40**	**IC95%**		**41-50**	**IC95%**		**51-60**	**IC95**
FM – distância FM-BM											
5 mm	2 (4,2%)	0,0	9,8%	0 (0,0%)	0,0	0,0%	2 (1,9%)	0,0	4,4%	1 (0,8%)	0,0
6 mm	1 (2,1%)	0,0	6,1%	3 (2,6%)	0,0	5,5%	3 (2,8%)	0,0	5,9%	2 (1,5%)	0,0
7 mm	9 (18,8%)	7,7	29,8%	9 (7,8%)	2,9	12,6%	13 (12,0%)	5,9	18,2%	22 (16,9%)	10,5
8 mm	14 (29,2%)	16,3	42,0%	36 (31,0%)	22,6	39,5%	28 (25,9%)	17,7	34,2%	40 (30,8%)	22,8
9 mm	9 (18,8%)	7,7	29,8%	26 (22,4%)	14,8	30,0%	29 (26,9%)	18,5	35,2%	29 (22,3%)	15,2
10 mm	8 (16,7%)	6,1	27,2%	21 (18,1%)	11,1	25,1%	19 (17,6%)	10,4	24,8%	24 (18,5%)	11,8
11 mm	1 (2,1%)	0,0	6,1%	7 (6,0%)	1,7	10,4%	8 (7,4%)	2,5	12,3%	2 (1,5%)	0,0
12 mm	2 (4,2%)	0,0	9,8%	11 (9,5%)	4,2	14,8%	4 (3,7%)	0,1	7,3%	5 (3,8%)	0,5
13 mm	2 (4,2%)	0,0	9,8%	3 (2,6%)	0,0	5,5%	2 (1,9%)	0,0	4,4%	5 (3,8%)	0,5
FL – distância FL-CV											
1 mm	0 (0,0%)	0,0	0,0%	2 (3,4%)	0,0	8,1%	1 (1,9%)	0,0	5,4%	2 (3,1%)	0,0
2 mm	1 (4,2%)	0,0	12,2%	5 (8,6%)	1,4	15,8%	7 (13,0%)	4,0	21,9%	4 (6,2%)	0,3
3 mm	6 (25,0%)	7,7	42,3%	11 (19,0%)	8,9	29,1%	3 (5,6%)	0,0	11,7%	10 (15,4%)	6,6

4 mm	2 (8,3%)	0,0	19,4%	7 (12,1%)	3,7	20,5 %	7 (13,0%)	4,0	21,9%	5 (7,7%)	1,2
5 mm	6 (25,0%)	7,7	42,3%	9 (15,5%)	6,2	24,8 %	16 (29,6%)	17,5	41,8%	6 (9,2%)	2,2
6 mm	3 (12,5%)	0,0	25,7%	10 (17,2%)	7,5	27,0 %	13 (24,1%)	12,7	35,5%	18 (27,7%)	16,8
7 mm	5 (20,8%)	4,6	37,1%	10 (17,2%)	7,5	27,0 %	6 (11,1%)	2,7	19,5%	9 (13,8%)	5,4
8 mm	0 (0,0%)	0,0	0,0%	2 (3,4%)	0,0	8,1%	1 (1,9%)	0,0	5,4%	4 (6,2%)	0,3
9 mm	1 (4,2%)	0,0	12,2%	0 (0,0%)	0,0	0,0%	0 (0,0%)	0,0	0,0%	0 (0,0%)	0,0
10 mm	0 (0,0%)	0,0	0,0%	2 (3,4%)	0,0	8,1%	0 (0,0%)	0,0	0,0%	3 (4,6%)	0,0
11 mm	0 (0,0%)	0,0	0,0%	0 (0,0%)	0,0	0,0%	0 (0,0%)	0,0	0,0%	4 (6,2%)	0,3
5mm											
Até 5 mm	15 (62,5%)	43,1	81,9%	34 (58,6%)	45,9	71,3 %	34 (63,0%)	50,1	75,8%	27 (41,5%)	29,6
>5 mm	9 (37,5%)	18,1	56,9%	24 (41,4%)	28,7	54,1 %	20 (37,0%)	24,2	49,9%	38 (58,5%)	46,5
4mm											
Até 4 mm	9 (37,5%)	18,1	56,9%	25 (43,1%)	30,4	55,8 %	18 (33,3%)	20,8	45,9%	21 (32,3%)	20,9
>4 mm	15 (62,5%)	43,1	81,9%	33 (56,9%)	44,2	69,6 %	36 (66,7%)	54,1	79,2%	44 (67,7%)	56,3
FL distancia FL-ADA											
1 mm	1 (5,3%)	0,0	15,3%	0 (0,0%)	0,0	0,0%	1 (2,3%)	0,0	6,7%	0 (0,0%)	0,0
2 mm	1 (5,3%)	0,0	15,3%	8 (16,0%)	5,8	26,2 %	1 (2,3%)	0,0	6,7%	4 (7,5%)	0,4
3 mm	0 (0,0%)	0,0	0,0%	0 (0,0%)	0,0	0,0%	2 (4,5%)	0,0	10,7%	5 (9,4%)	1,6

4 mm	4 (21,1%)	2,7	39,4%	7 (14,0%)	4,4	23,6%	6 (13,6%)	3,5	23,8%	9 (17,0%)	6,9
5 mm	1 (5,3%)	0,0	15,3%	1 (2,0%)	0,0	5,9%	1 (2,3%)	0,0	6,7%	2 (3,8%)	0,0
6 mm	0 (0,0%)	0,0	0,0%	5 (10,0%)	1,7	18,3%	9 (20,5%)	8,5	32,4%	9 (17,0%)	6,9
7 mm	6 (31,6%)	10,7	52,5%	15 (30,0%)	17,3	42,7%	10 (22,7%)	10,3	35,1%	12 (22,6%)	11,4
8 mm	4 (21,1%)	2,7	39,4%	6 (12,0%)	3,0	21,0%	8 (18,2%)	6,8	29,6%	6 (11,3%)	2,8
9 mm	2 (10,5%)	0,0	24,3%	2 (4,0%)	0,0	9,4%	3 (6,8%)	0,0	14,3%	1 (1,9%)	0,0
11 mm	0 (0,0%)	0,0	0,0%	2 (4,0%)	0,0	9,4%	1 (2,3%)	0,0	6,7%	3 (5,7%)	0,0
12 mm	0 (0,0%)	0,0	0,0%	4 (8,0%)	0,5	15,5%	2 (4,5%)	0,0	10,7%	2 (3,8%)	0,0
5mm											
Até 5 mm	7 (36,8%)	15,2	58,5%	16 (32,0%)	19,1	44,9%	11 (25,0%)	12,2	37,8%	20 (37,7%)	24,7
>5 mm	12 (63,2%)	41,5	84,8%	34 (68,0%)	55,1	80,9%	33 (75,0%)	62,2	87,8%	33 (62,3%)	49,2
8mm											
Até 8 mm	17 (89,5%)	75,7	103,3%	42 (84,0%)	73,8	94,2%	38 (86,4%)	76,2	96,5%	47 (88,7%)	80,1
>8 mm	2 (10,5%)	0,0	24,3%	8 (16,0%)	5,8	26,2%	6 (13,6%)	3,5	23,8%	6 (11,3%)	2,8
FL-BM											
Até 5 mm	7 (36,8%)	15,2%	58,5%	16 (32,0%)	19,1%	44,9%	11 (25,0%)	12,2%	37,8%	20 (37,7%)	24,7%
> 5 mm	12 (63,2%)	41,5%	84,8%	34 (68,0%)	55,1%	80,9%	33 (75,0%)	62,2%	87,8%	33 (62,3%)	49,2%
Comprimento do LA											

1	4 (50,0%)	15,4%	84,6%	10 (25,0%)	11,6%	38,4%	13 (37,1%)	21,1%	53,2%	9 (31,0%)	14,2%
2	4 (50,0%)	15,4%	84,6%	28 (70,0%)	55,8%	84,2%	20 (57,1%)	40,7%	73,5%	19 (65,5%)	48,2%
3	0 (0,0%)	0,0%	0,0%	2 (5,0%)	0,0%	11,8%	2 (5,7%)	0,0%	13,4%	1 (3,4%)	0,0%
Comprimento do LA											
1	7 (46,7%)	21,4%	71,9%	27 (36,5%)	25,5%	47,5%	24 (37,5%)	25,6%	49,4%	22 (40,7%)	27,6%
2	8 (53,3%)	28,1%	78,6%	44 (59,5%)	48,3%	70,6%	35 (54,7%)	42,5%	66,9%	29 (53,7%)	40,4%
3	0 (0,0%)	0,0%	0,0%	3 (4,1%)	0,0%	8,5%	5 (7,8%)	1,2%	14,4%	3 (5,6%)	0,0%

*p<0.05, teste qui-quadrado de Pearson

Legenda: CA: crista alveolar; CV: cortical vestibular; BM: base da mandíbula; ADA: Ápice do dente adjacente; FM:Forame mentual; FL: foramina lingual

6. CONCLUSÃO GERAL

Diante dos capítulos apresentados pode-se concluir que:

1. As fraturas de TG são eventos raros que podem ocorrer espontaneamente e de forma isolada associada ao edentulismo, ou por etiologia traumática como observado em acidentes automobilístico e associada a outras fraturas mandibulares.
2. No planejamento de procedimentos cirúrgicos na região anterior deve-se considerar a presença da FL, pois a depender do número e calibre dos vasos linguais na área da linha média, sangramentos importantes podem ocorrer caso os canais linguais sejam injuriados.
3. Observou-se uma prevalência muito variada do LA a partir de estudos em diferentes populações mundiais, sendo que, a região imediatamente anterior ao FM não pode ser considerada totalmente segura para procedimentos invasivos, tendo o LA apresentado um comprimento médio variando de 0,89mm a 3,69mm.
4. Observou uma alta prevalência dos TG, sendo mais comumente encontrados dois TGs e com os homens apresentando medidas lineares maiores quando comparado com as mulheres, entretanto sem dimorfismo sexual. De acordo com a classificação proposta, o tipo mais observado foi o IIIA (38,7%) seguido do IIIB (36,3%).
5. De acordo com a estimativa de risco para procedimentos na região anterior da mandíbula, coleta de enxerto não deve ultrapassar 4mm de profundidade, a colocação de implantes em posição interforaminal deve ser planejada respeitando pelo menos 3mm de distância do FM e as osteotomias para genioplastia devem ser realizadas a pelo menos 5mm do FM.

7. REFERÊNCIAS BIBLIOGRÁFICAS (INTRODUÇÃO E REVISÃO DE LITERATURA)

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ANEXOS

ANEXO I. SEGUIMENTO DO REGIMENTO INTERNO

Art. 46 – As dissertações e as teses apresentadas ao Programa de Pós-Graduação em Odontologia da Universidade Federal do Ceará poderão ser produzidas em formato alternativo ou tradicional. O formato

alternativo estabelece: a critério do orientador e com a aprovação da Coordenação do Programa, que os capítulos poderão conter cópias de artigos e/ou relatórios de patentes de autoria ou coautoria do candidato, publicados ou submetidos para publicação em revistas científicas, escritos no idioma exigido pelo veículo de divulgação.

§1º - O orientador e o candidato deverão verificar junto às editoras a possibilidade de inclusão dos artigos na dissertação ou tese, em atendimento à legislação que rege o direito autoral, obtendo, se necessária, a competente autorização, deverão assinar declaração de que não estão infringindo o direito autoral transferido à editora.

§2º - A dissertação e a tese em formatos tradicionais ou formatos alternativos deverão seguir as normas preconizadas pelo Guia para Normalização de Trabalhos Acadêmicos da Biblioteca Universitária disponível no sítio http://www.biblioteca.ufc.br. As partes específicas do formato alternativo deverão ser feitas em concordância com o *Manual de Normalização para Defesa de dissertação de Mestrado e tese de Doutorado no formato Alternativo do PPGO,* disponível no sítio http://www.ppgo.ufc.br.

§3º - As dissertações defendidas no formato alternativo deverão constar de, no mínimo, 01(um) capítulo, enquanto que as teses no mesmo formato deverão constar de, no mínimo, 02 (dois) capítulos.

§4º - Admite-se que a dissertação ou a tese sejam escritas e/ou defendidas em língua estrangeira seguindo as diretrizes definidas no regimento interno do Programa;

ANEXO II - PARECER CONSUBSTANCIADO DO CEP

UNIVERSIDADE FEDERAL DO CEARÁ/ PROPESQ

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: ASPECTOS TOMOGRÁFICOS DENTOMANDIBULARES EM UMA SUBPOPULACÃO CEARENSE: UM ESTUDO MULTICÊNTRICO TRANSVERSAL

Pesquisador: DANIEL ALMEIDA FERREIRA BARBOSA

Área Temática:

Versão: 1

CAAE: 57343616.7.0000.5054

Instituição Proponente: Departamento de Clínica Odontológica

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.757.620

Apresentação do Projeto:

Será realizado um estudo multicêntrico, transversal, quantitativo e descritivo com tomografias computadorizadas realizadas através de tomógrafos
do tipo feixe cônico em 5 centros de imagens brasileiros localizados no estado do Ceará, sendo estes a Clínica de Radiologia do Curso de
Odontologia da Faculdade de Farmácia,Odontologia e Enfermagem da Universidade Federal do Ceará, a Clinica de Radiologia do Curso de
Odontologia da Universidade de Fortaleza e as Clínicas privadas Perboyre Castelo e Dental Imagem localizadas na cidade de Fortaleza, e o serviço
de imagem Clínica Ciros localizada em Sobral.A tomografia computadorizada de feixe cônico (TCFC) tem sido frequentemente solicitada para avaliação de dentes e reparos anatômicos
mandibulares que podem influenciar no plano de tratamento relativo a diversos procedimentos odontológicos. Portanto, o presente projeto objetiva
realizar um estudo epidemiológico sobre aspectos imaginológicos de dentes e reparos anatômicos mandibulares em uma subpopulação cearense.
Será realizada uma pesquisa de caráter descritivo, quantitativo e transversal, com TCFC de quatro centros de imagem odontológica em Fortaleza e

um em Sobral, no período entre2006 e 2017. Serão realizados estudos radiomorfométricos (medições lineares absolutas/relativas,
verticais/horizontais) mandibulares (canal mandibular, forame mentual e canal incisivo), estudos topográficos dentais (terceiros molares
inferiores),bem como serão coletas informações demográficas (sexo, idade e procedência. Todas as análises serão realizadas por único observador
e, para tanto, será realizado estudo piloto prévio para se determinar o índice de concordância intraexaminador. Os dados coletados serão analisados
quanto à sua frequência absoluta/relativa, e testes estatísticos apropriados serão aplicados, considerando-se valor de p<0,05 como significativo.
Espera-se com essa pesquisa conhecer o perfil epidemiológico radiográfico em uma parcela da população cearense, bem como reforçar a
importância de estudos tomográficos sobre reparos anatômicos e topografia dental mandibulares correlacionados clinicamente com diversos
procedimentos odontológicos.

Objetivo da Pesquisa:

Objetivo Primário:

Realizar um estudo epidemiológico multicêntrico de aspectos tomográficos dentomandibulares em uma subpopulação cearense no período entre
2006 e 2017.

Objetivo Secundário:

1. Avaliar aspectos radiomorfométricos relativos ao forame mentual emtomografias computadorizadas de feixe cônico;2. Avaliar aspectos
radiomorfométricos relativos ao canal mandibular em tomografias computadorizadas de feixe cônico;3. Avaliar aspectos radiomorfométricos relativos
ao canal incisivo mandibular em tomografias computadorizadas de feixe cônico;4. Avaliar aspectos topográficos relativos a terceiros molares
mandibulares em tomografias computadorizadas de feixe cônico;5. Avaliar aspectos topográficos relativos aos tubérculos genianos mandibulares em
tomografias computadorizadas de feixe cônico;6. Correlacionar os aspectos radiomorfométricos e dentais mandibulares com sexo, idade e
procedência das tomografias computadorizadas de feixe cônico.

Avaliação dos Riscos e Benefícios:

Riscos:

Os riscos desta pesquisa são mínimos pois se trata de um estudo observacional com imagens de tomografias computadorizadas, onde não há
envolvimento direto com pacientes. Para pesquisas com banco de dados de imagens, semelhante ao presente projeto, considera-se como risco
mínimo a divulgação de informações sigilosas que possam identificar o indivíduo que submeteu-se ao exame, por motivos outros. Entretanto, para a
presente pesquisa, a quebra do sigilo dos dados não será permitida a nenhum dos pesquisadores envolvidos, bem como entre os serviços de
imagem participantes.

Benefícios:

1. conhecimento sobre os aspectos imaginológicos de reparos anatômicos mandibulares, bem como estudo topográfico de terceiros molares
inferiores em virtude de sua reconhecida aplicabilidade com diversos procedimentos odontológicos.2. conhecimento da apresentação tomográfica,
bem como aspectos geográficos, relativos a tais estruturas mandibulares de uma subpopulação cearense.

Comentários e Considerações sobre a Pesquisa:

Pesquisa de relevância para a área de odontologia, especialmente para a área de radiologia odontológica.

Considerações sobre os Termos de apresentação obrigatória:

Todos os termos foram entregues adequadamente, inclusive com a assinatura do termo de fiel depositário e da autorização dos locais das cinco instituições envolvidas no projeto.

Recomendações:

Não se aplica.

Conclusões ou Pendências e Lista de Inadequações:

Sem pendências.

Considerações Finais a critério do CEP:

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

UNIVERSIDADE FEDERAL DO CEARÁ/ PROPESQ

Continuação do Parecer: 1.757.620

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_746157.pdf	24/06/2016 13:59:25		Aceito
Outros	Termo_compromisso_utilizacao_dos_dados.pdf	24/06/2016 13:58:38	DANIEL ALMEIDA FERREIRA	Aceito
Projeto Detalhado / Brochura Investigador	Daniel.pdf	24/06/2016 13:57:27	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito
Outros	Carta_apreciacao_Comite_de_Etica.pdf	24/06/2016 13:56:08	DANIEL ALMEIDA FERREIRA	Aceito
Orçamento	Orcamento2.pdf	24/06/2016 13:55:08	DANIEL ALMEIDA FERREIRA	Aceito
Orçamento	Orcamento1.pdf	24/06/2016 13:54:40	DANIEL ALMEIDA FERREIRA	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	isencao_TCLE.pdf	24/06/2016 13:52:56	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito
Outros	Termo_de_fiel_depositario_UNIFOR.pdf	24/06/2016 13:52:06	DANIEL ALMEIDA FERREIRA	Aceito
Outros	Termo_de_fiel_depositario_UFC.pdf	24/06/2016 13:51:52	DANIEL ALMEIDA FERREIRA	Aceito
Outros	Termo_de_fiel_depositario_Perboyre.pdf	24/06/2016 13:51:29	DANIEL ALMEIDA FERREIRA	Aceito
Outros	Termo_de_fiel_depositario_Dental_Imagem.pdf	24/06/2016 13:50:46	DANIEL ALMEIDA FERREIRA	Aceito
Outros	Termo_de_fiel_depositario_Cyros.pdf	24/06/2016 13:50:14	DANIEL ALMEIDA FERREIRA	Aceito
Declaração de Pesquisadores	Declaracao_concordancia.pdf	24/06/2016 13:47:11	DANIEL ALMEIDA FERREIRA	Aceito
Cronograma	Cronograma_daniel.pdf	24/06/2016 13:46:44	DANIEL ALMEIDA FERREIRA	Aceito
Declaração de Instituição e Infraestrutura	Autorizacao_institucional_UNIFOR.pdf	24/06/2016 13:46:18	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito
Declaração de Instituição e Infraestrutura	Autorizacao_institucional_ufc.pdf	24/06/2016 13:46:08	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito
Declaração de Instituição e Infraestrutura	Autorizacao_institucional_Perboyre.pdf	24/06/2016 13:44:29	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito
Declaração de Instituição e Infraestrutura	Autorizacao_institucional_Dental_Imagem.pdf	24/06/2016 13:44:15	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito
Declaração de Instituição e Infraestrutura	Autorizacao_institucional_Cyros.pdf	24/06/2016 13:44:03	DANIEL ALMEIDA FERREIRA BARBOSA	Aceito

Endereço: Rua Cel. Nunes de Melo, 1000
Bairro: Rodolfo Teófilo **CEP:** 60.430-275
UF: CE **Município:** FORTALEZA
Telefone: (85)3366-8344 **E-mail:** comepe@ufc.br

Folha de Rosto	FOLHA_DE_ROSTO.pdf	24/06/2016 13:14:18	DANIEL ALMEIDA FERREIRA	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

FORTALEZA, 03 de Outubro de 2016

Assinado por:
FERNANDO ANTONIO FROTA BEZERRA
(Coordenador)

ANEXO III - STATUS DE ACEITE DO CAPÍTULO 3 NA REVISTA JOURNAL OF ENDODONTICS

JOE
Journal of Endodontics

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MAIN MENU • CONTACT US • SUBMIT A MANUSCRIPT • INSTRUCTIONS FOR AUTHORS • POLICIES

em Editorial Manager

Role: Author Username: danielbarbosajoe

Submissions with an Editorial Office Decision for Author Daniel Almeida Ferreira Barbosa

Page: 1 of 1 (1 total completed submissions) Display 10 results per page.

Action	Manuscript Number	Title	Initial Date Submitted	Current Status	Date Final Disposition Set	Final Disposition
Action Links	JOE-21-474	Mental foramen and anterior loop anatomic characteristics: a systematic review and meta-analysis of cross-sectional imaging studies.	Jun 02, 2021	Completed	Aug 14, 2021	Accept

Page: 1 of 1 (1 total completed submissions) Display 10 results per page.

ANEXO IV - NORMAS DE SUBMISSÃO DA REVISTA JOURNAL OF ORAL BIOLOGY AND CRANIOFACIAL RESEARCH

ELSEVIER

JOURNAL OF ORAL BIOLOGY AND CRANIOFACIAL RESEARCH

Official Journal of the Craniofacial Research Foundation

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DESCRIPTION

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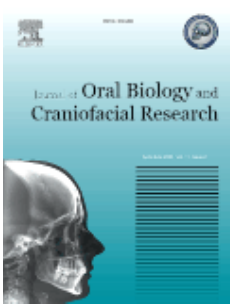
ISSN: 2212-4268



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The journal aims to provide a common platform for both clinical and translational research and to promote interdisciplinary sciences in craniofacial region. JOBCR publishes content that includes diseases, injuries and defects in the head, neck, face, jaws and the hard and soft tissues of the mouth and jaws and face region; diagnosis and medical management of diseases specific to the orofacial tissues and of oral manifestations of systemic diseases; studies on identifying populations at risk of oral disease or in need of specific care, and comparing regional, environmental, social, and access similarities and differences in dental care between populations; diseases of the mouth and related structures like salivary glands, temporomandibular joints, facial muscles and perioral skin; biomedical engineering, tissue engineering and stem cells.

The journal publishes reviews, commentaries, peer-reviewed original research articles, short communication, and case reports.

ABSTRACTING AND INDEXING

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Vision:

• The journal will cover a major contribution of research in oral biology and craniofacial area • Will have a wide readership, hence good popularity and fan following
• Will bring craniofacial research carried out in India to a global platform
• Will be a dream for a researcher in this field to be an author of this journal

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Action	Manuscript Number	Title	Initial Date Submitted	Status Date	Current Status
Action Links	JOBCR-D-21-00093	Surgical-related morphometric aspects and proposal of a new classification of genial tubercles in cone-beam computed tomography	Feb 12, 2021	May 21, 2021	Under Review

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ANEXO VI - NORMAS DE SUBMISSÃO DA REVISTA INTERNATIONAL JOURNAL OF ORAL AND MAXILLOFACIAL IMPLANTS

The International Journal of
Oral & Maxillofacial Implants

ISSN 0882-2786 (print)
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February 2020