

Full Length Research Paper

Prospective study of dental implantology related patents in Brazil

Lídia Audrey Rocha Valadas^{1,3*}, Rosueti Diógenes Oliveira Filho¹, Carlos Eduardo Francischone⁵, Mara Assef Leitão Lotif¹, Mary Anne Medeiros Bandeira¹, Marta Maria de França Fonteles¹, Taynã Coelho Simões¹, Francisco Josimar Girão Júnior⁴, Ana Cristina de Mello Fiallos¹ and Carlos Ricardo de Queiroz Martiniano^{2,3}

¹School of Pharmacy, Federal University of Ceara, Brazil.

²Department of Clinical Dentistry, School of Dentistry-Campus Sobral, Federal University of Ceara, Brazil.

³Ceara Academy of Dentistry, Brazil.

⁴Department of Physiology and Pharmacology, Federal University of Ceara, Brazil.

⁵Bauru College of Dentistry, University of Sao Paulo, Brazil.

Received 21 December, 2019; Accepted 28 May, 2020

Technological innovation and the development of new products is what currently boost the competitiveness between enterprises and moves the economy. The technical-scientific advances in Dentistry grow each day and there are great investments by research centers and universities in new materials, especially in dental implantology. The objective was to evaluate the patents deposited and granted in implantology at the National Institute of Industrial Property (INPI) in Brazil. This is a prospective study with searches performed during March 2020 on patents in dental implantology deposited and granted in the INPI. The research was carried out in titles and abstracts of reports on patent applications from the first deposit through to the most current using the search terms "dental implants" and "implantology". The information was extracted from documents and organized into tables and graphs. From 1988, the date of the first deposit, through to 2019 there were 139 patent application deposits. Among the deposited patents, 54% (75) were classified as utility model patents and 25% (35) as invention patents, the others 21% (29) have been in analysis. Brazil holds 80.6% (112) of deposits, and the others are from countries in Latin America, North America, Europe and Africa, and virtually all patents are of type A, which refers to products of human needs. Most deposits of patents for use in implantology in the INPI relate to implant and prosthetic component accessories, indicating greater investment by industry in Brazil in this sector. However, in 30 years there were only 134 deposited patents, suggesting that the importation of products in the area is still great, which consequently makes the products of this area more expensive. Thus, investments in patents play an important role in technological and economic development of a country.

Key words: Dental implants, intellectual property, patents.

INTRODUCTION

Technological innovation and the development of new products is what currently boost the competitiveness

between enterprises and moves the economy (Dalmarco et al., 2011). The technical-scientific advances in dentistry

grows each day and there are great investments by research centers and universities in new materials, especially in dental implantology, which depends on the evolution of materials/instruments/processes to be an increasingly safer and accessible option as an alternative to removable prosthetics (Lotif et al., 2018).

The prognosis and long-term safety of prostheses in implants are already well documented in both laboratory and clinical-epidemiological studies. Like any area, materials and instruments may be subject to failures, making the search for safer materials and innovative methods one of the main interests of industries and scientific studies in Implantology, not only in relation to implants, prostheses and biomaterials, but also aseptic/antiseptic substances used to disrupt bacterial biofilm, improving long-term performance (Sandhu et al., 2017); thus, the scarcity and search to improve products increases industrial investment in production and development (John and Prates, 2015). The global biomaterials market in general is currently expanding, especially in the United States and Europe, being very expressive and profitable. It has two types of modalities: The first relates to compounds that constitute biomaterials such as metals, ceramics, and natural products, etc.; the second relates to the application form, which includes biomaterials used in dentistry (Pires et al., 2015).

Investing in technological innovation, especially in industries, is essential to keep up with the market. Patents are intellectual property that guarantees the inventor(s) the right over an invention or a utility model, also ensuring safety in profits in possible negotiations (Amadei and Torkomian, 2009). Therefore, the inventor(s) will have the exclusive right to commercialize the product for a certain time, varying according to the patent type and laws of the country, or even transfer rights to companies, which is very common practice when the inventor is not able to invest in the production of his/her invention (Furtado Júnior et al., 2018; Haase et al., 2005). In Brazil, for example, there is only one company among the largest depositors, as the others are individuals and universities (Pieroni et al., 2010).

The investments and the search for patent protection are increasingly disseminated in capitalism, where the whole system operation relates to scientific and technological advancement. Although patent law is known worldwide, most people, even researchers, do not partially or totally understand the process of preparation and deposit of patents (Tejedor and Romero, 2014).

After the deposit, intellectual property banks are responsible for analyzing documents and providing patents. Some of the major banks in the world are the

National Institute of Industrial Property (INPI-Brazil), the Canadian Intellectual Property Office (CIPO-Canada), the German Patent and Trade Mark Office (DPMA-Germany), the Japanese Patent Office (JPO-Japan), the Intellectual Property Office (IPO-United Kingdom), the United States Patent and Trademark Office (USPTO-United States) and the World Intellectual Property Organization (WIPO-Europe) (Valadas et al., 2017). Therefore, the objective of this study was to evaluate deposited and granted patents regarding dental implantology at the National Institute of Industrial Property (INPI) in Brazil in order to assess the main materials and industrial production in implantology.

MATERIALS AND METHODS

This is a prospective study of exploratory analysis performed in March 2020, in which searches were conducted for Implantology patents deposited and granted in the National Institute of Intellectual Property (INPI), which is the bank responsible for intellectual property in Brazil.

For this, searches on the INPI bank, were performed in titles and abstracts of reports on patent applications related to dental Implantology, from the first deposit through to the most current. First, a search with the term "dental implants" was performed, which returned 44 patent deposits. Next, a search with the term "implantology", which returned 100 deposits. After reading the reports and deleting duplicate documents or those unrelated to implantology, 139 reports on patents were selected and have been read and analyzed. The information extracted from the reports, as year of the deposit, type of patent and products were organized in tables and figures in GraphPad Prism 6.

RESULTS AND DISCUSSION

From 1988, the date of the first deposit, through to 2019 there were 139 patent application deposits. Among the deposited patents 54% (75) were classified as utility model patents and 25% (35) as invention patents, the others 21% (29) have been in analysis.

Figure 1 shows the distribution of the reports at INPI along the years. There were no reports of deposits recorded between 1988 and 1996. Although the amount is modest, the number of deposits increased in 2007 and 2008.

Figure 2 shows the countries of the depositors. Brazil holds 80.6% (112) of deposits, and the other 19.4% are countries in Latin America, North America, Europe and Africa. After Brazil, the United States has the most deposited patents in the most recent years.

In Figure 3, when analyzing the applications for patents of companies/individuals in Brazil regarding the distribution of Brazilian regions, the Southeast region holds 74 deposits, which represents more than half of the

*Corresponding author. E-mail: lidiavaladas@gmail.com. Tel: +55 85 33668000.

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

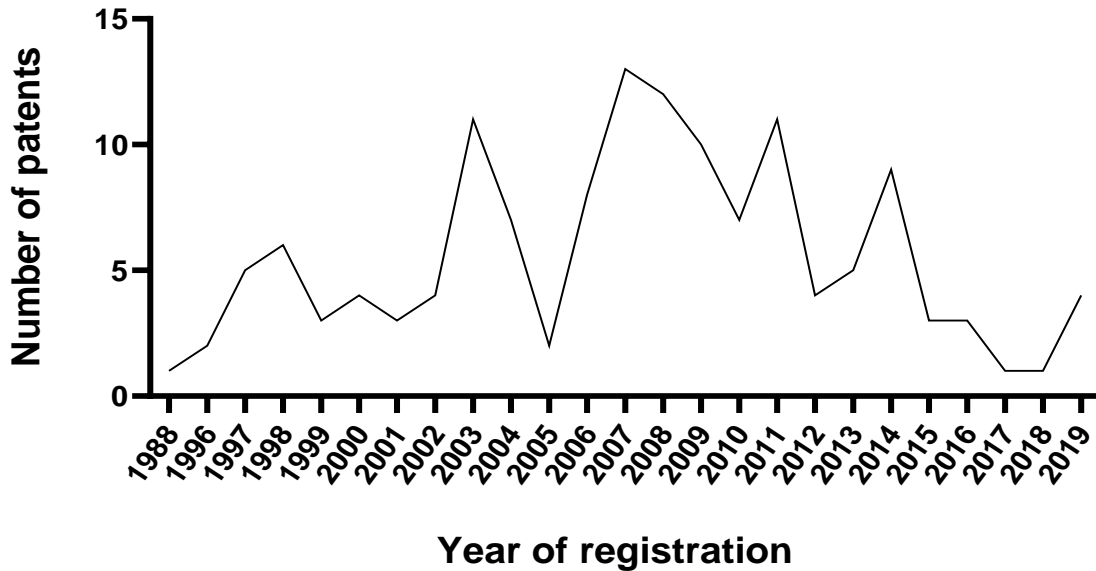


Figure 1. Amount of patents per year with the term "Implantology" and "Dental Implants" at INPI, Brazil, 2019.

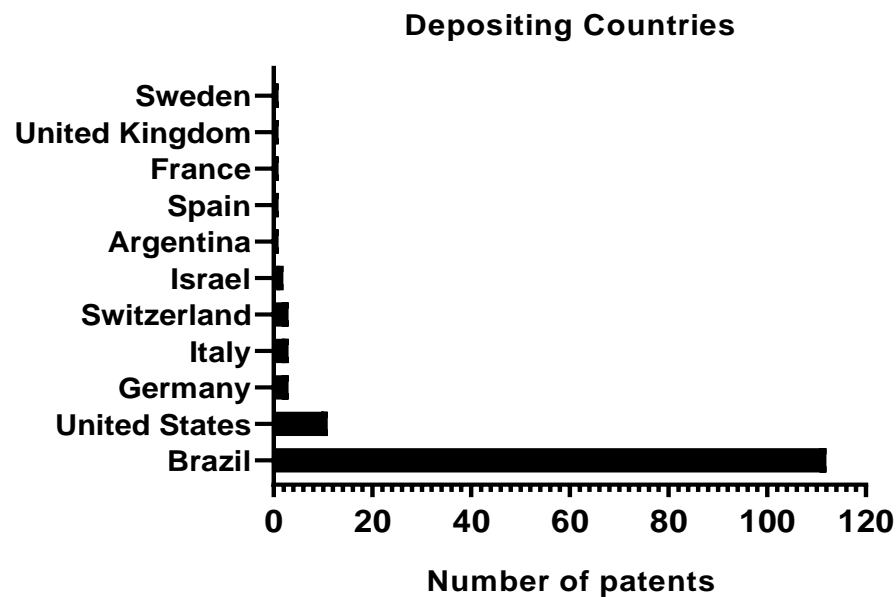


Figure 2. Depositors of patents by country with the term "Implantology" and "Dental Implants" at INPI, Brazil, 2019.

patent applications (68.5%), followed by the South region, with 26.8% (33) deposits. The North region has no record of deposits.

Table 1 shows the amount of products with application in dental implantology. The largest number of deposits relates to accessories of implants (28.78%); the lowest amount of deposits was related to accessories/instruments for grafts (7.91%).

In order to standardize the deposits, every patent is classified in accordance with the IPC - International Patent Classification, which is the international

classification system created in 1971, distributing patents by codes. The products are divided into technological areas of types A through H, and each type has its divisions and subdivisions (subclasses). Table 2 shows that virtually all deposits are type A (94.24%), which refers to products of human needs. Type C, related to chemicals/metallurgy, had only 2.16%, and type G, which refers to physical processes, had 3.6%. Types B, D, E, F and H had no deposits because they do not apply to the area.

Since the description of the osseointegration principle

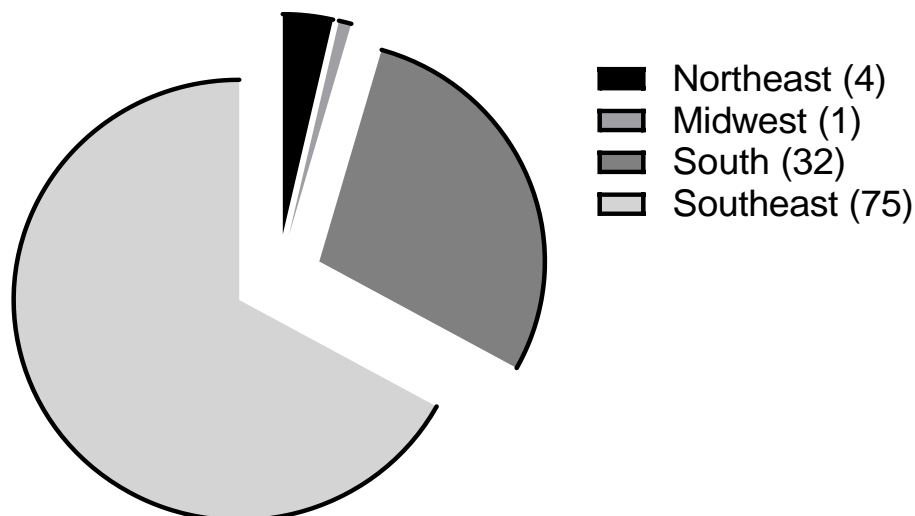


Figure 3. Distribution of patent deposits with the term "Implantology" and "Dental Implants" by regions of Brazil, 2019.

Table 1. Amount of deposited patents by type of material at *INPI*, Brazil, 2019.

Description of the patent material	Quantity (%)
Antimicrobial accessories/materials	7 (5.04)
Accessories/instruments for grafts	11 (7.91)
Implants	20 (14.39)
Accessories for implants	40 (28.78)
Protheses (materials/components)	29 (20.86)
Systems/methods	20(14.39)
Others (packaging, positioners, etc.)	12 (8.63)
Total	139

by Branemark and colleagues more than 45 years ago, a new era emerged in the research of materials for dental Implantology. Currently, there are approximately 1,300 different implant systems, each one with its particularities in relation to format, materials, surface treatment, prosthetic components, etc. Although rehabilitation with dental implants presents high rates of long-term success, new technologies are developed in order to promote long-term osseointegration in cases in which more failures occur, such as low quantity and bone quality and patients with comorbidities (Smeets et al., 2016).

In relation to scientific production in dental materials in the world context, Brazil has great expressivity. Studies in implantology in Brazil have been increasing, and dental materials had the highest number of published articles up until 2016 (13,708 articles). Nevertheless, the amount of patents is modest, as the process for a product to be patented is complex and the number of depositories is not proportional to the number of scientific studies in the area (Rosa et al., 2016).

Unlike developed countries, the government in Brazil is the main responsible organ for funding Research and

Development (R&D), while the main source of investment in other countries comes from private capital/sources (Castro and Souza, 2012). However, in recent years, the trend to develop more complex studies by large companies and basic studies by universities has been increasing due to the costs (Dalmarco et al., 2011). Thus, the universities are responsible for most studies in Brazil, especially public ones, but the amount of products being patented by them is still small and a new phenomenon, indicating that the participation of Brazilian universities is modest, especially in the area of dental Implantology, probably because the country has few graduate programs in implantology (Valadas et al., 2017).

Regarding the Brazilian regions, the Southeast region has the highest amount of patent deposits in universities, especially being represented by the universities of São Paulo, followed by the South region in second place and the Northeast in third. These results result from a major investment of funding agencies, in addition to concentrating most studies in the country, which tends to decrease because of guidelines created for the decentralization of scientific and technological activity

Table 2. Classification of deposited patents with the term "Implantology" and "Dental Implants" at *INPI*, in accordance with the International Patents Classification - IPC.

Classification by section	Subclass of patent	Quantity (%)
Type A (human needs)	A61C	107 (76.98)
	A61K	12 (8.63)
	A61L	5 (3.6)
	A61B	4 (2.88)
	A61F	1 (0.72)
	A61N	1 (0.72)
	A41D	1 (0.72)
Type C (chemistry/metallurgy)	C01B	1 (0.72)
	C23C	1 (0.72)
	C23F	1 (0.72)
Type G (Physics)	G01B	1 (0.72)
	G01L	2 (1.44)
	G03B	2 (1.44)

A41D, External clothing; protective costumes; accessories; A61C, dentistry; oral or dental hygiene; A61K, preparations for medical, dental and hygienic purposes; A61L, methods or apparatus for sterilizing materials or objects in general; Disinfection, sterilization or deodorization of air; Chemical aspects of bandages, dressings, absorbent pads or surgical articles; materials for bandages, dressings, absorbent pads or surgical articles; A61F, Filters implanted in blood vessels; prostheses; devices that promote clearing or prevent collapse of tubular structures of the body, such as stents; orthopedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid cases; A61N, electrotherapy, magnetotherapy; radiation therapy; ultrasound therapy; A61B, diagnosis; surgery; identification; C01B, non-metallic elements; their compounds; C23C, coating of metallic materials; coating of materials with metallic materials; materials with surface treatment of metallic materials by diffusion, by chemical conversion or replacement; coating by vacuum evaporation, sputtering, implantation of ions or chemical deposition in vapor phase, in general; C23F, non-mechanical removal of metallic materials of surfaces; G01B, measuring of lengths, thicknesses or other similar linear dimensions; measurement of angles; measurement of areas; measuring surface irregularities, or outline; G01L, measurement of force, tension, torque, work, mechanical power, mechanical efficiency, or pressure of fluids; G03B, instruments or provisions to take photographs or to project them or view them; instruments or provisions that use similar techniques by means of waves different from optical waves; accessories for them.

(Oliveira and Velho, 2009). In the present study, only 3.73% (Pires et al., 2015) deposits were from public (federal) universities in the Southeast region.

This trend in depositing the products generated by searches will probably increase, because of Law 10,973 of 2 December 2004, which deals with measures to encourage innovation and scientific and technological research by the Federal Government, states and municipalities and development agencies to increase partnerships with companies and entities dedicated to scientific and technological researches, requiring an Information Technology Core (NIT) from each public university to strengthen this partnership (Dagnino and Silva, 2009; Mueller and Perucchi, 2014; Valadas et al., 2017).

Patents may be invention (IP) or utility model (UM). In the present study, 68.2% of deposits were UM and 31.8% were IP, suggesting more Brazilian investment in improving and adapting inventions than create original products. The number of accessories of implants was significantly higher than the number of implants patented in Brazil; thus, the country's industries are not investing in invention or adaptation of new implants. The same occurs regarding biomaterials, which have a significant participation in the market both quantitatively and

qualitatively in generating profits; however, only two patents (UM 7700936-3; IP 1106507-9) were recorded in this area (Table 1) (Pires et al., 2015; Amadei and Torkomian, 2009).

Regarding prostheses and their components, the survey indicated that they had 29 (20.86%) of related deposits, an expressive number. For the development of new increasingly sophisticated prosthetic materials, aesthetics are not the only goal. Behind it, the industry uses engineering, physics and chemistry techniques, making the work not only increasingly more aesthetic but also functional and resistant, and this multiprofessional interaction is essential for this improvement (Hattori et al., 2011).

Studies indicate that the Brazilian dental industry used to focus on the production of restorative materials; however, the current trends are investments in technology, because there is a concern to improve the development of biomaterials (Rosa et al., 2016).

When observing the provision of deposits of patents over the years at the INPI bank, the last decade (2000-2010) had a lot more deposits than the current decade, indicating that technological innovation in the industry of dental implants and related materials decreased in the current decade. In 2017, for example, had only one

deposit record (BR 1020170069222) (Silva, 2017), but possible deposits can still be processing. Reports indicate that after the creation of the National Sanitary Surveillance Agency (ANVISA) in 1999, there was a greater demand of companies in providing products with guaranteed quality and increasingly more safety, thus influencing the development of new products in the last decade (Pieroni et al., 2010). Another explanation is that there were many mergers of companies in the health area in Brazil between 2005 and 2006, when more than 250 business transactions with international companies occurred (Burkhardt and Tardio, 2006).

Multinational companies commonly perform deposits in countries other than of their origin in order to increase the protection and disclosure of their products, which is normally done through the Patent Cooperation Treaty (PCT), known as the international patent. When depositing the invention in this way, the product is protected in all country members of the Treaty. Deposits on intellectual protection of products for application in dental Implantology are made by several countries, especially the United States, which is the country with the largest market movement of biomaterials (Pires et al., 2015). Although the data are modest, the existence of other countries as depositors indicates an interest in the Brazilian market, whose growth in the area and prospect of increased demand is attracting an increasing number of deposits by international companies (Tejedor and Romero, 2014).

There is a regional inequality of technical-scientific production in Brazil, in which the state of São Paulo and the Southeast region as a whole have a greater participation and enormous importance in the system of innovation in the country. Having the highest GDP (Gross Domestic Product) in the country, a large part of the universities, industries and scientific production are decisive factors for this scenario. An indicator of this scenario is deposits of patents, as in the present study, in which the Southeast and South regions together have almost 80% of the deposits (Albuquerque and Cassiolato, 2002).

The Northeast region has only four of the 112 Brazilian patent applications, where the state of Ceará has half the deposits, followed by Bahia and Pernambuco, with only one deposit each. Although the production is virtually non-existent, the development and protection of new products in the dental implantology market in Ceará may be considered an advance.

In Brazil, the industry of products for health services has large participation, in which dentistry is the only area that features a trade surplus and the second largest market in the world, only behind the United States. However, most of its products are low- and medium-technology. Regarding innovative products, the use of American products still prevails in Brazil. The current context requires new challenges and major investments in technology in this sector (Pieroni et al., 2010).

Conclusion

Records of patents are essential to evaluate the technological level of a given area. Analyzing the patent deposits for use in dental implantology at INPI provided a panoramic view and showed that the majority relate to accessories of implants and prosthetic components, indicating greater investment by industries in Brazil in this sector.

The number of patent applications in the years 2007 and 2008 increased, yet the number of deposits is small, since only 139 patents were deposited in 30 years, suggesting that the importation of products in the area is still great, which consequently makes the products of the area more expansive.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENT

The authors appreciate the Federal University of Ceará for supporting this study.

REFERENCES

- Albuquerque E, Cassiolato J (2002). As especificidades do sistema de inovação do setor saúde. *Revista de Economia Política* 22(4):134-151.
- Amadei JRP, Torkomian ALV (2009). As patentes nas universidades: Análise dos depósitos das universidades públicas paulistas. *Ciência da Informação* 38(2):9-18.
- Burkhardt C, Tardio S (2006). Converging trends drive industry consolidation. *M&A Analysis. Medical Device and Diagnostic Industry* 1(1):1-11.
- Castro BS, Souza GC (2012). O papel dos Núcleos de Inovação Tecnológica (NITs) nas universidades brasileiras. *Liinc em Revista* 8(1):125-140.
- Dagnino RD, Silva RB (2009). As patentes das universidades públicas. *Revista Economia and Tecnologia* 5(3):169-172.
- Dalmarco G, Dewes MF, Zawislak PA, Padula AD (2011). Universities' Intellectual Property: Path for Innovation or Patent Competition? *Journal of Technology Management and Innovation* 6(3):159-169.
- Furtado Júnior JH, Valadas LAR, Mendonça KS, Oliveira-Filho RD, Gadelha LMU, Fiallos NM, Neto EMR, Fiallos ACM, Fonteles MMF (2018). Propolis and its Dental Applications: A Technological Prospection. *Recent Patents on Biotechnology* 12(4):1-9.
- Haase H, Araújo EC, Dias J (2005). Inovações vistas pelas patentes: exigências frente às novas funções das universidades. *Revista Brasileira de Inovação* 4(2):12-22.
- Hattori KE, Marotti J, Gil C, Campos TT, Mori M (2011). Inovações tecnológicas em reabilitação oral protética. *Revista Gaúcha Odontologia* 59(1):59-66.
- John E, Prates RC (2015). Influência dos custos transacionais sobre a inovação: Um estudo multicaso de empresas industriais no Brasil. *Management and Connections Journal* 4(2):120-143.
- Lotif MAL, Marques LARV, Rodrigues-Neto EM, Dantas TS, Martiniano CRQ (2018). O uso do plasma rico em plaquetas para correção de defeitos ósseos maxilares em Implantodontia. *Full Dentistry in Science* 9(34):62-67.

- Mueller SPM, Perucchi V (2014). Universidades e a produção de patentes: Tópicos de interesse para o estudioso da informação tecnológica. *Perspectivas em Ciência da Informação* 19(2):15-36.
- Oliveira RM, Velho LMLS (2009). Patentes acadêmicas no Brasil: Uma análise sobre as universidades públicas paulistas e seus inventores. *Parcerias Estratégicas* 14(29):173-200.
- Pieroni JP, Reis C, Souza JOB (2010). A indústria de equipamentos e materiais médicos, hospitalares e odontológicos: Uma proposta de atuação do BNDES. *BNDES Setorial* 31(1):185-226.
- Pires ALR, Bierhalz ACK, Moraes AM (2015). Biomateriais: Tipos, aplicações e mercado. *Quimica Nova* 38(7):957-971.
- Rosa WLO, Silva TM, Lima GS, Silva AF, Piva E (2016). Fifty years of Brazilian Dental Materials Group: Scientific contributions of dental materials field evaluated by systematic review. *Journal of Applied Oral Science* 24(3):299-307.
- Sandhu PPK, Gindri IM, Siddiqui DA, Rodrigues DC (2017). Dicationic Imidazolium-Based Ionic Liquid Coatings on Zirconia Surfaces: Physico-Chemical and Biological Characterization. *Journal of Functional Biomaterials* 8(4):1-17.
- Silva ARL (2017). Implante justa ósseo, prototipado em titânio ou zircônia, ou fundido em titânio, para carga imediata e processo de produção. INPI, Brasil, 2017 BR1020170069222.
- Smeets R, Stadlinger B, Schwarz F, Beck-Broichsitter B, Jung O, Precht C, Kloss F, Gröbe A, Heiland M, Ebker T (2016). Impact of Dental Implant Surface Modifications on Osseointegration. *BioMed Research International* 2016(1):1-16.
- Tejedor LS, Romero ER (2014). Protección y gestión de la propiedad industrial. *Tecnica Industrial* 308(1):78-79.
- Valadas LAR, Queiroz LR, Bandeira MAM, Oliveira-Filho RD, Diógenes ESG, Fiallos ACM, Fiallos NM, Silva RA, Filho JRLC, Dias CC, Ponte ED, Fernandes CEL, Capistrano AB, Bruno PAM, Júnior JHCF (2017). Analyses of deposited and Granted Patents at Federal University of Ceara in Brazil. *Journal of Young Pharmacists* 9(3):307-310.