Int. J. Odontostomat.,
15(3):702-711, 2021.

Metal Alloys in Dentistry: An Outdated Material or Required for Oral Rehabilitation?

Aleaciones Metálicas en Odontología: ¿Un material Excedido o Necesario para la Rehabilitación Oral?

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MATOS, J. D. M.; DOS SANTOS, A. C. M.; NAKANO, L. J. N.; DE VASCONCELOS, J. E. L.; ANDRADE, V. C.; NISHIOKA, R. S.; BOTTINO, M. A. & LOPES, G. R. S. Metal alloys in dentistry: an outdated material or required for oral rehabilitation? *Int. J. Odontostomat., 15(3)*:702-711, 2021.

ABSTRACT: The present study aims to describe through a literature review, the main types of noble and non-noble alloys in dentistry looking to identify the adhesion mechanisms, compositions and mechanical properties, and its applicability as a rehabilitation resource nowadays. A bibliographic search was conducted in the main health databases PUBMED (www.pubmed.gov) and Scholar Google (www.scholar.google.com.br), in which studies published from 1971 to 2021 were collected. Laboratory studies, case reports, systematic and literature reviews, which were developed in living individuals. Articles that did not deal with metal alloys and its use in dentistry were excluded. Through the review, it was possible to verify that all works presented the metal alloys and their main properties, indicating that they are divided into three main types: high noble alloys, noble alloys and base metal alloys differing in their levels of constituent noble metals. Several alloys and metals are available for the dental market each presenting advantages and disadvantages, mainly based on its specific composition.Continuous research and development are resulting in the production of new technologies and products, giving dental surgeons even more options in the design and manufacture of restorations using metal alloys and understanding that these resources will still be viable alternatives in oral rehabilitations. However, further studies on metal alloys are needed to better understand this subject.

KEY WORDS: dental alloys, metal ceramic alloys, dentistry, dental research.

INTRODUCTION

The classification of dental materials in dentistry is basically divided into three: Ceramics, polymers and metals. The metals when found in pure form constitute the metal alloys that are present in various dental instruments, prosthetic parts and in implants (Anusavice, 2013).

In 1774, Duchâteau used porcelain for the first time in dentistry, making a complete denture for himself (de Oliveira Bauer *et al*., 2004; Anusavice). Favorable aesthetics and biocompatibility are important characteristics of porcelain and favored its dental application (Marklund *et al*., 2003; de Oliveira Bauer *et al*.). However, these materials are highly friable, which does not allow use when subjected to great mechanical stress, as the risk of fracture is imminent (Akagi *et al*., 1992; Chain, 2013). In 1960, the favorable characteristics of porcelain were taken advantage of in view of the development of metal alloys, which led to the use of metal-ceramic restorations, which have

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Received: 2021-01-14 Accepted: 2021-03-17

since been undergoing technological advances in infrastructure and especially in terms of metal-porcelain adhesion, which remains a challenge for the final success of restorations (Callister Junior, 1994).

Metals are made up of a large number of equal atoms, with each atom surrounded by eight to twelve other atoms of the same metallic element, having equal attractions in all directions, which provides a crystalline structure (Chen *et al*., 2018). In this context, the atoms of metals have few electrons in the last electronic layer, consequently the electrons escape easily and pass freely through the crystalline lattice, in turn being called electron clouds, allowing the union of metal atoms (Hampel *et al*., 1971). Therefore, this structure in lattices and this type of chemical bond results in a series of properties that differentiate metals from other substances (Koizumi *et al*., 2019).

In addition, metals are chemical substances of mineral origin that are presented in dentistry for restorative, rehabilitating and surgical purposes, allowing an intimate relationship with the oral environment and guaranteeing the longevity of treatments (Roberts *et al*., 2009). However, they are subject to several physical-chemical and biomechanical changes (de Oliveira Bauer *et al*.; Anusavice). Noble metals have high resistance to corrosion, but their use in the form of alloy considerably increases their resistance to imposed stresses and, consequently, the physical properties and resistance to corrosion are improved (Vallittu & Kokkonen, 1995). The compositions of the alloys are also extremely important to prevent corrosive effects and stains, due to chemical attacks promoted by the presence of metals in the oral oral cavity in direct contact with intraoral fluids, causing failures in oral rehabilitation (Wataha, 2001).

There are several properties of metals, which can highlight the brightness, malleability,ductibility, conduction of electricity and heat, high density, high melting and boiling points,tensile resistance, oxidation, corrosion and compression, surface hardness, flow that allows burnishing, low smelting shrinkage, biological compatibility, low cost, among others (de Oliveira Bauer *et al*.; Anusavice). Realizing the infinite properties that metal alloys had in the 1930s, base metal alloys were used for structures of removable partial dentures, since they have great advantages over noble alloys such as reduced cost and weight and can be offered in a wide range scale for the population in the various rehabilitation / restorative procedures nowadays (Wolfaardt & Peters, 1992).

In dentistry, metal alloys can be classified according to the number of elements; when this number of components involves only two elements combined in their various proportions, we call them binary systems (Zwilsky & Langer, 2001; Zineli *et al*., 2003). When it involves three or more elements, it is called tertiary (Zavanelli, 2000). Therefore, these components are related to numerous elements that make up the alloys (Tkachenko *et al*., 2014). The definition of highly noble alloys occurs when they contain 40 to 60 % gold, iridium, platinum, rhodium, palladium, ruthenium and osmium (Valittu & Kokkonen, 1995), unlike the predominantly basic or non-noble alloys, which have more than 75 % of common components, be they Nickel-Chromium and Chromium-Cobalt (Okuno *et al*., 1989).

Due to the widespread use of metal alloys in dentistry, further studies are needed to deepen the knowledge about these dental materials. Therefore, through this literature review, it is intended to evaluate the main types of noble and non-noble alloys in dentistry looking for identify the adhesion mechanisms, compositions and mechanical properties, and its applicability as a rehabilitation resource nowadays.

MATERIAL AND METHOD

Source Selection. A bibliographic search was conducted in the main health databases Pubmed (www.pubmed.gov) and Scholar Google (www.scholar.google.com.br), in hich studies published from 1971 to 2021 were collected. In the first stage, the list of retrieved articles was examined by reading the titles and abstracts. In the second stage, the studies were selected by reading the full contents. Two authors (JDMM and LJNN) performed stages 1 and 2. Experimental, clinical, case-control, randomized controlled and laboratory cohort studies, case reports, systematic reviews and literature reviews, which were developed in living individuals, were included. Therefore, articles that did not deal with the subject in question, letters to the editor, opinion article, duplicated literature in databases and literature that did not address the variables under study, were excluded.

Data Source. Through bibliographic search 90 articles were selected, which 77 articles were extracted from PUBMED (www.pubmed.gov) and 13 Scholar Google (www.scholar.google.com.br). The following specific medical subject titles and keywords were used: Dental alloys (DeCS/MeSH Terms); Metal Ceramic Alloys(DeCS/MeSH Terms); Dentistry (DeCS/MeSH Terms); Dental Research(DeCS/MeSH Terms) (Fig. 1).

According to Table I, it can be seen that the average publication of articles in the period from 1971 to 2021 from the Pubmed database was 2.41 and with a standard deviation of 2.08. While at Scholar Google, the average was 0.39 and the standard deviation 0.77. Thus, it was possible to verify that there was a significant variation in the number of articles in both databases (Fig. 2).

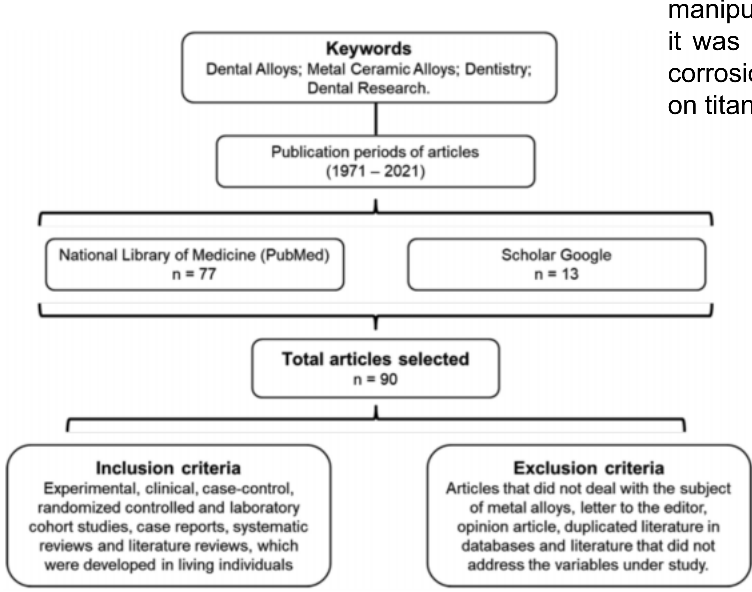

Fig. 1. Articles selection flowchart.

Table I. Mean ± standard deviation of the number of studies in the main health databases.

Database	Mean ± Stardard Deviation	Total Studies (1971-2021)
Pubmed	2.41 ± 2.08	77
Google Scholar	0.39 ± 0.77	13

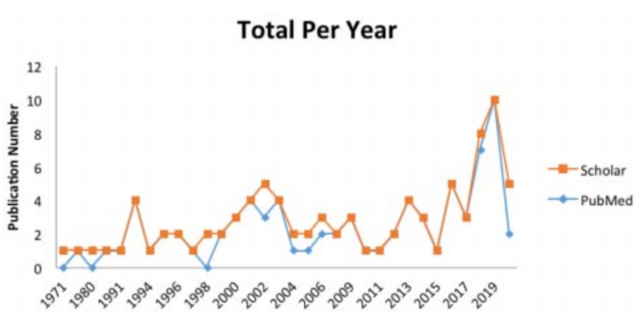

Fig. 2. Total articles published per year in the two main health databases.

RESULTS AND DISCUSION

Through the literature review, it was possible to verify that all works presented the metal alloys and their main properties, indicating that they are divided into three main types: high noble alloys, noble alloys and base metal alloys differing in their levels of constituent noble metals (McLean, 1980; Anusavice). The authors reported that for the use of alloys in metal-ceramic restorations, castability depends considerably on the structures present and also on special techniques and manipulations for different types of alloys. In addition, it was shown that silver-based alloys suffer greater corrosion among the available alloys and those based on titanium have the best properties.

Data analysis and integration. The metal alloys present in the dental market today must have the following fusibility properties; fracture toughness, corrosion, deflection; high mechanical resistance, so the professional who wants to rehabilitate patients with this resource must choose alloys with such requirements (Espevik *et al*., 1979). These materials are classified according to the levels of noble metals in their compositions, cost and mainly by the elements that compose them (Espevik *et al*.; Chen *et al*., 2016).

High noble alloys are present in dentistry for few patients, because due to their high cost they become inaccessible to a large part of the population (Anusavice).. There is a large amount of gold in its composition, as 40 % of its weight is composed of this type of metal. They are single-phase and easy to handle, except for gold-platinum-zinc alloys (Au-Pt-Zn) (Hensten-Pettersen, 1992; Wataha, 2002). These alloys will almost always have oxide builders next to their composition to increase their adhesive properties to porcelain such as indium, gallium, tin and iron (Wataha & Messer, 2004).

Noble alloys have gold (Au) and palladium (Pd) in their main composition and are commonly associated with non-noble metals, such as copper (Cu), gallium (Ga) and cobalt (Co), which makes the alloy with shades dark (Wataha, 2002). Golden alloys are widely used in dentistry due to their low corrosion properties and good marginal adaptation, however their use in

Table II. Types of metal alloys and their main indications.

Type I	Soft Alloy	They are weak and soft, being useful in areas not subject to occlusal stresses. They are not widely used (Anusavice, 2013).
Type II	MediumAlloy	They are used for inlays and onlays, in which there is a possibility to burnish the edges to increase the strength of the restorations (Asakura *et al.,* 2012; Anusavice, 2013).
Type III	Hard Alloy	They are used in inlays, onlays, three-quarter crowns, retainers and ponticsof fixed prosthodontics, where burnishing is less important than resistance (Hu *et al.,* 2010; Anusavice, 2013).
Type IV	Extra Hard Alloy	They are hard and not ductile, being indicated in regions of high tension as removable partial denture. They are not used extensively due to cost (Sun *et al.,* 2009; Anusavice, 2013).
Type V	Alloy for metal-ceramic restorations (copings)	They are used for metal-ceramic restorations (copings) (Anusavice, 2013; Rahman *et al.,* 2019).

metalloceramic restorations is difficult due to the gold not producing enough oxides that are favorable to the adhesion of porcelain (Wataha, 2002; Romão *et al*., 2018; Matos *et al*., 2020). The limitation is in the greatest probability of suffering deformations at the moment when the porcelain is being melted, as they have low elastic modulus, consequently, their resistance is lower, being contraindicated in extensive restorations (Suansuwan & Swain, 2001; Roberts *et al*.) (Table III).

Basic metal alloys are nickel-chromium (Ni-Cr), cobalt-chromium (Co-Cr) which have low cost, high modulus of elasticity, high strength, low flexibility, high melting temperature and low density (Okuno *et al*.; Vallittu & Kokkonen). Titanium is also included in this class, being classified in its pure form as a basic metal and in the form of alloy as non-base metal (Takeuchi *et al*., 2020). However, basic alloys also have disadvantages, such as high hardness, which makes it difficult to finish prosthetic parts and restorative materials, porcelain pigmentation and low corrosion resistance in relation to noble alloys (Tkachenko *et al*.) (Table IV).

The casting process of the alloys is extremely important for its use, since during the process it is necessary to know the correct melting temperature due to the particularity for each type of alloy components, in which correct handling and techniques are required (Wataha & Messer). Laboratory procedures have been improved and components added to porcelain to optimize metalloceramic restorations, such as leucite, which in the early 1960s was incorporated into porcelain with the proposal of making the degree of thermal expansion between them and metal alloys more compatible (Wataha, 2002; Romão *et al*.; Matos *et al*.).

Castability is of great importance due to the fine structures that are related to the manufacturing process (de Oliveira Bauer *et al*.). An example is Ni-Cr alloys, where beryllium (Be) plays a very important role in the process due to a decrease in melting temperature and an increase in fluidity (Okuno *et al*.; Vallittu & Kokkonen). In Co-Cr alloys, molybdenum (Mo) is added to decrease the thermal expansion coefficient and ruthenium (Ru) is used to improve its meltability (Wataha, 2002).

Interesting to elucidate with regard to the softener heat treatment, it must follow a specific protocol, in which after the casting step, the ring of the centrifuge is removed, waiting until the alloy loses its red color, and then the ring is immersed in cold water, causing a rapid cooling through a thermal shock (Callister Junior; Anusavice).Then, the hardening heat treatment can be carried out through three steps, the first is placing the restoration (ring) in the oven at a temperature of 450º C, for five minutes, immediately after the oven is turned off, and wait to reach a temperature of 250º C, subsequently immersing the ring in cold water for 15 minutes (Callister Junior; Anusavice).The second method is to place the ring in the oven at 370º C for 15 minutes, then it is removed from the oven and cooled slowly (Callister Junior; Anusavice; Chain). The third method, consists of the casting of the ring, with subsequent cooling at room temperature (Callister Junior; Anusavice; Chain).

With regard to titanium alloys, it is possible to highlight the greatest limitations in comparison to other alloys, due to their high melting temperature and low density, which require special techniques and complex equipment for their use, in addition to requiring porcelain with a low thermal coefficient, with temperature below the transition temperature of titanium itself for metalloceramic restorations (Hanawa, 2019; Koizumi *et al*.). However, titanium has satisfactory properties that promote its use in the medical / dental field, such as biocompatibility with bone tissues, has excellent resistance to corrosion (compared to other metallic alloys) and also resistance

Table III. Main chemical elements of metal alloys and their applicability in dentistry.

Metal alloy constituent elements	Applicability in Dentistry
Aluminum	It increases tensile strength and ductility, especially when associated with nickel (Morrel, 1996).
Beryllium	It reduces the melting temperature of the alloy (100 degrees Celsius), the ductility and the resistance to corrosion (Zwilsky & Langer, 2001).
Carbon	The surface hardness of the alloy increases when it is above 0.2 %, the alloy becomes very hard, so the casting process is impossible to occur (Harper, 2000).
Cobalt	It increases the resistance (hardness) and elasticity (Vallittu & Kokkonen, 1995; Morrel, 1996).
Copper	It increases the resistance by up to 20 %, increases the hardness and reduces the melting zone of the alloy, allowing greater homogeneity of the alloy (Morrel, 1996).
Chrome	It increases the resistance to loss of shine and corrosion, and should not exceed 29 % (Okuno *et al.,* 1989; Callister Junior, 1994).
Gold	It provides resistance to oxidation and increases the ductility and malleability of the alloy (Okuno *et al.,* 1989; Wataha, 2002).
Silver	It improves the alloy's ductility, neutralizes the reddish color conferred by copper and facilitates burnishing (Wataha & Messer, 2004).
Platinum and Palladium	It provides greater resistance to oxidation and corrosion, increasing the strength and hardness of the alloy (Callister Junior, 1994; Morrel, 1996; Wataha & Messer, 2004).
Tin	It increases malleability (Callister Junior, 1994; Morrel, 1996).
Molybdenum	When it has 3 to 6 %, it increases resistance to corrosion and increases ductibility (Callister Junior, 1994; Morrel, 1996).
Manganese	Increases the flow of the alloy (Okuno *et al.,* 1989; Wataha, 2002).
Nickel	It increases the malleability of the alloy (Okuno *et al.,* 1989; Callister Junior, 1994).
Niobium	It acts as an inducer of bone formation, cell growth and corrects deleterious bone defects (Johansson & Albrektsson, 2001; Ribeiro *et al.,* 2009).
Titanium	It acts as a prosthetic rehabilitation material, replacing a lost dental element (Hanawa, 2019; Koizumi *et al.,* 2019).
Zinc	It acts as an antioxidant agent (Morreu, 1996; Wataha & Messer, 2004).
Zirconia	It acts as an aesthetic rehabilitation material, being used in fixed dentures on teeth and on implants (Piconi & Maccauro, 1999; Mehjabeen *et al.,* 2018; Matos *et al.,* 2020).

to attacks by acids, minerals or chlorides (Osman *et al*., 2013).

Another alloy that has shown prominence are those composed of niobium (Nb), in turn presenting the same number of protons and electrons, about forty-one in their composition and atomic mass 92.9u (Johansson & Albrektsson, 2001). Niobium has physical and chemical properties similar to that of the chemical element tantalum and, therefore, both are difficult to distinguish (Johansson & Albrektsson). Tantalum is widely used in metal alloys, especially in the production of special steels used in pipeline tubes and in the production of fluid-conducting tubes, under normal conditions it presents itself as a white solid (Johansson & Albrektsson; Ribeiro *et al*., 2009). Although these alloys contain a maximum of 0.1 % niobium, this small percentage gives a high mechanical resistance to steel (Johansson & Albrektsson; Ribeiro *et al*.). The thermal stability of super alloys that contain niobium is important for the production of dental engines and in various superconducting materials (Ribeiro *et al*.).

Table IV. Distribution of mechanical properties of materials.

Materials	Elastic modulus (GPa)	Poisson ratio
Zirconia (Piconi & Maccauro, 1999)	220	0.30
Titanium (Osman *et al.,* 2013)	110	0.34
Niobium (Johansson & Albrektsson, 2001)	103	0.38
Aluminum (Morrel, 1996)	69	0.33
Beryllium (Zwilsky & Langer, 2001)	128	0.25
Carbon (Harper, 2000)	220	0.25
Cobalt (Morrel, 1996)	209	0.31
Copper (Morrel, 1996)	115	0.34
Chrome (Callister Junior, 1994)	286	0.21
Gold (Morrel, 1996)	77	0.42
Silver (Callister Junior, 1994)	84	0.36
Platinum and Palladium (Morrel, 1996)	171	0.39
Tin (Morrel, 1996)	44.3	0.33
Molybdenum (Morrel, 1996)	320	0.32
Manganese (Callister Junior, 1994)	198	0.29
Nickel (Morrel, 1996)	204	0.31
Zinc (Morrel, 1996)	104.5	0.25

Niobium in the form of oxide (Nb2O5) is a semiconductor with numerous applications in optical devices and in heterogeneous catalysis, as an active phase (Zanetta-Barbosa *et al*., 2002a). All of these destinations are noble, but could be further refined, so other applications of these alloys include chemistry, biology, bioengineering, dentistry and medicine

(Zanetta-Barbosa *et al*., 2002b). With regard to dentistry, it is known that through chemical reactions the material becomes more reactive and with special properties that allows a wide use in dentistry, whether in bleaching gels, dentifrices, making structures for oral rehabilitation and surface treatment of implants (Zanetta-Barbosa *et al*., 2002a,b).

Laboratory studies have shown that this biomaterial is non-toxic, biocompatible, bactericidal, low elastic modulus, high corrosion resistance, thermodynamic stability, adequate mechanical properties, low toxicity and no negative behavior towards the living organism (Johansson & Albrektsson; Zanetta-Barbosa *et al*., 2002a,b; Ananth *et al*., 2018). In addition, its excellent physical-chemical properties can be highlighted, especially when evaluating the cell viability of this metallic alloy, as the material has a high capacity to enhance the induction of bone formation, cell growth and corrective of deleterious bone defects, it especially owes its bioactivity property (Kokubo *et al*., 2003; Miyazaki, 2008). But not only that, the ability to establish a direct reaction with bone tissue can also be highlighted, producing an effect of tissue and bone regenerator and with maximum antimicrobial effect (Anselme, 2000).

In addition, niobium, like titanium, has a protective surface oxide layer (Jelínek *et al*., 2017). This oxide is niobium pentoxide, which forms quickly and spontaneously when the metal is exposed in oxygen-containing media (Bleckenwegner *et al*., 2017). This layer, in turn, is considered stable and responsible mainly for the biocompatibility of the alloy, thus being widely used in antiallergic coatings of implant-supported prostheses (Bleckenwegner *et al*.; Jelínek *et al*.). However, new studies have demonstrated the addition of oxides on the surface of these materials allowing it to stimulate the interaction with bone tissue, so that the osseointegration between the implant and the tissue is improved, resulting in a reduction in recovery time of the patient (Ficarro *et al*., 2008; Tolosa *et al*., 2018; Fernandes *et al*., 2019a,b).Some surface characteristics that improve interaction with the biological environment and promote better osseointegration are: topography, roughness, porosity, hydrophilicity, oxide crystallinity and surface chemical composition (Eisenbarth *et al*., 2006; Ficarro *et al*.; Tolosa *et al*.). Therefore, the surface playing a fundamental role in the responses of the implants to biological tissues and often, due to adequate surface treatments, exhibit different characteristics in relation to the original substrate (Nowak & Ziolek, 1999; Ficarro *et al*.).

In the oral environment, the alloys must exercise their most favorable properties efficiently so that the patient's rehabilitation does not damage their oral health, both in aesthetic and functional aspects, thus, properties such as corrosion resistance are essential factors when choosing a type alloy (Johansson & Albrektsson; Zanetta-Barbosa *et al*., 2002a). It is known that noble alloys in general are less influenced by external chemical agents, being less corroded (Fernandes *et al*., 2019a,b). Alloys with silver (Ag) in their composition, a non-noble element, react chemically with air, water and sulfur, generating dark substances such as silver sulfate (Tchaplyguine *et al*., 2018; Oleshko *et al*., 2019). Titanium is the metal that has better properties against corrosion, since in its surface layer it is formed by stable oxides that protect the material from this type of destruction (Sri *et al*., 2019; Mello *et al*., 2019).

The search for oral rehabilitation procedures as a way to guarantee the proper function of oral structures allowed the metal alloys to play an important role in the patient's quality of life, especially when they are applied in implant-supported prostheses, removable partial prostheses, fixed prostheses, restorations in dentistry and unitary implants (Wataha, 2002; de Oliveira Bauer *et al*.; Roberts *et al*.). It is important to note that the applicability of the different types of alloys is specific to each case (Wataha, 2002).

The noble alloys present in the market today were the first to be used by dentists in clinical practice, which promoted the evolution of research (Roberts *et al*.). The development of science has allowed the emergence of alternative alloys such as basic metal alloys, which have a lower cost (Wataha, 2002; Anusavice).

For the correct use of metal alloys, it is necessary to evaluate their properties, with mechanical resistance, ease of casting and low corrosion being the most relevant factors at the moment of choice (Shillingburg, 1998). Each type of alloy has qualities and defects, so the dental surgeon and dental technician must have the discretion to choose them in each specific case, evaluating the properties of each material (Wataha, 2002; Anusavice).

When selecting high noble alloys that have a large amount of gold in their composition, production costs should be considered, as they have a high value (Schuster, 1996). However, this alloy when evaluated from the point of view of biological safety has excellent advantages, and there is no doubt that it is the most biocompatible with oral tissues (Roberts *et al*.). High noble alloys, generally present in their composition other metals that alter their properties, such as, for example, gallium that reduces its melting temperature in metal-ceramics, as well as indium, tin and iron that increase the formation of oxides and promote greater adhesion porcelain (Matos *et al*.).

Widely used in dentistry due to their low cost and excellent properties, basic metal alloys are on the market with great acceptance from the dental community due to their superior mechanical properties, such as high mechanical strength values and high hardness, in addition to being more resistant to deformations at high temperatures (Sadowsky, 2020). Because of this, these alloys were widely introduced in prosthetic rehabilitation and metal-ceramic restorations (Wataha, 2002; de Oliveira Bauer *et al*.; Roberts *et al*.).

The use of metal alloys for rehabilitation treatments has great advantages, since its wide use has promoted several studies for a better understanding of the materials used and improvement of existing limitations (de Oliveira Bauer *et al*.; Reitemeier *et al*., 2006; Roberts *et al*.; Jesus *et al*., 2020). In this context, a well-known material is highlighted for being considered the white metal of dentistry: zirconia (Piconi & Maccauro, 1999; Matos *et al*.).This metal presents as raw material the minerals of zirconium (ZrSiO4) and baddelyite (B-ZrO2) (Hanawa; Campos *et al*., 2020). Thus, zirconium is intended for an application as a metal, while oxide white zirconium crystalline is designated as dental ceramic (Piconi & Maccauro; Matos, 2020).

Zirconia oxide appears as a transition metal in the periodic table, having a dark blue color in its raw form (Piconi & Maccauro; Matos *et al*.). After laboratory procedures, this metal acquires its crystalline shape, modifying its properties and showing the characteristic aspect in white, allowing the opacification of darkened dental remnants and infrastructures, in addition to masking in areas of thin periodontal tissue, which highlights its potential as a superior aesthetic metal (Shi *et al*., 2016; Sadowsky).The zirconia metal alloy has good resistance to corrosion in acidic environments, which increases its applicability in relation to other metals (Tkachenko *et al*.; Mehjabeen *et al*., 2018). The non-toxic metal characteristic is favorable and guarantees a bio-inert behavior when intimate with oral structures, therefore, it allows its use as a structural component of dental products, from restorative materials to dental implants (Wataha, 2002; Nie *et al*., 2014). Some of the different metallic alloys sold have adverse hypersensitivity effects, with zirconia as a safe alternative to cases of allergic sensitivity (Rinke *et al*., 2013; Sadowsky).

The choice of materials for application in the oral environment must consider factors such as microbial adhesion to the product of choice and a low thermal conductivity (Campos *et al*.; Matos *et al*.). Zirconia shows reduced bacterial growth on its surface, which guarantees a reduction in complications in soft and hard tissues, as well as a longevity of treatments, in addition to preventing the spread of thermal stimuli to support structures (Chen *et al*., 2016; Hanawa). The high hardness, good mechanical resistance and less wear compared to titanium alloys allow to define zirconia as a material with excellent physical properties (Osman *et al*.; Mehjabeen *et al*.; Hanawa).

The ability to osseointegrate and excellent adhesion to soft tissues are important characteristics that increase the use of zirconia alloys, as it allows better clinical performances and durability to the treatments performed (Matos *et al*.; Sadowsky). Considering the need for materials with excellent properties for use as new rehabilitation resources, zirconia is able to meet these requirements and play great potential among the other available metals (Roberts *et al*.; Rinke *et al*.; Hanawa). The use of zirconia reinforces the applicability of metal alloys in relation to other existing dental materials and allows us to understand that these resources are still viable alternatives in rehabilitation treatments because they present high advantages, accessible cost and mastery of the techniques of use (McLean; Kokubo *et al*.; Matos).

CONCLUSIONS

It can be concluded from this study that several alloys and metals are available for the dental market each presenting advantages and disadvantages, mainly based on its specific composition. Continuous research and development are resulting in the production of new technologies and products, giving dental surgeons even more options in the design and manufacture of restorations using metal alloys and understanding that these resources will still be viable alternatives in oral rehabilitations. The use of zirconia reinforces the applicability of metal alloys in relation to other existing dental materials and allows us to understand that these resources will still be viable alternatives in rehabilitation treatments. However, further studies on metal alloys are needed to better understand this subject.

ACKNOWLEDGMENTS

This work was supported by the São Paulo Research Foundation (FAPESP – grant numbers 2019/24903-6).

MATOS, J. D. M.; DOS SANTOS, A. C. M.; NAKANO, L. J. N.; DE VASCONCELOS, J. E. L.; ANDRADE, V. C.; NISHIOKA, R. S.; BOTTINO, M. A. & LOPES, G. R. S. Aleaciones metálicas en odontología: ¿un material excedido o necesario para la rehabilitación oral?. *Int. J. Odontostomat., 15(3)*:702-711, 2021.

RESUMEN: El presente trabajo tuvo como objetivo describir a través de una revisión de la literatura, los principales tipos de aleaciones nobles y no nobles utilizados en odontología buscando identificar los mecanismos de adhesión, composiciones y propiedades mecánicas, así como reflejar su aplicabilidad como recurso rehabilitador en la actualidad. Realizamos una búsqueda bibliográfica em las principales bases de datos de salud PUBMED (www.pubmed.gov) y Scholar Google (www.scholar.google.com.br), en la que se recopilaron estudios publicados desde 1971 hasta 2021. Estudios de laboratorio, informes de casos, revisiones sistemáticas y bibliográficas, que se desarrollaron en individuos vivos. Sin embargo, se excluyeron los artículos que no trataban sobre aleaciones metálicas y su uso en odontología. Se pudo observar que todos los trabajos presentaban las aleaciones metálicas y sus principales propiedades indicando que se estas dividen en tres tipos principales: aleaciones altamente nobles, aleaciones nobles y aleaciones de metales base que difierenen sus niveles de metales nobles constituyentes. Hay varias aleaciones y metales disponibles para el mercado dental, cada uno presenta ventajas y desventajas, principalmente en función de su composición específica. La investigación y el desarrollo continuo están dando como resultado la producción de nuevas tecnologías y productos, brindando a los cirujanos dentistas aún más opciones en el diseño y fabricación de las restauraciones, utilizando aleaciones metálicas y, permite concluir que estos recursos seguirán siendo alternativas viables en los tratamientos de rehabilitación. Sin embargo, se necesitan más estudios sobre el tema abordado en el trabajo, para una comprensión más profunda del tema.

PALABRAS CLAVE: aleaciones dentales, aleaciones de cerámica y metal, odontologia, investigación dental.

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