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Alloys and Ceramics Used for Crowns and Bridges: Survey Among Dentists in Private Section in The City of Casablanca Morocco

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ABSTRACT

Introduction: *This study aims to know the most used alloys and ceramics used by dentists and to make an inventory of their knowledge in this field.*

Material and methods: *A descriptive epidemiological survey was conducted among 309 dentists, holding a private practice in Casablanca, through an anonymous questionnaire.*

Results: *Our study had a participation rate of 85.8% and found that the majority of practitioners used Nickel-Chromium-based alloys for crowns and bridges' substructures, whereas only 30% use Co-Cr.*
Precious alloys are used by 11% of practitioners.

The alloy's essential selection criteria are the mechanical properties 62.6%, the cost 41.9%, the clinical situation 40.8% and the processing technique 23.8%. Zirconia based ceramics were the most used materials (more than 70%) by our practitioners for ceramic restorations followed by glass ceramics and then aluminous based ceramics.

Discussion: *Our survey showed that Ni-Cr alloys are the most commonly used by our practitioners. While in Sweden and Japan, Co-Cr based alloys are widely favored.*
Precious alloys were still used in New Zealand. The practitioners must take into account the mechanical and biological properties when choosing an alloy.

According to the literature, the glass ceramics are preferred for anterior crowns and only anterior bridges with small extent. While Alumina and Zirconia based ceramics are preferred for anterior and posterior crowns and posterior bridges.

Conclusion: *The fixed dental prosthesis has undergone significant development due to the appearance of new ceramic and metallic materials. However, it can be difficult for the dentist to make a choice among these different materials, which is why it is important to know and understand the clinical considerations for each material.*

Keywords
Prosthodontics, Alloys, Ceramics, Crowns, Bridges.

Introduction
Fixed prosthodontics is an undeniable important discipline in dentistry. Its main objective is to ensure and maintain long-term oral function.

It includes all devices allowing the rehabilitation of the function and the aesthetics of existing teeth, the protection of endodontically treated teeth and the replacement of missing teeth [2,16,30,].

Thus, crowns and bridges find their place in the therapeutic arsenal of the dentist. Ceramo-metallic and all-ceramic crowns and bridges are known for their good functional and biomechanical aesthetic integration qualities and are nowadays widely indicated by dentists.

Choosing the right material for dental restorations has become increasingly difficult due to the great diversity of metallic and ceramic materials, and the avenue of new shaping processes. The dentist is therefore having to know the mechanical, physical and aesthetic properties and especially the clinical considerations of each material.

This diversity of materials has led us to conduct a survey in the private dental offices of the city of Casablanca, Morocco, to identify the most commonly used alloys and ceramics in practice for making crowns and bridges.

Materials and Methods
The study was conducted through an individual, anonymous questionnaire. Dentists who are exclusively specialized in orthodontics and dentofacial orthopedics and periodontics were excluded from our study.

The survey is conducted among a random sample of dentists, randomly selected by the SPSS software, from a list provided by the council of the order of dentists. The sample was 309 dentists out of a total of 1650.

The support of the survey is an individual, anonymous questionnaire, composed of 6 pages and 21 questions, divided into 4 categories: Identification, the alloys used in fixed prosthesis, the ceramics used in fixed prosthesis and finally the relationship dentist / prosthetist.

A preliminary survey was conducted before sending it to the sample dentists in order to:
- Check the relevance of the questions.
- To detect possible difficulties of comprehension.

It allowed us to make some small modifications on the questionnaire, namely:
-The addition of "I do not know" among the proposed answers.
-The addition of certain trade names of ceramics.

The paper questionnaires were distributed to dentists in their offices and retrieved over a period of two and a half months, from February 7 to April 21, 2018.
The attitudes of the dentists were diverse:
- The majority preferred to leave the questionnaire and return later.
- Some preferred to fill it instantly.
- Others refused to participate.
- And others have pointed us to their laboratory technicians.
Data entry was done with Microsoft Excel 2013 and statistical analysis with SPSS software.

Results
Of the 309 dentists selected, only 265 completed our questionnaire. (Despite anonymity, 31 refused to participate in the study and 13 others felt that the study should have been conducted among laboratory technicians), giving a participation rate of 85.8%.

Regarding the infrastructure of unit and multiple restorations, the main alloy used was nickel chromium with a percentage exceeding 60%. Cobalt chromium has come in second place. Precious alloys are rarely used by our practitioners, the percentages did not exceed 11% (Table 1).

10.2% and 11.3% of practitioners reported that they do not know the type of alloy used by their laboratory, when making crowns and bridges respectively. The properties 62.6% and the cost 41.9% of the alloy were the most criteria.

Regarding the ceramic materials used we found that (Table 2):
- For anterior crowns: 71.3% zirconia, 36.2% glass ceramic. The main choice criteria were the aesthetic. 6% mentioned their preference for PFM crowns.
- For posterior crowns: 73.2% zirconia, 11.3% aluminous ceramic. The choice criteria were the mechanical strength. 9.1% preferred PFM crowns in this case.
- For anterior bridges: 72.1% zirconia, glassceramics 16.6%. 9.4% preferred ceramic-metal bridges.
- For posterior bridges: 72.8% zirconia, 8.3% glassceramics. 14% preferred PFM bridges over all ceramic.

The choice criteria for plural restorations was essentially mechanical strength.

Table 1: Alloys used for PFM restorations.

	Effectifs	Percentages
PFM crowns		
Nickel Chromium alloys	169	63.80%
Cobalt Chromium alloys	84	31.70%
Precious alloys	30	11.30%
I don't know	27	10.20%
PFM bridges		
Nickel Chrome	164	61.90%
Cobalt Chrome	78	29.40%
Precious alloys	24	9.10%
I don't know	30	11.30%

Table 2: Ceramics used for all ceramic restorations.

Posterior crowns	Effectifs	Percentages
Glass ceramics (Emax, Empress) 28 10.6%		
Alumina ceramics	30	11.30%
Zirconia ceramics	194	73.20%
Preference for PFM	24	9.10%
Anterior bridges:		
Glass ceramics (Emax, Empress) 44 16.6%		
Alumina ceramics	33	12.50%
Zirconia ceramics	191	72.10%
Preference for PFM	25	9.40%
Posterior bridges:		
Glass ceramics (Emax, Empress)	22	8.30%
Alumina ceramics	16	6%
Zirconia ceramics	193	72.80%
Preference for PFM	37	14%

Discussion

Alloys used in fixed prosthesis

The results of our investigation have shown that dentists mainly use non-precious alloys when making crowns and bridges with metal substructures, mainly Ni-Cr with a percentage exceeding 60%. Co-Cr is used only by a minority of practitioners.

The choice of non-precious alloy for prostheses differs in the world; while some countries favor Ni-Cr alloys with or without beryllium, others currently use Co-Cr alloys. Concerns about the biocompatibility of Ni-Cr and Ni-Cr-Be alloys have even led to their banning in some European countries. In Sweden, Titanium and Co-Cr alloys are the most popular substitutes for gold [11].

The 2015th study made by Kassapidou in Sweden showed that of the 181 participating laboratories, the percentage of Co-Cr use is 75% for fixed restorations [17].

In 2003, Eliasson performed a clinical evaluation on 51 bridges and 12 crowns with Co-Cr infrastructure. No complications were observed at the crown level, giving a success rate of 100%. However, they revealed that 17 bridges had biological and / or technical complications. Six were loosened during the observation period, one bridge was fractured and nine had bursting in ceramic [11].

Although Co-Cr alloys have better properties, further studies are needed to evaluate its physical and mechanical properties as well as its durability in fixed prosthesis [1,17]. Precious alloys have many advantages, especially in biological and mechanical terms. Indeed, several factors have created the conditions for their success:
- The malleability that facilitates their work;
- The adaptability to chewing forces;
- The biocompatibility...

Unfortunately, the evolution of metallurgical, prosthetic techniques and the economy at the end of the 20th century profoundly changed the use of gold. Indeed, our present study has shown that the percentage of dentists using this material does not exceed 11%. This could be explained by the high cost of precious alloys. In the United Kingdom, economic crises have led to the adoption of cheaper non-precious alloys with satisfactory properties [34].

A survey conducted in 2010 in New Zealand among some laboratories, identified the different alloys used for making crowns and bridges and revealed the use of 55 brands of alloys of which 48 (87%) are made of noble metals [2]. Nevertheless, these results show only the types of alloys used, it would be wrong to conclude that 87% of crowns and bridges consist essentially of precious alloys.

Some dentists have reported their acknowledgment of the alloy used by their laboratory. This could be explained by a lack of involvement when choosing the metal infrastructure alloy or by lack of communication between the laboratory and the dentist. Meanwhile others reported the submission of the choice of alloy.

However, the practitioner not only needs to know which alloys are used by the laboratory but importantly justify and adapt each alloy to each clinical case.

According to Article 24 of Title II of the dentist's code of ethics in Morocco, any doctor who has agreed to give care to a patient in his office or other, undertakes to provide him with care and informed by the data acquired from Science [7].

In Europe and according to the requirements of the public health code, the practitioner must inquire about the complete composition of the alloys used by his laboratory and check the technical sheet of the chosen alloy (CE marking) or the data sheet of security. A certificate of conformity established by the practitioner is provided to the patient for each prosthetic element made [3].

The criteria when choosing the alloy:

Based on the results of our investigation, we found that practitioners were significantly oriented towards mechanical properties (62.6%), cost (41.9%), clinical situation (40.8%), and ease of use (23.8%). Note that some practitioners have chosen other criteria than those proposed in the questionnaire namely allergy, material availability, elasticity ....

Indeed, the Ni- Cr based alloys widely chosen by practitioners, meet all the mentioned criteria. In addition to the pecuniary advantage, Ni-Cr alloys have better properties for the use as an infrastructure of ceramic-metal restorations (35). These better properties are higher values of hardness and modulus of elasticity compared to gold (9). However, it is important to note that between 10% and 20% of the population is hypersensitive to nickel (23), which is why a precise interrogation should be carried out for each patient and taken into consideration when choosing the alloy.

Co-Cr as well as Titanium and Zirconium oxide could be, because of their stiffness, their high resistance to corrosion and their

biocompatibility, good alternatives to Ni-Cr, but their design remains delicate and requires great dexterity of the technician. It should be known that the shaping process of each alloy plays a very large role during the production of a metal-ceramic prosthesis.

Ceramics used in unitary fixed prosthesis

The metal-ceramic restorations have good mechanical properties, satisfactory esthetic results and an acceptable biological quality for periodontal health. However, some properties limit their use, for example, the aesthetics reduced by the presence of the metal and the opaque ceramic layer necessary to hide it thus decreasing the natural appearance of the prosthesis [4].

The demand for aesthetic restorations has led to the introduction of metal-free materials. These must have sufficient strength to constitute an alternative to the manufacture of fixed metal prostheses. The final properties of ceramic prostheses result from the chemical nature of the material and the process of their shaping. The same material can be shaped in different ways, thus impacting its properties.

The majority of participants (more than 70%) said they prefer zirconia ceramics when making crowns. This contrasts with Makhija's 2006 study, which reported that the two main ceramics were for:
The anterior crowns: glass ceramic 54%, laminated zirconia 17% [19]. The posterior crowns: 32% in Zirconia and 21% in Vitroceramic [22,19].

Zirconia crowns have gained popularity due to their high strength and toughness. However, some dentists may decide not to use it because of their opacity and long-term degradation [5]. Zirconia laminated ceramic restorations are considered a more aesthetically pleasing option, but the relatively low coefficient of thermal expansion of zirconia leads to complications in the form of fracture and delamination of cosmetic ceramics over time [19].

The Swedish study cited before reported that 64% of the laboratories surveyed used zirconium dioxide [17]. The zirconium oxide marketed under the name zirconia Y-TZP has better chemical, mechanical and physical properties as well as good clinical success [25].

However, zirconium oxide ceramic restorations need more time to be fully proven as to the suitability of their long-term strength [6]. Indeed, dentists who have used it have reported clinical failures. These failures seem to be mainly fractures at the level of the cosmetic ceramic [6,9].

The EmaxZirpress® IPS system would be ideal for combining both aesthetics and mechanical strength. In this category, zirconia is used to have a strong substructure on which a fluoroapatite glass ceramic is pressed. This system would also be recommended for anterior plural restorations [36].

Lithium Disilicate-rich glass ceramic, known as IPS Emax®, is another popular choice for crowns. It is more translucent than zirconia [14] and used mainly for anterior restorations. According to two prospective studies carried out in 2006 in Germany [20] and 2005 in Turkey [32] on 27 and 20 crowns in Lithium Disilicate reinforced glass ceramics, the cumulative survival rate of these crowns was of the order of 100% at 5 years for the first study and 2 years for the second study and this regardless of the sector. The authors concluded that this material was suitable for crowns.

Another glass ceramic has inspired confidence since its appearance in terms of aesthetics. It is the Leucite-reinforced glass ceramic, known under the trade name IPS Empress®, it would be more translucent than Lithium Disilicate [15] but less resistant than this one; studies [13,18,29] have evaluated the clinical performance of Leucite-reinforced glass ceramics at different monitoring periods. At 2 years, the Lehner study [18] showed a survival rate of 95%, however the authors pointed out the occurrence of fractures 2 months after the pose and that they were related to a manufacturing defect. They concluded that survival could be improved.

At 4 years, retrospective follow-up of 75 crowns showed a survival rate of 91% and showed that fractures mainly affected molars and premolars [29]. It can be deduced that the clinical performance of crowns with Lithium Disilicate or Leucite reinforced substructure is satisfactory, but their poor follow-up rate in the posterior sector would limit their indication to anterior crowns in the absence of parafunctions.

Concerning Aluminous ceramics, a retrospective study of 546 anterior and posterior alumina crowns reported a survival rate of 99.1% after six years of service [28].

Whereas In 2000, McLaren studied the survival of 408 crowns in Ceram Alumina® in 107 patients for 3 years. The crowns were placed on anterior and posterior teeth. The average survival rate was 96%, with better longevity for anterior (98%) than posterior (94%) crowns [21].

Ceramics used for plural fixed prosthesis

The results of our study have reported that the main ceramic used by our practitioners during the realization of bridges is ceramic based on zirconia.

A search in the literature has allowed us to identify the types of ceramics used for the realization of all bridges and their indication.

IPS Empress2® Lithium Disilicate Glass Ceramics are recommended only for small (3-element) anterior bridges because of the high susceptibility to fractures [8]. Indeed, two prospective studies on 30 and 31 bridges of 3 elements in lithium disilicate showed survival rates of about 93% at 2 years for the first study, and 78% at 5 years for the 2nd study. The authors emphasized the occurrence of fractures most often associated with inappropriate dimensions of the connection areas [12,20].

Aluminous ceramics (InCeram Alumina®) are intended only for anterior restorations subjected to medium mechanical forces. Sorensen reported in his study that the survival rate was 100% at the anterior sector compared to 83% at the posterior sector where fractures of the connections were observed [10].

Aluminous ceramics enriched in Zirconia (InCeram zirconia®) are mostly intended for restorations subject to significant forces without major aesthetic imperative. They can be used for small extent anterior and posterior bridges.

Zirconia ceramics have mechanical properties that are twice as high in flexion as reinforced glass ceramics, allowing their use for posterior bridges [6]. The clinical results of several studies carried out on Zirconia restorations, have shown that the use of this material would be favorable with a survival rate of 100% after 5 years of function [33]. However, some complications have been observed such as the occurrence of secondary caries and fractures at the bridge or covering ceramic [24,26 27,31]. The first results of the studies concerning zirconia are promising, the clinical performance of Zirconia for small bridges is higher than that of alumina bridges. However, the bursting rate of the zirconia ceramic remains higher than that of the metal-ceramic; longer-term studies are needed to better evaluate clinical performance.

The criteria for choosing ceramics

Our investigation revealed that the main criteria for the selection of ceramic materials was the aesthetics for anterior restorations and the mechanical properties for posterior restorations.

However, there was a discrepancy; Zirconia was the material of choice for anterior restorations for the majority of our sample and does not meet this criterion. Indeed, the first zirconia ceramic was known for its reduced aesthetic qualities and opacity, however the new available zirconia Prettau® can promise high aesthetic qualities.

Overall, any ceramic system should be chosen based on physical properties such as strength, fracture resistance, wear resistance and long-term results as well as aesthetic considerations.

PFM vs All ceramic

Our study revealed that despite the great diversity of ceramic materials, some practitioners would seem to prefer metal-based restorations. Indeed, the advantages of PFM systems lie in their predictable structure, performance, versatility, and the fact that less knowledge is needed to opt for an appropriate system. The structural performance of metal ceramic restorations remains much better than ceramic-ceramic systems.

+From a functional point of view, ceramics have a greater hardness than enamel which can lead to excessive wear of the opposing teeth.
+Ceramics are intrinsically fragile and have poor resistance to bending and thus to transverse shear forces.
+It is impossible to repair or modify the restoration by adding materials. When a fracture or crack of ceramics appears, the case is indirectly considered a failure because the remake is the only valid solution.

These results could also be explained by:
- The high cost and the low reimbursement by the social security bodies clearly insufficient for them to be integrated into the daily treatment plans.
- Their clinical implementation requires great rigor in all stages of implementation.
- Their use in the laboratory requires for the majority of ceramic systems a highly qualified staff specialized in a particular ceramics technology. -A laboratory can be specialized in one or two ceramic technologies, rarely more, which limits the practitioner's choice and therapeutic options.

Conclusion

To our knowledge, this is the first study that reported the different materials used to make crowns and bridges by dentists from the private sector of the city of Casablanca, Morocco.

Our results indicate that Nickel-Chromium remains the main alloy used by our practitioners. Zirconia is the most used ceramic for all ceramic crowns and bridges.

Despite the great diversity of ceramic materials, some practitioners seem to prefer metal-based restorations.

Recommendations

An analysis of the literature allowed us to draw up two tables summarizing the alloys and ceramics used:

Alloys	Properties /limits
Ni Cr	- Hardness + - Shear bond strength ++ - Low cost - Allergy - Large indication
Co Cr	-Hardness ++ -Elasticity modulus -Biocompatibility + -Shear bond strength + -Hindsight in fixed prosthodontics -
Precious alloys	-Hardness depends on its composition -Corrosion resistant -Biocompatibility ++ -High cost

Types de céramique	Systèmes	Indications
Les vitrocéramiques : Lithium Disilicate (SiO2-Li2O) Leucite (SiO2-Al2O3-K2O)	IPS Empress 2 IPS Emax press IPS Empress2	 Anterior crowns and bridges Only Anterior crowns
Alumina ceramics	In Ceram Alumina In Ceram Spinell In Ceram Zirconia	Crowns and bridges Only anterior crowns Crowns and bridges
Zirconia ceramics	Lava Cercon Denzir Procera	Crowns and bridges

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