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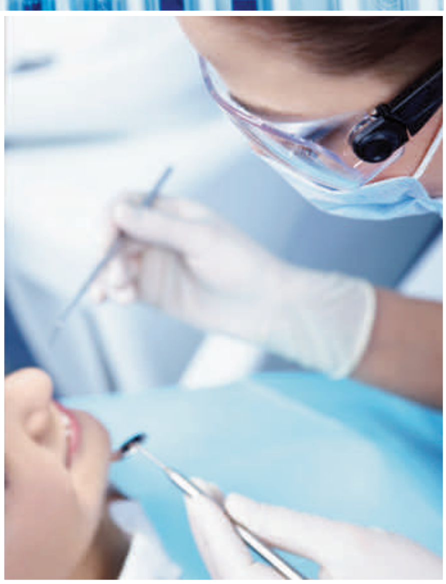

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editorial

Dr. Jesús Calatayud Sierra
Editor of Científica Dental.

In this issue we present various papers that we hope are of great interest for the readers.

Dr. García-Riart et al. present a review on the scientific evidence available at this time in the criteria for performing prophylactic extractions of third molars, discussing the aspects of consensus and those of controversy.

The paper by Dr. David E. Villares et al. on the causes of extraction of permanent teeth in a Primary Care Centre takes us to the clinical reality of the day-to-day practice of public dentistry.

Dra. Mónica López et al. bring us an interesting "in vitro" study on the resistance of the implant zirconium abutments, where they find a high resistance to fracture.

Dr. Rocío Durán et al. review the current principal criteria for dental extractions in prophylaxis and treatment of malocclusions and dentofacial deformities.

We also have two papers on clinical cases in endodontics. Dr. Antonio Montero presents the modern step-by-step techniques of apicoectomy with microsurgery. And Dr. Norberto Quispe et al. present a clinical case on how to solve an invasive cervical resorption in a maxillary central incisor.

As always, I want to thank the authors and all the members of the editorial staff of the journal *Científica Dental* for the disinterested effort that they have so that our colleagues may have the works that help them in their daily tasks.

Greetings to all.

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Bibliographic review

Therapeutic approach for third molars: Extraction or surveillance?

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ABSTRACT

One of the daily challenges facing the oral or maxillofacial surgeon is the therapeutic management of asymptomatic and disease free third molars. To date, there has been a lack of conclusive information, with problems in the interpretation of recent literature as well as different views among professionals regarding whether to perform an extraction or maintain active surveillance. The aim of this paper is to review recent literature regarding the therapeutic decisions in these cases; discuss aspects of consensus and controversies; and look for scientific evidence to justify the prophylactic extraction of the third molar. Controversy over the optimal therapeutic management of an asymptomatic third molar, free of disease continues today. This review found no scientific evidence to justify the prophylactic extraction of third molars. Much more scientific evidence, as well as the design of randomised clinical studies to compare the short- and long-term active surveillance and extraction of third molars is needed.

KEYWORD

Retained third molar; Asymptomatic third molar; Prophylactic extraction of third molar.

BACKGROUND

The therapeutic approach for symptomatic third molars (3Ms) or with pathology is simple, but there is controversy over whether to perform extraction or surveillance of asymptomatic and pathology-free 3Ms[1].

Historically, the American Association of Oral and Maxillofacial Surgeons (AAOMS) recommends the extraction of 3Ms before the patient reaches adulthood[2]. However, the American Public Health Association has the opposite attitude to prophylactic extraction that subjects individuals and society to unnecessary costs; thus avoiding potential morbidity and surgical risk[2,3]. It must be borne in mind that supporting just one of these two extreme positions can be a mistake, as common sense should dictate the better of these two extreme strategies in each particular case.

To date, there has been a lack of conclusive information. Thus, it is better to follow a criterion in accordance with clinical and radiological findings and based on scientific evidence to bring together the best available information before making a decision. The professional and patient can take a mutually agreed therapeutic decision: tooth extraction or surveillance (following a monitoring and follow-up protocol at all times)[1].

The objectives of this article are to review the recent literature related to therapeutic decisions in asymptomatic, pathology-free 3M cases to discuss aspects of consensus and controversies and seek scientific evidence to justify prophylactic extraction of the 3M.

A search was performed in Spanish and English with the full text and without limiting the publication year.

ASYMPTOMATIC AND PATHOLOGY-FREE 3M

The term asymptomatic is insufficient to describe the state of a 3M, as the absence of symptoms is not the same as the absence of pathology[4,5]. Furthermore, this term is ambiguous in the literature, making the interpretation of comparisons difficult[4].

For example, in many cases the patient does not refer to symptoms in the area of 3M in which a radiolucent radiographic inspection image is seen. However, the frequency of occurrence of cysts or benign tumours is very low and, although such cases and images provide compelling data, pre-emptive extraction of a retained 3M to prevent the occurrence of these diseases is not justified[4].

Therefore, the extraction of an asymptomatic 3M must be supported by evidence demonstrating that “asymptomatic” does not necessarily mean the “absence of disease”[5].

Also, the terms asymptomatic and pathology- or disease-free for 3Ms[1, 4, 6] should be differentiated (Table 1).

In 2012, Dodson et al systematically developed a classification of 3Ms by clinical and radiological examination to avoid the ambiguity of the term asymptomatic (Table 2), and concluded that the estimate of the prevalence of truly asymptomatic, pathology-free 3Ms had a range of 11.6-29%[4,6].

PROPHYLACTIC EXTRACTION VS ACTIVE SURVEILLANCE

To date, there are insufficient data to prefer either of the two options, i.e. the two strategies are currently valid and accepted[2]. A systematic review by Metters et al in 2005 found no evidence to defend or reject routine prophylactic extraction as a strategy for management of asymptomatic retained 3Ms. Therefore, these authors defend the surveillance and monitoring approach[7].

Given the available literature, therapeutic management of 3Ms should be performed after rational judgment based on clinical and radiological evidence. Therefore, after a balanced assessment of the risks and benefits of both treatment options,

Table 1: Criteria for establishing an asymptomatic and pathology-free 3M

1. If the 3M shows no symptoms or the patient has no concerns. Symptoms are vague, self-limiting or cannot easily be attributed to 3Ms.
2. If the 3M is retained or impacted, cannot be probed or the probe depth is less than 4mm, if partially erupted.
3. If the 3M is erupting, there must be enough space for eruption into a functional position.
4. If the 3M has erupted, it must be functional, maintaining good hygiene, have adequate gingiva around the tooth, be free of decay or be easily restorable.
5. There is no obvious pathology in the radiographic examination.

the study of each particular case will dictate the best strategy[2].

To assess the right time for extraction, it is essential to predict the tooth eruption and recognize in advance if it may trigger a pathological process in the future. According to the Current Care Guideline, preventive dental extraction in young people is justified in the case of a mandibular third molar for three groups: partially erupted horizontally, partially erupted upright and incomplete growth of the roots near to the dental nerve canal[8]. Tolstunov recently suggested a 3M extraction protocol based on the strong association between age and the development of signs and symptoms related to 3Ms, the degree of coronal exposure and the risks and benefits of 3M extraction[9] (Table 3).

Table 2: 3M Classification according to clinical symptoms

Group A: (PATHOLOGY + / SYMPTOMATOLOGY +)
Based on clinical history, clinical examination and radiography (symptomatic pericoronitis, caries, inflammation or pain due to an infection secondary to a cystic lesion, for example).
Group B: (PATHOLOGY - / SYMPTOMATOLOGY +)
Symptoms of dental pain due to the normal process of eruption or vague symptoms of pain in the region of 3M, without evidence of pathology.
Group C: (PATHOLOGY + / SYMPTOMATOLOGY -)
Clinically and radiologically evident pathology, but without symptoms (inflammation of the soft tissues, caries, plaque accumulation, increased probing depth, cystic lesions, rhizolysis or decay in adjacent teeth.
Group D: (PATHOLOGY - / SYMPTOMATOLOGY -)
The patient has no symptoms and there is no 3M pathology based on clinical and radiological examination.

Table 3: Tulstunov et al extraction protocol depending on age

Patient age	Treatment strategy
0-15	3M extraction not recommended.
16-25	Symptomatic and asymptomatic 3M extraction is recommended if the benefits outweigh the risks.
26-35	Extraction of symptomatic or asymptomatic 3Ms if exposed, when the benefits outweigh the risks.
≥ 36	Extraction of symptomatic 3Ms if exposed. Extraction of asymptomatic 3Ms not recommended.

Why is it important to know in advance which retained 3Ms should be removed in the future? The answer is cost. Extraction of a retained 3M in a young patient is simpler and involves fewer complications, so the risks can be reduced by performing the extraction preventively in young patients[8]. It is clear that maintaining dental retention is not a low cost alternative, considering the periodic active monitoring and risks of delaying intervention[11].

In addition, it may be more important to predict which 3Ms will develop a pathological condition or symptoms, so it can be extracted in time when the risks are minimal. It is essential to predict the onset of risk factors such as pericoronitis, caries and periodontal problems to indicate prophylactic extraction[8].

PREDICTING A 3M ERUPTION

This is one of the most significant interests in orthodontics and oral surgery. Extraction of premolar or other teeth for orthodontic purposes must be performed before the age of 20 when 3Ms are expected to erupt to correct for the missing space. In 1979, the Consensus Conference of Third Molars reported that there were no reliable methods for predicting the eruption of 3Ms. Later, in 1993, the AAOMS stressed it was not possible to accurately predict changes in the position of 3Ms. For this purpose, it seems that panoramic radiography is the best tool; in addition to other techniques, such as cephalometric studies, bitewing radiographs and anteroposterior and periapical radiographs[8].

There is extensive literature that has contributed to increasing knowledge in predicting the eruption of the 3Ms. Since the 1993 Workshop, predictive accuracy has greatly improved, with values up to 97% efficiency. The most significant variable associated with eruption seems to be the retromolar space. In clinical practice, simple and easy application methods are needed. In general, it should be noted that the prediction of the eruption has shown to be relevant only for a short period of time in young adolescents up to 20 years. The 3Ms which have not erupted at age 20 are often removed (74% of the time) compared with partially erupted (64%) and erupted (50%)[8].

LONG-TERM CONSEQUENCES OF RETAINING THE 3M

These are often unknown and unpredictable. Given the high probability of developing a future pathology, active surveillance with periodic clinical and radiographic examination is recommended to detect any pathology before it becomes symptomatic[2,5,10,11].

It is clear that retained 3Ms may remain asymptomatic and free of disease; however, they are unlikely to remain static and unchanged in their position over time, so they may eventually trigger a pathological process [5,10]. According to Ventä et al, retained teeth may change position from the middle of the third decade of life[12].

There is sufficient evidence in the literature to show that retained 3Ms do not remain static; i.e. changes in angulation and position of the retained 3M should be considered as risk markers. In addition, it must be said that there are no predictive positional data and probably will not be in the near future; this is usually due to the lack of information available and costs required to carry out longitudinal studies of different populations[10].

Different prospective studies in periodontal disease and the incidence of caries associated with retained 3Ms show that asymptomatic 3Ms do not necessarily reflect the absence of disease and that there is a "surge" of pathology directly proportional to age. While recent studies[18,19,20,21,22] have shown a series of compelling arguments for the early extraction of the retained 3Ms to prevent disease, previous and usually retrospective studies have been based on the identification and development of pathological variables, such as odontogenic cysts, rhizolysis and commitment to the integrity of 2M[5].

In short, considering the consequences of retaining the 3Ms as a whole, there is sufficient evidence to justify the extraction of asymptomatic 3Ms: inflammatory disease, tooth decay, the relationship between periodontal disease and systemic disease, expenses related to the maintenance of an (apparently pathology-free) 3M and 3M surgery in older and probably ill patients[5,14].

However, for active surveillance, the high frequency of inflammatory and asymptomatic pathology associated with 3Ms must be reviewed, while taking into account the risks and benefits of maintaining the 3M and the importance of regular monitoring and periodic re-evaluation[5].

A very interesting study by the AAOMS and published in 2012, Proceedings of the Third Molar Multidisciplinary Conference, suggested a cost model to try to find a balance between the decision to extract and the disadvantages associated with maintaining retained 3Ms [15] (Table 4).

It has been suggested that there are 2 options for the maintenance and surveillance of a retained 3M[2]:

1.- Active surveillance: a prescribed programme of regular monitoring and periodic evaluation of the 3Ms.

2.- "Necessary" monitoring: maintenance and monitoring when the 3M is symptomatic or the pathology is manifest.

Active surveillance is a "non-operative" management strategy of asymptomatic retained 3Ms, characterised by the prescription of a series of regular visits, including a reassessment of clinical history, clinical examination and periodic radiography [(2,5)]. Given the age-related risk of complications when extracting a 3M, this is reasonable. Symptoms usually appear in advanced stages of the disease, which justifies regular monitoring visits to detect and treat the disease before symptoms appear (2,5). It must be borne in mind that delaying an extraction may increase the risk of complications associated with this, which is directly proportional to age [2,5,11,13,14].

The rationale for the selection of biannual visits is compelling. Pathology develops slowly, and clinically significant evidence of progression of periodontal disease, for example, may appear within 2 years[2,11].

Short-term cross-sectional studies suggest that active surveillance is the least expensive treatment option[(23-27)]. However, these studies did not have the lifetime risks associated with retention of the 3M: future extraction costs, absence from work, school or regular activities, as well as treatment of complications. Thus, the current and future costs of active surveillance and the risk of incurring future costs of surgical treatment or a clinical emergency situation should be considered[2].

Table 4: Cost model - Extraction vs. Active surveillance

Extraction costs
– Added cost of extraction.
– Cost of managing complications multiplied by the probability of developing future or added complications.
– Cost of absence from school or work.
Active surveillance costs
– Cost of extraction, multiplied by the delayed extraction over time.
– Cost of follow-up visits, multiplied by the average number of monitoring visits until extraction or patient death.
– Cost of absence from school or work, multiplied by the probability of delayed extraction over time.
– Cost of managing complications following dental treatment (adjusted for age) multiplied by the probability of delayed extraction over time.
– Cost of necessary active surveillance, adjusted to present value to compare future costs with extraction costs.

3M SURVEILLANCE AND EXTRACTION RISKS AND BENEFITS

The professional is responsible for providing the patient with impartial advice on therapeutic options for 3Ms and for highlighting the risks and benefits of 3M extraction and active surveillance[2,5,11].

The risks associated with 3M extraction are well known, whereas the risks and benefits of maintaining dental retention are not[2,11]. The immediate benefit of active surveillance is to avoid the risks and costs associated with extraction of the 3M, but this does not guarantee tooth extraction will be avoided in the future, with the costs, risks and complications associated with age[11].

Maintaining the retention has costs associated with monitoring 3Ms for the development of pathologies and the risk of incurring future costs and the complications of tooth extraction in elderly patients[2]. Therefore, when deciding to adopt an expectant attitude with an asymptomatic 3M, the potential long-term impact should be considered[2, 5].

Therefore, the professional must review the wide range of therapeutic possibilities based on the symptoms and status of tooth retention: from maintaining 3M retention with active surveillance, "necessary" monitoring with regular monitoring while taking into consideration its proper periodontal and conservative care, to dental extraction or coronectomy.

Making decisions based on clinical evidence should combine the data from the current literature with the experience and skill of the professional, while explicitly incorporating patient preferences, taking into account the risks, benefits, costs and perceived and real desires[2,5,11].

CONCLUSIONS

The controversy continues over the optimal therapeutic management of an asymptomatic and pathology-free 3M, as there is still no answer as to which strategy is best or the position which would lead to the best results in the future. Much more scientific evidence and the development of well-designed studies to compare the short- and long-term maintenance and surveillance compared with the extraction of the 3M is needed to find an answer to this dilemma.

Until such information or evidence is available to guide clinical decision-making, it is recommended that all patients be subjected to timely examinations, i.e. during adolescence or young adulthood, to identify and categorise the type of dental retention, depending on its symptoms, pathology status and to identify potential future risks that may develop.

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Original article

Analysis of the causes of permanent tooth extraction in a Primary Health Care Centre dental practice

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ABSTRACT

Background

This study seeks to understand the causes of tooth extraction in the Dentistry Practice of the Juncal Primary Care Health Centre (Torrejon de Ardoz), evaluate which teeth are more likely to be removed, the number of extractions according to age and sex, the frequency of extractions in the immigrant population and the burden of tooth extractions as part of the daily healthcare pressure in the Oral Health Unit.

Method

A descriptive, observational, cross-sectional epidemiological field study in patients older than 6 years attending the Primary Care dentistry practice who had one or more permanent teeth extracted.

Results

773 tooth extractions, 48% male and 52% female, mean age 46.72 years, the group with the highest number of extractions was between 60-69 (21.73%). Tooth decay was the most common cause of tooth extraction (63.9%), followed by periodontal disease (17.6%) and alteration of the eruption of wisdom teeth (6.7%).

Conclusions

Dental prevention should be promoted in children aged 6-15 in Primary Care and oral hygiene activities implemented in adults to decrease the rate of tooth extractions in Oral Health Units.

KEYWORDS

Dental extraction; Tooth extraction; Primary health care; Causes of tooth extractions.

BACKGROUND

Dental care was included as part of the work performed by Primary Care (AP) Health Centres (CS) in the Community of Madrid. The coordination of dentistry, oral medicine and dental hygienists with other CS members is very important to enhance the oral health of the reference population, especially in the promotion of prevention measures in children.

Among these measures, dental hygiene is as important as dietary evaluation in controlling dental disease, including advice and instructions on food choices and dietary habits to prevent caries and periodontal disease. Check-ups by dentists and oral health practitioners are also important to assess, for example, periodontal status, bacterial control or dental plaque, perform periodontal probing, determine tooth mobility and update medical and dental history.

An AP dental practice mainly implements health promotion and disease prevention measures. Much of the effort of dentists and dental hygienists in the AP Oral Health Units (USBD) is aimed at promoting qualitative changes in living habits and attitudes related to oral health. Nevertheless, performing extractions represents a high percentage (37-66%) of the activity in an AP dentistry, and constitutes almost 90% of the surgical treatments[1,2]. As Donado suggests, you can be sure that extraction is the basis of oral surgery[3].

Despite the existing prevention and promotion measures in the Madrid Community AP Standardised Services Portfolio[4] and modern repair techniques and dental reconstruction, tooth extraction is still the most common procedure performed and in certain social media it is the only dental treatment received, contributing to the sometimes unnecessary increase in the edentulous population. This has an impact on the quality of life of the patient, because the mouth cavity is used to talk, smile, kiss, touch and taste, so that changes in the mouth can hinder performance at school, work, and in the family; it may also be responsible for thousands of lost hours annually in both the workplace and school, causing a high psychosocial impact[5-7].

The 2010 oral health survey in Spain8 found the number of edentulous people to be 16.7% in the 65-74 years age group and zero in the 35-44 age group, with an average of 26.6 teeth each for this group (in an analysis of 28, excluding third molars); while the 65-74 age group had an average of 16.11 teeth present.

The immigrant population needed 4 times more extractions than native Spaniards; as they had both a greater number and more serious cases of caries, which meant their treatment was also more complex.

The General Council of Dentistry and Oral Medicine in Spain stated that the main indications for extraction were9: a high degree of deterioration of a tooth which could not be restored or rehabilitated; changes in the position or dental situation due to other changes that could not be resolved by other means and orthodontic, prosthetic or surgical reasons.

Most studies in the general population identified caries and periodontal disease as the main causes of tooth removal[10-13]. A low socio-economic and education status and poorer standards of hygiene were other factors that influenced the appearance of the above causes10. Tooth extraction due to periodontal disease or prosthetic considerations was more common with increasing age[10-13].

Therefore, an analysis of the different causes affecting tooth extraction needs to be performed, due to the importance of maintaining teeth for aesthetic, functional and psychological reasons; because most studies published on this topic are prior to 2000 and conducted in a private or public/private setting, and not specifically in the public sector, such as AP; and to increase interest in this field of study.

Knowing the prevalence of causes of tooth extractions performed in AP USBD could help in preparing specific plans to increase oral health and the quality of oral tissue. It may also be necessary to offer conservative dentistry of decreasing complexity and substantially increasing minimally invasive restorative treatments in the youth population, with a growing complexity of treatments in the adult population, including senior citizens.

The CS Oral and Dental Health Centre of El Juncal, belonging to the Eastern Care Management (DAE) of the Primary Care Management (GAP) of Madrid Community, was concerned about the impact of extractions on the health of our population. It therefore conducted a study mainly to determine the proportion of individuals in AP who were indicated extractions and their causes. This was to be merged with one of the objectives of the Oral and Dental Health in Spain for the year 202014 to reduce tooth loss and the percentage of edentulous people in cohorts of adults; thus increasing average number of functional teeth and strengthening the promotion and prevention measures to be implemented, mainly in children. The distribution by age, sex and nationality of the number and causes of tooth extraction; the possible association of the number and causes of tooth extraction with these variables; and evaluation of which teeth are the most likely to be extracted were also intended to be studied.

MATERIAL AND METHODS

Design, scope and study population

An observational, descriptive, cross-sectional epidemiological field study was designed with these objectives in mind, in routine clinical practice at the Juncal CS, Torrejón de Ardoz, which has a reference population of 78,050 users over 5 municipal areas.

The study population was patients over 6 years of age attending the AP dentistry practice, on their own initiative or after referral by a family doctor, who were indicated extraction, during April - November 2014.

Patients not amenable to treatment in an AP outpatient clinic were excluded (patients with severe systemic disorders or mental disorders, as well as for services not covered in the AP services portfolio4), as were those patients who refused to participate in the study.

Sample size and selection

All patients who met the aforementioned selection criteria were included, and the sample size calculated by the descriptive studies sample calculation formula, whose main variable is categorical and defined in a finite population for a subsidiary extraction population of 3,356 users (the prevalence of extractions in the study period was 4.3%)8, with a confidence level of 95% and accuracy of 1.62%, resulting in an estimated sample size of 510 individuals. No patient refused inclusion.

Variables

The number of extractions performed in the study with the variables described below were recorded:

Dependent variables

- **Cause of tooth extraction:** 6 categoríes[3] were chosen, according to the criteria of the General Council of Dentistry and Oral Medicine in Spain[9]:
- **Dental caries:** Conservative treatment or its failure were not indicated.
- **Periodontal disease:** Advanced, with marked dental mobility and the presence of periodontal abscesses preventing conservative surgical treatment is a common indication for tooth extraction.
- **Mixed:** Dental caries and periodontal disease.
- **Trauma (acute or chronic):** Preservation of the tooth is allowed, providing it is not infected **and is usable for correct occlusion.**
- **Orthodontic indications.**
- **Other reasons not included in the previous sections:** Prosthetic, attrition, malposition, impaction or eruption problems.
- **Number of extractions per patient:** Quantitative discrete variable (single/multiple). Multiple considered as more than one tooth extracted in the same visit.

Independent variables

- **Age:** Quantitative continuous variable.
- **Sex:** Dichotomous categorical variable **(male/female).**
- **Tooth extracted:** Categorical variable with 32 categories, according to the International Dental Federation[15].
- **Country of birth:** Dichotomous categorical variable (native / immigrant).
- **Total number of consultations (on demand) performed in a day:** Discrete quantitative variable.

Data collection

Patients in the study were diagnosed and treated by a single investigator (dentist) with extensive professional experience. He performed the examination, diagnosis, treatment and routine clinical practice, with help from a dental hygienist and dental student for treatment and registration. The dentist decided whether to perform the extraction of one or more permanent teeth, following the General Council of Dentistry and Oral Medicine in Spain criteria9, and specified the cause.

Analysis

The mean and standard deviation (SD) of the quantitative variables were calculated; and the frequencies and percentages calculated for the categorical variables. Student's t-test for independent samples was used to compare means.

The data were recorded and then analysed statistically using the SPSS 19.0 program.

Ethical aspects

Informed consent to be included in the study was requested from the patients, or the patient's mother, father or legal guardian in the case of minors. The confidentiality of patient data was guaranteed as no personally identifiable information needed to be recorded.

The study was approved by the Local Research Commission of the Eastern Care Management belonging to the Madrid Community AP management.

RESULTS

A total of 1,587 patients attended El Juncal USBD CS in the study period, at an average of 15.8 patients per day.

Of these patients treated at the USBD during the study period, 510 patients (32.1%) were indicated tooth extraction. Thus, tooth extraction was performed in nearly one in 3 users seen in the USBD.

The mean age of the patients who underwent one or more extractions was 46.78 years (SD 16.62). There were 248 (48.6%) males and 262 (51.4%) women; 419 (82.2%) of Spanish nationality and 91 immigrants (17.8%), with the most common country of origin being Romania (5.3%), followed by Morocco (3.9%) and Peru (1.4 %).

A total of 773 dental extractions were performed on 371 (48%) males and 402 patients (52%) women; 81.6% of the extractions were performed on the native population and 18.4% on immigrants. There were no statistically significant differences in the average number of extractions by sex or nationality. Figure 1 shows the distribution of tooth extractions by age group. No extraction was performed in the 6-13 year age group, while the group with the largest number of extractions (168, 21.73%) was the 60-69 years group. Multiple extractions were performed In 79 patients (15.5%). The total number of teeth extracted in multiple extractions was 258, representing an average of 3 teeth (SD 3) in each multiple extraction.

Caries was the cause in 63.9% of tooth extractions and periodontal disease in 17.6%, with a mixed cause in 5.6%. The other causes were trauma 1.3%, orthodontics 0.1% and for other reasons, comprising prosthetic, wisdom teeth, elongation, wounds and Impaction, in 11.5%. Extraction due to alteration of the eruption of wisdom teeth accounted for 6.7%, which was the 3rd most common cause (Table 1).

The mean patient age per tooth extraction cause can be seen in Table 2; for caries this was 47.02 years (SD 17.25) and periodontal disease was 60.34 years (SD 12.5), which was a statistically significant difference ($p < 0.0001$).

The extraction cause per sex distribution can be seen in Table 3. Caries occurred in 70.88% of the total cases of men and 57.46% of women. Periodontal disease was the second most common cause in men, with 15.03% of tooth extractions and 19.4% in women.

The causes of tooth extraction per country of origin are shown in Table 4 and show no statistically significant differences between causes of tooth extractions in the immigrant population and in the native population. The most frequent cause was caries (70.4%) in the immigrant population followed by periodontal disease (16.9%).

Figure 2 shows the percentage of total extractions per tooth, while referring to the most frequent cause of extraction and the average age. The posterior section had a frequency higher than the anterior section (82.6% and 17.4%, respectively); while the average age of extraction was 46.66 years (SD 16.84), and tooth 18 the one removed most often (6.9%). Wisdom teeth were the type of tooth removed most often (23.6%), with the average age of extraction being 41.26 years (SD 14.15). The most common cause of tooth extraction in the posterior section was caries (66.24%) followed by periodontal disease (13.81%) and alteration of the eruption of wisdom teeth (8.16%). In the anterior section, the average age of extraction was 63.88 years (SD 10.16); the main cause was caries (52.94%) but there was a higher proportion due to periodontal disease (35.29%) as a cause of tooth extraction. The tooth removed the most due to periodontal disease was number 31 (80% removed due to periodontal disease), followed by numbers 41 (50%) and 21 (50%).

DISCUSSION

Knowledge of the causes of tooth extractions in the population is key to assessing both the implementation of corrective measures of prevention and promotion and as an indirect indicator of intermediate health outcomes to assess the impact of previous performances.

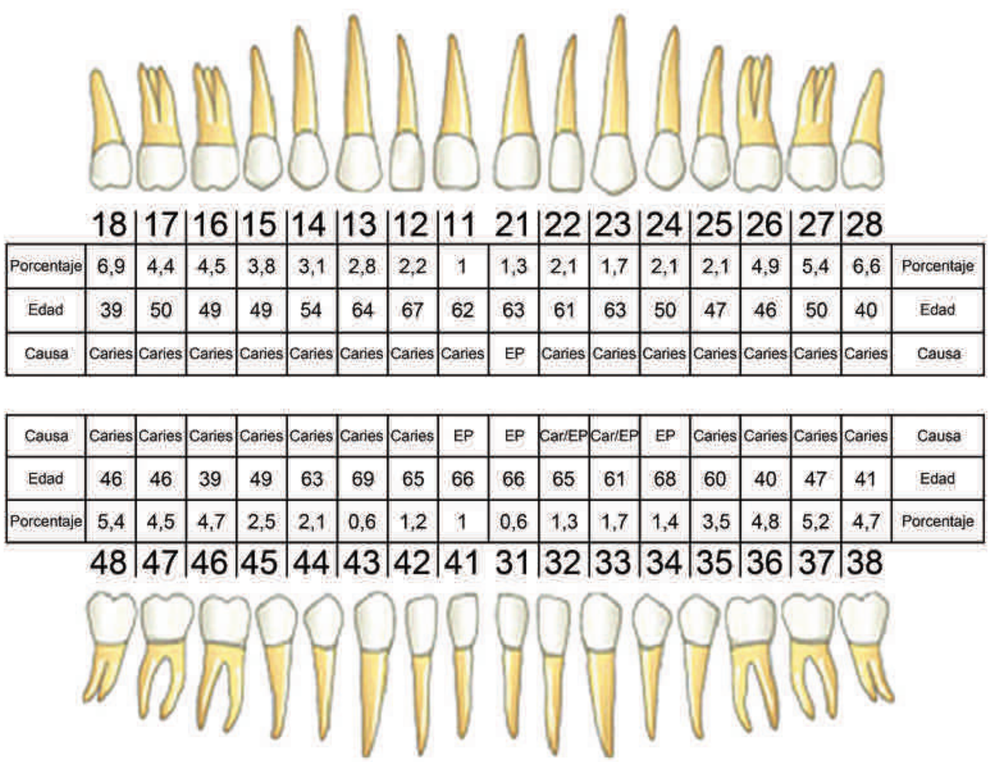
The prevalence of each, depending on the age of onset, sex and tooth affected, means different health strategies can be designed in the population served.

Most of the studies in the literature refer to services provided in mixed (public and private) health systems. The only study in our scope to be used as a reference, at the national level and provided in the public sector exclusively for people over 6 years old was the Cardona study[10]. There are other studies in the public health system, but only in the adult[16,17] or male[18] population.

During the 8-month study, the care load due to tooth extractions in the practice was over 40% of those services, taking into account the average extractions per day (6) and the time dedicated to daily consultation (180 minutes). Extractions were performed in 1 in every 3 of those appearing in consultation (32.1%), which has been declining in recent years (66-37%)[1,2], due mainly to cultural changes in the AP USBD, where the main objective of its service portfolio is the deployment of promotion and prevention measures.

Although no significant differences were found in the gender distribution of tooth extractions performed, it was higher in women (52%) than in men (48%), as was observed in the study conducted in Greece (Chrysanthakopoulos[13]) and contrary to that observed in the Cardona[10] and Ainamo[19] studies. Multiple extractions were similar across the sexes (15.72% in males and 15.26% in women), and the mean number of teeth extracted in each multiple extraction surgery was also similar (3.17 in men and 3.35 in women). These data support a greater demand for dental extraction in women in our population.

Figure 1. Distribution of extractions by age group



	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Porcentaje	6,9	4,4	4,5	3,8	3,1	2,8	2,2	1	1,3	2,1	1,7	2,1	2,1	4,9	5,4	6,6	Porcentaje
Edad	39	50	49	49	54	64	67	62	63	61	63	50	47	46	50	40	Edad
Causa	Caries	Caries	Caries	Caries	Caries	Caries	Caries	Caries	EP	Caries	Caries	Caries	Caries	Caries	Caries	Caries	Causa

	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38	
Causa	Caries	Caries	Caries	Caries	Caries	Caries	Caries	EP	EP	Car/EP	Car/EP	EP	Caries	Caries	Caries	Caries	Causa
Edad	46	46	39	49	63	69	65	66	66	65	61	68	60	40	47	41	Edad
Porcentaje	5,4	4,5	4,7	2,5	2,1	0,6	1,2	1	0,6	1,3	1,7	1,4	3,5	4,8	5,2	4,7	Porcentaje

Figure 2. Tooth extraction frequency, average age and cause.

One relevant fact of this study was related to patient age, in that there is no record of extractions in the age range 6-13 years. The youngest recorded patient was 14 years old, which may be influenced by the prevention activities performed in our child population of 6-15 years as part of the service portfolio in this AP USBD. The highest percentage of tooth extractions was performed in the 30-49 year group (41.2%); indicating the need to continue health education activities in this age bracket.

The main cause of tooth extraction was caries (Table 1), as was found in most studies analysed[10-13,17,18,21].

Table 1. Reasons for tooth removal

	Frequency	Percentage
Caries	494	63.9
Periodontal disease	136	17.6
Mixed	43	5.6
Trauma	10	1.3
Orthodontics	1	0.1
Prosthetic	29	3.8
Wisdom teeth	52	6.7
Elongation	3	0.4
Wounds	1	0.1
Impaction	4	0.5
Total	773	100

No study from 2000 was found with periodontal disease as the most common cause of tooth extraction.

Caries was the main cause of extraction in all age groups, especially the 40-49 age range, after which the frequency decreases due to the rise of periodontal disease in this age group[20,21], with the greatest impact after 58 years, due to a greater presence of systemic diseases and harmful habits, among others. This aspect also supports the mixed causes having a greater frequency between 50 and 59 years.

Trauma as a cause of tooth extraction appears in the elderly population from 50 years as a result of chronic trauma (e.g. attrition, abrasion and abfraction).

Within the group of "other causes" are those due to prosthetic reasons and alteration of the eruption of wisdom teeth. Prosthetic reasons for tooth extractions have a higher incidence in the 60-69 year group, perhaps due to increased prosthetic treatments in the elderly population and the need for specific oral care to help in chewing facilitate and promoting the patient aesthetics[22]. The average age for alteration of the eruption of wisdom teeth as a cause of tooth extraction was 32.53 years (SD 9.41) and the third most frequent cause of extraction after caries and periodontal disease. This is relevant in an AP USBD, as until recently it was a reason for referral to specific hospital maxillofacial surgery services for resolution.

Table 2. Mean age for reasons of tooth extraction (in years)

Variables	Average age ± SD
Caries	47.02 ± 17.25
Periodontal disease	60.34 ± 12.50
Mixed	54.35 ± 11.16
Trauma	61.00 ± 15.11
Prosthetic	65.34 ± 12.75
Wisdom teeth	33.88 ± 9.40
Elongation	42.67 ± 2.30
Impaction	47.33 ± 23.46

One of the specific objectives in our study was to identify the teeth most often extracted. The data show that the upper third molars are most often extracted, with the upper right wisdom tooth being more frequent than the left (6.9% compared to 6.6%); and caries being the most frequent cause of extraction in each.

Analysis of the specific data related to each tooth (Figure 2) shows that tooth loss usually begins with the wisdom teeth (mean age 41.26 years), and progresses towards the midline as age increases. From the fifth decade of life (63.49 years), tooth extrac-

Table 3. Distribution of causes of tooth extraction by gender

	Male (%)	Female (%)	Total
Caries	263 (70.88)	231 (57.46)	494
Periodontal disease	58 (15.63)	78 (19.40)	136
Mixed	14 (3.77)	29 (7.21)	43
Trauma	6 (1.62)	4 (0.99)	10
Orthodontics	0 (0)	1 (0.24)	1
Other	30 (8.08)	59 (14.67)	89
Total	371	402	773

Table 4. Distribution of reasons by origin

	Nationality		
	Spanish (%)	Foreign (%)	Total
Caries	394 (62.44)	100 (70.42)	494
Periodontal disease	112 (17.75)	24 (16.90)	136
Mixed	38 (6.02)	5 (3.52)	43
Trauma	9 (1.43)	1 (0.7)	10
Orthodontics	1 (0.16)	0 (0)	1
Other	77 (12.20)	12 (8.45)	89
Total	631	142	773

tions are more frequent in the anterior group, and the most frequent cause is caries. However, periodontal disease has a greater relevance, especially in the lower central incisors and in the upper left central incisor. Once again, these data show the importance of oral hygiene, which is most difficult in the posterior section which manifests as tooth decay at younger ages. The ease of oral hygiene in the front group influences the delay of caries in these teeth, and therefore the indication for tooth extraction at older ages. As mentioned previously, the increased presence of periodontal disease in the anterior group at an advanced age is due to lifestyle habits (e.g. smoking and drinking alcohol), immune disorders due to age and systemic affectations (e.g. diabetes mellitus)[23].

CONCLUSIONS

Caries is the most common cause of tooth extraction in our study population, followed by periodontal disease and alteration of the eruption of wisdom teeth. This requires oral hygiene promotion to be maintained in the Health Centre, led by USBD professionals; and with greater emphasis on the female population, as the study showed extraction was more frequent in this group than the male.

The teeth extracted the most were upper third molars, which reflects the greater specificity in the work of the USBD; thus avoiding referrals to specialised care. This also facilitates the resolution of the clinical process to the user and saving both the time lost in travelling to the hospital and delay in treatment.

The posterior teeth are affected at an earlier age leading to the consequent teeth loss and the need to provide ongoing oral health support in the young adult population. The involvement of dentists and dental hygienists in the Health Centre training plan for health professionals is key to promoting health education activities aimed at this group of users, who can also suffer chronic diseases that affect their oral health.

There was no difference in the causes of tooth extractions in the native and immigrant population, so the actions to be taken in both populations must be the same.

Promoting dental care service activities in children of 6-15 years in AP and the involvement of all CS professionals in maintaining oral hygiene activities in adults is essential to reducing the rate of extractions in daily USBD consultations and thus increasing the oral health and general health of patients. The results obtained in our study show the association between age and the reason for tooth extraction, with periodontal disease having more effect on tooth decay with increasing patient age.

Given the results of this study and its possible significance on the oral health of the population, the need to implement it in AP in the Madrid Community is clearly understood.

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Zirconia implant abutments: biomechanical behaviour

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ABSTRACT

The ceramic, aluminium oxide (alumina), was introduced in 1993, but the first fully ceramic abutment was introduced a year later, in 1994, and consisted of highly sintered alumina (CerAdapt, Nobel Biocare). However, the problem with this abutment was its fragility. The mechanical properties of zirconium oxide (zirconia) abutments were improved and they offered new opportunities for restorations. Zirconia plays a vital role in modern biotechnology because of its inertness and excellent mechanical properties of strength and hardness. This ceramic abutment is manufactured from yttria-stabilised zirconia (Y-TZP), which has been used in orthopaedic surgery for over 20 years. However, zirconia has not been used in the dentistry field for very long, so no long-term studies of its mechanical behaviour in the mouth have been conducted.

The overall objective of this work is to study the static strength and fatigue from in vitro tests on upright abutment specimen samples of the standard zirconia implant diameter made according to the standard UNE-EN ISO 14801.

The main findings of this study are as follows: all abutments break at the neck; all abutments can be used long-term in the anterior maxilla; and finally all studies on prosthetic attachments should be carried out using an established protocol (standard UNE-EN ISO 14801), to make comparisons easier between them.

KEYWORDS

Zirconia abutments; ceramic implant abutments; Breaking force; Fatigue; Zirconia abutment stress rupture.

BACKGROUND

The demand for aesthetic dental prostheses in patients is today an indisputable fact. The scientific community has spent some time researching this topic to provide solutions increasingly related with the image of a natural tooth by removing the metal and making pure ceramic prostheses.

Implant abutments have traditionally been made of metal. The use of titanium reduced galvanic and corrosive effects. Titanium abutments involve the use of metal-ceramic crowns upon them, with the aesthetic drawbacks this entails. The introduction of fully ceramic abutments improved the Vickers hardness (2000 kg/mm^2 for alumina or aluminium oxide and 1200 N/mm^2 for zirconia), the colour and design of the emergence profile meant crowns could be made with a completely ceramic coating without metal, which was more translucent. However, their fragility was still a problem under stress forces. In brittle materials, the fracture starts from a defect (e.g. a pore or crack). Forces produced from chewing, for example, can start a crack that can fracture the material. Recently, a tremendous effort has been made to improve manufacturing methods of dental ceramics and, as a result, two highly resistant ceramics have appeared on the market: made of alumina and of zirconia[1].

Alumina ceramics were introduced in 1993, but the first fully ceramic abutment was introduced a year later, in 1994, and consisted of highly sintered alumina (CerAdapt, Nobel Biocare). However, the problem with this abutment was its radiolucency and fragility[1].

Zirconium is used in dental ceramics partially stabilised with yttrium (Y-TZP). This gives exceptional qualities of hardness and bending strength, which other ceramics lack. The introduction of zirconia abutments brought improved mechanical properties and provided new opportunities for restorations[1].

Numerous researchers have studied the biomechanical properties of these abutments over the last 15 years; some of the most representative articles are listed below:

In 2001, Boudrias et al[2] indicated that ceramic abutments must only be placed in the anterior section and in premolars not subject to excessive occlusal loading, due to having a lower mechanical strength than metal. They were not considered suitable for molars, canines or incisors where there is greater than 50% overbite.

In 2001, Butz[3] compared zirconia-reinforced titanium abutments (ZiReal, 3i) with pure alumina and titanium abutments in external hexagon implants exposed to 1.2 million chewing cycles until their fracture. He found similar average fracture loads of 324N for Ti and 239 for Al.

In 2006, Att et al4 evaluated the fracture strength of zirconium dioxide implant crowns on various abutments of alumina, zirconia and titanium, which were subjected to loading and high temperature cycling. The fracture strength was 1251, 241 and 457N for the Ti, Al and Zr groups, respectively. Therefore, all abutments studied could withstand the physiological occlusal forces of the anterior sector.

González Perera[1] referred to an overall lack of long-term studies on the strength of these ceramic abutments for both single-tooth implants and for short-span bridges.

In another study in 2008, Aramouni et al[5] evaluated Certain implants and Straumann SLA ITI implants into 3 groups according to the abutments that each group had: Group 1 (Certain implants with ZiReal abutments), Group 2 (SLA implants with synOcta Ceramic Blank abutments) and Group 3 (Certain implants with UCLA noble alloy abutments). An Instron machine was used and the load applied at an angle of 45°. The fracture strength results were: Group 1 (792.7N), Group 2 (604N) and Group 3 (793.6N).

In 2011, Apicella et al6 evaluated the differences in fracture strength of titanium abutments (TiDesign 3.5/4.0) and zirconia abutments (ZirDesign 3.5/4.0, 5.5; 1.5mm). Both groups were subjected to loads until they broke. The Ti group showed significantly higher fracture strength loads (552.3 ± 23.1N), while the Zr group had a strength of 296.6 ± 45.4N. However, the authors concluded that the two types of abutments were suitable to withstand physiological mastication forces in the premolar area.

In 2013, Foong et al[7] determined the fracture strength of titanium (TiDesign, 3.5/4.0; 4.5 from Astra Tech) and zirconia abutments (ZirDesign 3.5/4.0; from Astra Tech). CAD/CAM crowns were made and a fatigue test performed at an angle of 30°. The titanium abutments fractured at an average of 270N after 81,935 cycles, while the zirconia lasted until 140N after 26,296 cycles. The fracture mode was specific for the type and design of abutment material, while the zirconia abutments fractured before the fastening screw failed.

Given the variability of results observed in the previous studies (mean fracture figures of 140N for Foong et al[7], through 296N with Apicella et al6 and up to 792N with Aramouni et al[5]), the justification of this work lies in the need to obtain sufficient and reliable scientific evidence supporting the use of zirconia abutments, while specifying the loads they are capable of supporting, for both the machined titanium base type and the entirely ceramic ones, for both internal and external connections.

The main objective of the work was to study the static and fatigue strength under load in the anterior sector via in vitro testing of a sample of straight zirconia abutment specimens with a standard diameter implant, made according to the standard UNE-EN ISO 1480188.

MATERIAL AND METHODS

The following materials were used to carry out this work:

- 6 x CAP454 abutments and 6 x Biomet 3i gold-plated screws (Biomet 3i, Palm Beach, USA).
- 6 x RC Straumann Anatomic IPS e.max straight abutments, GH 2mm, MO, O, ZrO2 and 6 titanium screws (Straumann, Basel, Switzerland).
- 6 x ZirDesign 4.5/5.0 abutments, diameter 5.5 and 1.5 mm, Astra Tech implant system and 6 titanium screws (Dentsply Implants, Mölndal, Sweden).

To perform the static testing, 9 sample holders were made according to the standard UNE-EN ISO 14801. In addition, a tool was designed for positioning the samples in the testing machine. The implants were fixed to a load-bearing, Multicore HB composite (Ivoclar Vivadent AG, Schaan, Liechtenstein). This composite was used due to its modulus of elasticity (18 GPa), which is similar to that of human bone.

The sample testing preparation method was as below:

1. Cleaning any foreign matter from inside the implants by compressed air.
2. Attaching the abutment to the implant using a screw at the different torques recommended by the manufacturer: Biomet 3i to 20 Ncm, Straumann to 35 Ncm and Astra Tech to 25 Ncm (Figure 1).
3. Fixation of a spherical attachment by adhesive to the abutment to transmit load to it. A period of at least 24 hours was left from placing the spherical attachment on the specimens until they were tested. Three samples were tested for each abutment type in the static tests and three samples per abutment for fatigue tests.

Figure 1. Abutment assembly

Figure 2. Static strength testing assembly.

Static tests were conducted using the test stand as described. The force applied induced a bending moment on the abutment as recommended by the standard UNE-EN ISO 14801. This study was conducted with a deviation from the described standard, in relation to the distance holding the sample, as the top of the implant was at the nominal bone level.

The static load tests were performed with an ELIB-20 (Ibertest, Madrid, Spain) universal testing machine at a speed of 1 mm/min using a 2kN load cell. The environmental test conditions were 20°C ± 5°C with a relative humidity of 50% RH ± 20% RH (Figure 2).

After testing was finished, the breaking force was recorded and the samples were photographed to document the failure that had occurred. The samples were stored and identified according to the study.

Fatigue testing was performed according to the standard UNE-EN ISO 14801. The installation was performed so that the load application angle was guaranteed as 28 - 32° (Figure 3).

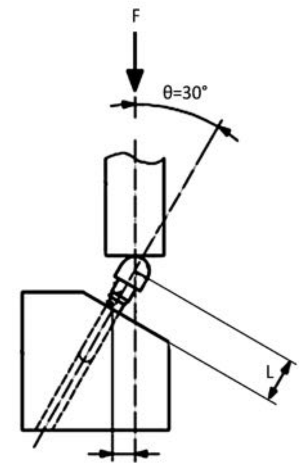

Figure 3. Testing scheme [8].

These tests were conducted with an ElectroPuls E3000 machine (Instron, Norwood, USA) at a frequency of 10Hz up to 5 million cycles, or until the abutment, screw or implant failed. The environmental test conditions were 20°C ± 5 ° C with a relative humidity of 50% RH ± 20% RH. Once the test was completed, the number of cycles was recorded and the samples photographed to document the failure that had occurred.

In accordance with the standard UNE-EN ISO 14801, the tests were performed maintaining a fatigue ratio R of 0.1 (R = Fmin/Fmax). This involves a cyclic loading oscillation during the test between a minimum value, Fmin, and a maximum value, Fmax, while keeping a constant ratio of 10%.

The Fmax value taken in each case was 25% of the aforementioned static test breaking force value.

Statistical analysis

The values obtained from the tests were expressed as the mean ± standard deviation. An analysis of variance was performed with a significance level of 5%. If there were any significant differences, a post hoc SD contrast was performed. Student’s t-test was done when comparing test values before and after undergoing fatigue tests. The statistical package used to analyse the results was the SPSS 15.0 for Windows (IBM SPSS, Chicago, USA).

RESULTS

Static testing

A total of 9 abutments, 3 from each brand, were tested until breaking. Figure 4 shows the force-displacement curves for the 3 abutments studied. The highest point of the curve was taken in all cases as the breaking force point for calculation purposes.

The average breaking force was 1058 ± 225N for AstraTech, 866 ± 189N for Biomet 3i and 873 ± 402N for Straumann.

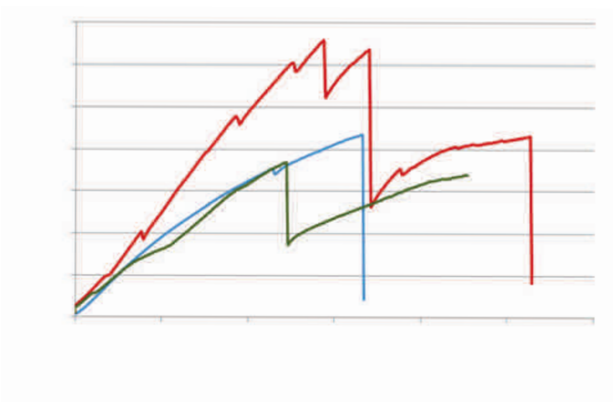

Figure 4. Force-displacement curves for the 3 abutment types studied

The inclination given to the abutment during testing (in accordance with the standard) produced a complex stress state, with peaks situated at the union of the abutment with the implant. The stress state at the abutment point with the highest load was calculated to compare the strength of the abutments of different lengths and areas, under the following assumptions:

- The abutment was considered a perfect hollow cylinder, with no peaks or protrusions.
- The stress was calculated as if the load was shared equally on the surface of the abutment upon which the load was applied.
- The maximum force was experienced at the abutment base.

This force scheme is shown in Figure 5.

Where,

F is the load applied by the testing machine.

θ is the tilt angle provided by the load block (30°).

L is the distance from the point of application of the load (F) to the support surface.

Applying a load (F) according to the standard produces a bending moment (Mf) due to the part of the load that is projected on the axis perpendicular to the abutment by the same component of the force. A constant shear force (Q) is taken into account, and a normal force (N) is produced in the direction of the implant abutment attachment point for the component in the axis parallel to the abutment.

$$M, = F \bullet Sen\theta \bullet L$$

$$N = F \bullet Cos\theta$$

$$Q = F \bullet Sen\theta$$

Where Is the angle between the direction of the load applied to the abutment (i.e. 30°). The factors required to calculate the stress on the abutment are the force (F), the distance from the load application point to the abutment (L) and the abutment cross-sectional area (A) at the point with the highest nominal load. These dimensions were determined experimentally and are shown in Table 1.

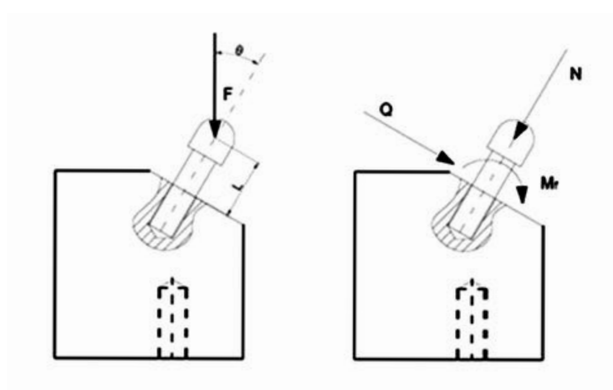

Figure 5. Distribution of forces and moments in the implant

The following procedure is followed to calculate the stresses, distinguishing between traction and compression:

$$\sigma_{trac} = -\frac{N}{A} + \frac{M_f}{I_x} \bullet r$$

$$\sigma_{comp} = -\frac{N}{A} + \frac{M_f}{I_x} \bullet r$$

$$\sigma_{1,3} = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

Following the Von Mises criterion:

$$\sigma_{equivalente} = \frac{1}{2}\sqrt{\left(\sigma_1 - \sigma_3\right)^2 + \sigma_1^2 + \sigma_3^2}$$

The bending moments and equivalent tensile and compression forces for each of the samples were calculated from the above expressions (Table 2).

No statistically significant differences ($p > 0.05$) were found between the stress values for the different abutments. The failure mode produced in each abutment is shown in Figure 6.

TABLE 1. ABUTMENT DIMENSIONS

	Length (mm)	Area (mm2)
Astra	8,5	9,33
Biomet	11	6,28
Straumann	11	8,16

Fatigue testing

As described in the experimental method, 25% of the static breaking force was used as the maximum test load for fatigue testing. Table 3 shows the fatigue test conditions for each of the abutments studied.

All abutments lasted for 5,000,000 cycles under these test conditions, except for one of the Biomet 3i abutments which broke at 501,497 cycles.

The abutments which survived were tested under static conditions and checked for differences before and after being subjected to the fatigue testing, to assess whether the load cycles they underwent affected their strength.

The results obtained are shown in Table 4.

The results were analysed using hypothesis testing and the Student's t-test performed at a significance level of 5%. No statistically significant differences ($p > 0.05$) were found for any of the brands between the static load values before and after subjecting them to 5,000,000 fatigue cycles at a force of 25% of the static breaking force.

DISCUSSION

The ceramic abutments with the greatest strength were made of HIP zirconia, as reflected in the numerous studies[9-11], with a tensile strength of approximately 1000MPa. However, even with these

TABLE 2. STATIC LOAD COMPRESSION TESTING RESULTS

	Force (N)	Bending) moment (Nm	Tensile stress (MPa)	Compressive stress (MPa)
Astra	1058 ± 225	4,5 ± 1,0	669 ± 142	863 ± 183
Biomet	866 ± 189	4,8 ± 1,0	894 ± 195	1131 ± 247
Straumann	873 ± 402	4,8 ± 2,2	1061 ± 488	1245 ± 573

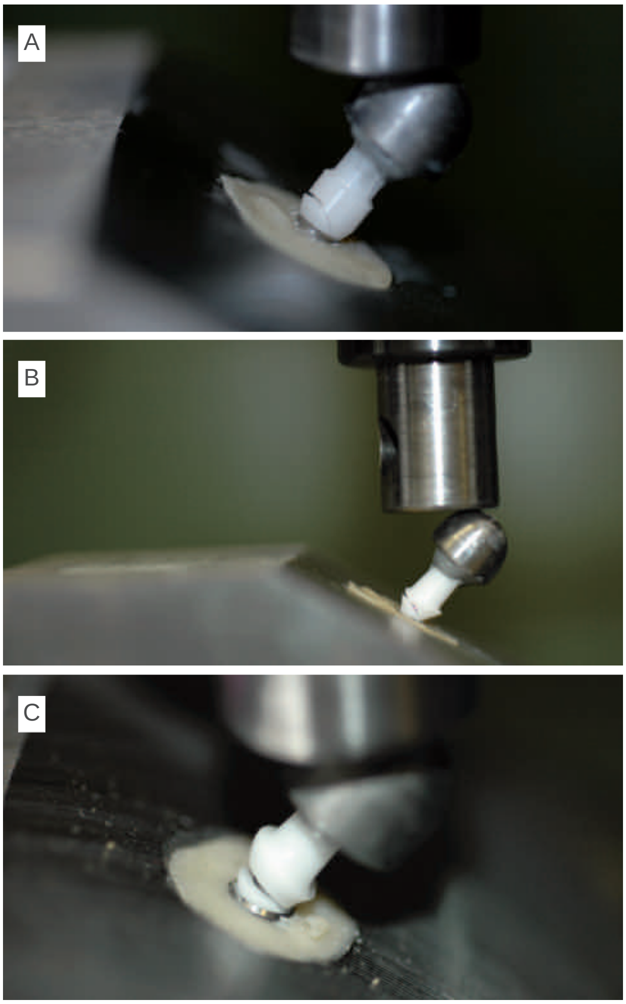

Figura 6. Fractura pilares. Biomet 3i (a), Astra (b), Straumann (c).

additions, the weak point of the "implant-ceramic abutment-screw-ceramic crown" system is the ceramic abutment. This has the greatest risk of restoration failure due to fracturing at the level of the neck. This is due to several factors: the drilling of the abutments, the abutment shape before drilling and, consequently, the stress suffered by the abutment due to the occlusal loads.

Moreover, the fracture resistance - defined as of the ability of a material to dissipate the fracture energy - of the titanium alloy used mostly in dentistry (Ti-6Al-4V) is between 84-107 MPa·m½. While the fracture resistance of zirconia (Y-TZP-HIP) is 5.5-6.7 MPa·m½. This lower fracture resistance, compared to the titanium alloy, is the major limitation of ceramic materials, as they are more susceptible to the presence of defects and so can break with giving any warning; unlike metals, which undergo plastic deformation before breaking.

To assess the strength of the zirconia abutments and their indication for use in the maxilla section where they are placed, it needs to be considered that occlusal forces in adults decrease from the molar to the incisor region; between the first and second molar, these forces vary from 400 to 800N. In premolars, canines and incisors, average forces of 300, 200, and 150N, respectively, have been recorded[12-19].

According to our study results, the abutments under static load failed at forces of 866 ± 189 to 1058 ± 225 (N), and could therefore withstand the occlusal physiological forces of the anterior sector without problems.

One of the most controversial factors in relation to the use of zirconia abutments is the observation time of the clinical studies, which include an observation of the strength of the abutments in the short term[20-24].

Exceptions are the Döring et al study[25], which had an observation period of 8 years; however, most of the abutments were made of titanium, with only 11 ceramic abutments; another study was by Ekfeldt et al[26], whose observation period was 5 years, for NobelProcera zirconia abutments made by the Biocare CAD/CAM system; and another study was by Zembic et al[27], with a 5-year observation period, which concluded that the zirconia abutments could be used very well in the posterior maxillar sectors. However, there are no clinical studies of the long-term behaviour of these abutments. Thus, in vitro or laboratory strength studies, such as this, that focus on simulating the long-term behaviour in the mouth, using fatigue tests are especially important.

The results found in reviewing the literature are very different, which may in our opinion be due to the different design of the in vitro testing.

Some studies, such as Att et al4 and Butz et al[3] differ greatly in their strength values for zirconia, alumina and titanium abutments, and not just between the two studies. Att et al[4], for example, have a large disparity between the strength values for the 3 abutment types; while Butz et al[3] have very similar strength values for the 3 types of abutment materials. Att et al[4] treated 48 maxillary central incisors on internal connection implants. Group 1 was alumina, group 2 was zirconia and the abutments control group was titanium. The crowns were cemented, and they underwent loading and high temperatures cycles. The strengths were 1251N, 457N and 241N for the Ti, Zr and Al groups, respectively. However, the Butz et al study[3] compared zirconium oxide reinforced abutments with titanium in the base (ZiReal abutment from 3i); pure alumina and pure titanium abutments in external hexagonal implants, with cemented metal crowns. They were exposed to load cycles until they fractured, with mean fracture loads of Ti (324 ± 85N), Zr (294 ± 53N) and Al (239 ± 83N). Their order of strength was consistent (Ti, Zr and Al) and all were able to withstand the physiological occlusal loads of the anterior sector; however, the results were much lower, especially for alumina. Thus, the different protocols, materials (external vs internal connection, and Zr vs Zr with titanium base) and methodology (loads and angles) in each study gave very different values. Therefore, it is considered very important to perform the tests following international standard parameters, as this has done using the UNE-EN ISO 14801 standard.

One of the most important factors that directly affect abutment performance is the design. This was seen in this study, where each abutment used was made by a different company with different dimensions and they produced different behaviour. Other authors, such as Aboushelib et al[28] and Foong et al[7], claim that the fracture mode is specific to the abutment material and design. Furthermore, other studies, such as Canullo et al[29] compare abutments from the same company, and find fewer differences between them; whereas, this study used abutments from different companies with their own designs and dimensions.

Breaking strength differences between abutments of different companies occur due to their different dimensions and designs. Thus, in our opinion, stress (MPa) and not force (Newtons) should be used to compare abutments of different dimensions and the points at which they fail.

TABLE 3. FATIGUE TESTING CONDITIONS

	Maximum force (N)	Maximum bending moment (Nm)	Tensile stress (MPa)	Compressive stress (MPa)
Astra	264,5	1,12	167,3	215,9
Biomet	216,6	1,19	223,6	282,9
Straumann	218,4	1,20	265,3	311,4

TABLE 4. STATIC LOAD TEST RESULTS AFTER FATIGUE TESTING

	Force (N)	Bending moment (Nm)	Tensile stress (MPa)	Compressive stress (MPa)
Astra	1063 ± 290	4,5 ± 1,2	672 ± 183	868 ± 237
Biomet	945 ± 61	5,2 ± 0,3	976 ± 63	1235 ± 80
Straumann	804 ± 245	4,4 ± 1,4	976 ± 298	1146 ± 350

It should also be considered that the abutments analysed in this study were tested under the conditions provided by the manufacturer, where they are usually fitted in the clinic to fit the actual situation in the mouth (the abutments were straight, with two of 11 mm length, as they usually have to be adapted to a certain inclination and a lower tooth length for the individual customer). These variations in length and inclination mean the forces the abutments can withstand vary significantly.

One example illustrating this is the Astra and Biomet abutments: the former has a shorter length and larger abutment (A) cross-sectional area, which means it can withstand a greater load before fracturing (1058 ± 225N) than the Biomet abutment (866 ± 189N), which is longer and has a smaller area.

Other authors have compared bending moments to determine the abutment behaviour[30,31]. The bending moment is produced when the force is not axial, as in our study, as anterior occlusal forces occur at an angle of 30°. The bending moment (Nm) required to fracture the abutments varied between 4.5 ± 1.0 and 4.8 ± 2.2 Nm, due to the different abutment dimensions.

Canullo et al[29] found that static testing with different abutment types gave bending moments significantly higher than those obtained by other authors, and attributed this to the dual zirconia/titanium attachment system used in these abutments.

However, as can be seen in the equations described above, the bending moment depends on the load applied and abutment dimensions; this should be considered carefully when evaluating the abutment strength.

Thus, a good assessment of abutment behaviour can be made by comparing the stress at which it breaks. The tensile stress endured by the abutments in our study ranged between 580-1612 Mpa, depending on the abutment dimensions and bending moment. If the stress that breaks the abutments is compared, it is observed that the Astra abutments failed at a stress of 669 ± 142 MPa, the Biomet at 894 ± 195 and the Straumann at 1061 ± 488, with no statistically significant differences between them ($p > 0.05$). As can be seen, the Astra abutment is the one with the least strength as it fails at the lowest stress; however, it can withstand the greatest force (1058N), if this parameter is compared.

From the dental point of view, the Astra abutment might be considered the best choice, as it can withstand a greater force (simply because it is shorter and has a larger area). However, the behaviour of the material for this abutment is the worst (as it fractures at a lower stress than the other abutments, whose fracture points are higher and closer to the theoretical tensile strength of zirconia).

Another factor not addressed in this study is the abutment design which can make the stress behaviour of the abutments vary significantly.

Table 4 shows the tensile stress is less than the compressive stress. However, the abutments failed after the crack developed on side of the abutment under tensile stress, although less than the compressive stress. The tensile stress produced is considered to be the main reason for the fracture at the abutment base, as the crack started and spread in this area.

Another important point to consider for the long-term good behaviour for restorations on a fixed prosthesis on an implant is the location of the zirconia abutment in the dental arch. There is no unanimity of criteria, however, to determine the arch position that would ensure adequate long-term clinical behaviour. In reviewing the literature, a wide range of ceramic abutments were placed in different locations on the jaw, which highlights the absence of objective, scientific evidence for positioning the zirconia abutments in the maxillary arch[20-25]. The data obtained in our work and the mean physiological occlusal forces in an adult suggest their use in the maxillary posterior area is not appropriate for long-term survival; they can be placed only in the anterior or premolar areas not subjected to excessive occlusal loading. This finding is in line with results obtained by other authors, such as Boudrias et al[2] and Cho et al[32]. According to Gehrke et al[16], it is reasonable to demand the abutments withstand up to 300N for the anterior area to 1000N for the posterior area.

This study showed a high long-term abutment survival rate, as only 1 abutment failed after being subjected to 5 million load cycles.

Comparing the static strength data after the fatigue test (Table 4) showed there were no statistically significant difference ($p > 0.05$) between the static load breakpoints before and after subjecting them to 5 million fatigue cycles, at a force of 25% of the static breaking force. These results confirm the abutments were not been damaged and maintained their initial strength.

There are several study limitations which need to be considered when making a proper correlation with clinical application. Firstly, studies with a larger number of samples are needed to obtain more representative results. Secondly, future studies should explore higher loads in fatigue testing.

CONCLUSIONS

1. Zirconia abutments fracture at the neck when overloaded.
2. The load (force) withstood by the abutment is strongly influenced by the abutment dimensions and positioning.
3. In our study, the zirconia abutment strength was unaffected by fatigue testing of 5,000,000 cycles using 25% of the static breaking force; so they have good long-term behaviour.
4. The zirconia abutments appear to be suitable for use in the anterior maxilla area.

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Topic of update

Extractions In Orthodontics: An update

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ABSTRACT

The aim of this article is to review the current main criteria for tooth extractions in the prophylaxis and treatment of malocclusions and dentofacial deformities. Dental extractions are an essential therapeutic weapon in the management of certain malocclusions. They are indicated for obtaining arch space, improvement of facial aesthetics and achievement of balanced occlusion, among others.

"Conventional" standards of therapeutic extractions correspond to different combinations of symmetrical extraction of premolars; however, atypical extractions which do not follow a definite pattern are becoming increasingly frequent. They are more common in adult patients and are performed for reasons related to the pathology of the extracted tooth itself or to the demands of unconventional malocclusion treatment. Examples of atypical extractions are that of a lower incisor with indications, contraindications and undesirable effects which are well defined.

Temporary teeth extractions may be performed as part of an eruption guide programme, which must be adapted to the situation of each patient and never considered as a rigid scheme of general application.

KEYWORDS

Extractions; Malocclusion; Orthodontics; Eruption guide; Facial aesthetics.

Figure 1: A. Edward H Angle and B. Calvin S Case.

BACKGROUND

The need to perform extractions as part of the treatment plan for some malocclusions remains one of the great controversies in orthodontics.

Since the dawn of the specialty, Angle passionately defended the conservation of all teeth for perfect occlusion. He eventually accepted the need to abandon this ultraconservative position and to take into account the impact on the profile, stability and other constraints, such as periodontal health and declared to have acted to maintain the complete dental provision of some of his patients at all costs. On the other hand, Calvin Case, who could be considered a contemporary scientific adversary, advocated the use of permanent teeth extractions, if necessary, to successfully resolve malocclusion (Figure 1).

Since then, there have been swings in prevailing currents of opinion regarding therapeutic extractions in orthodontics. On the one hand, these movements have been based on the different fashions presiding over facial aesthetics at different historical times; but also on the availability of therapeutic techniques and instruments of varying scientific bases, replacing what were previously inevitable extractions for handling certain malocclusions. Fundamental among these was the introduction of the palatal arch bar by Cetlin, distalisers, microscrews, and self-ligating bracket systems.

This review discusses the most relevant aspects surrounding the application of this important therapeutic tool in orthodontics, in the light of information found in the literature. We will focus on the indications for extractions and the patterns of teeth to extract.

I. INDICATIONS FOR EXTRACTION IN DENTISTRY

Therapeutic extractions in orthodontics are primarily done for the following reasons:

1. **Achieving arch space**: To correct negative osseodental discrepancy (DOD), which usually manifests as crowding.
2. **Facial aesthetics:** To reduce dentoalveolar protrusion.
3. **Occlusion:** To properly connect both arches in normo-occlusion.
4. **Stability:** To better maintain the results achieved.
5. **Others:** For example, periodontal health, dental and medical pathology.

1. Extractions and arch space: DOD

One of the most important and common indications for orthodontic extractions is the lack of space in the arch that usually manifests as more or less localised crowding.

Achieving proper dental alignment in their bony bases requires consideration of the compromise between the size of the teeth themselves and the size and shape of their bases within the framework of the dentofacial skeletal relationship for each patient. The orthodontist can act on the maxillomandibular skeleton well using orthopaedic means in children, as well as in adolescents with residual growth or with surgical care where there is no such growth. In every case, the limits imposed by the individual maxillomandibular anatomy must always be assessed when deciding whether a malocclusion with negative DOD can be resolved conservatively or whether one must resort to extractions.

Some multibracket systems, particularly self-ligating, have entered the market declaring they are able to reduce the need for extractions in a number of cases of negative osseodental discrepancy, where it would have been essential to remove teeth if conventional techniques had been applied. However, disputes in this regard are very important. Many authors consider that these techniques only produce a dental overexpansion of the arch which does not correspond to real production of alveolar bone to neutralise the DOD, and instead could lead to an unacceptable weakening of the alveolar bone tables.

Distalisation devices to prevent extractions by mesialisation of the maxillary molars where there is a lack of space deserve a special mention. Distalising these molars can lead to recovery of space in the arch that could otherwise only be obtained by extracting premolares[7-10].

Mention must also be made of the unquestionable contribution that micro-implant development has made in preventing many extractions; in fact, this is one of its numerous indications.

When there is a negative osseodental discrepancy due to excess transverse dimensions in the teeth, it is feasible to reduce this by a stripping technique. However, one or more teeth will have to be removed in many cases, even after reasonable expansion of the arches. This method does not exclude extractions, but in many cases is complementary to them; i.e. achieving a suitably wide arch is a goal in itself, which will not always guarantee that DOD extractions will be avoided.

2. Extractions and facial aesthetics

One of the main indications for orthodontic extractions is to achieve a more harmonious profile in patients with excessive facial convexity secondary to dental biprotrusion. It must be noted, in this regard, that the concept of the ideal profile has changed notably throughout the last century[6]. Several decades ago, the ideal Caucasian profile was flat or even slightly biretrusive, with relatively thin lips; while in recent times more convex profiles have become more popular with a marked lip relief and a wide smile with buccal corridors. This change in tastes for greater facial convexity is mainly for women and in Caucasians; whereas in the male and in oriental races, the flat profile is still considered more harmonious. Obviously, this is not the case in negroid races, one of whose most characteristic features is precisely biprotrusion.

The greater tolerance to convexity in our environment has naturally reduced the need for extractions due to biprotrusion and DOD. For example, Proffit performed a study on the changes in the pattern of extractions in the treatment of malocclusions during the last 60 years. It showed that the frequency of extractions was around 30% for the years 1953 and 1993: 40 years apart. However, interestingly, the analysis in 1968 gave a result of 76%. The explanation given for this high percentage was the trend at the time for removing all teeth outside of the arch. At present, this proportion is limited to 5%; 20% down on most studies[1].

However, there are some facial features linked to excessive convexity which are objectionable in any aesthetic framework and put a limit on the extraction option. One of those features is the hyperactivity of the muscles of the chin associated with biprotrusion which, in an effort to close the lips, gives the chin a kind of "golf ball" appearance.

The positive effect on the profile of extracting the bicuspids in patients with a normal vertical dimension or a little short and a marked biprotrusion, especially if associated with crowding, is generally clear; thus, there is usually agreement among authors for its indication[1]. This does not occur in the biprotrusive patients with a pattern of mandibular posterorotation and dolicofacial growth. The aesthetic result in these patients of resolving biprotrusion with extractions is unpredictable, if not clearly wrong; so the clinician is often faced with the choice of obtaining good occlusion at the risk of worsening facial aesthetics, or not altering the profile and accepting the limitations in the resolution of the malocclusion. Obviously, in cases where the dentofacial deformity is more severe, orthognathic surgery allows for both goals, facial and occlusial.

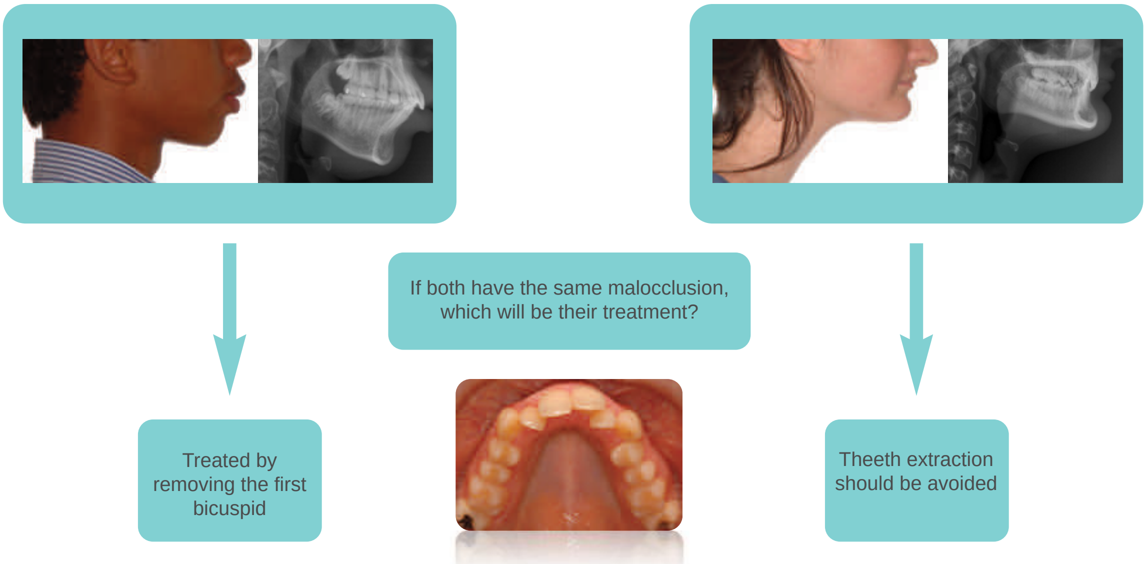

Figure 2: Patient A has a dentoalveolar biprotrusion with convex profile. Patient B has dentoalveolar biretrusion with concave profile. If both have the same malocclusion with crowding, patient A should be treated by removing the first bicuspid, while teeth extraction should be avoided in patient B if possible, due to potential undesirable effects in facial aesthetics.

A trait that also determines the indication for therapeutic extractions and the management of orthodontic appliances in these cases is the presence of overbite or open bite. Extractions tend to increase overbite, which is positive when there is a tendency to open bite and undesirable in patients with a deep bite.

In short, the indication of therapeutic orthodontic extractions is subject to multiple circumstances which need to be carefully assessed in the treatment plan. In fact, an identical malocclusion will require a conservative or extractive approach depending precisely on a rigorous evaluation of these circumstances. Figure 2 outlines this unquestionable reality (Figure 2).

3. Extractions and normalising occlusion

Achieving a class I canine is not an objective to be waived with a malocclusion; although in exceptional circumstances limitations have to be accepted in this regard, especially in adult patients.

However, although desirable, an Angle class I molar seems inessential for either oral or joint health. Nevertheless, the orthodontist usually tries to achieve it. When the patient is in growth, the use of orthopaedic and functional appliances may contribute to achieving this desired molar class I, linked to the normalisation of the skeletal relationship. When no residual growth remains, apparatus specifically aimed at the normalisation of occlusal relationships can be used. There are numerous molar distalisation devices to treat Class II teeth[7-9] and designs with microscrews for classes II, III and open bites, for example[10]. However, it is often not possible to achieve the objective of the molar normal occlusion, so extractions need to be resorted to for a class I canine, and other aesthetic or periodontal goals, for example. As discussed below, these can be planned according to a typical pattern (class II upper premolars and class III lower ones), or atypical patterns can be used, depending on the circumstances of each case.

4. Extractions and stability of results

One of the key aspects in the success of orthodontic treatment is the stability of long-term results, which depends on certain parameters such as the interincisive angle, overbite, overjet, appropriate transverse dimensions and good periodontal health. There is no general agreement on the impact of therapeutic extractions on the post-treatment stability of each of these parameters. One of the advantages that have been claimed for extractions is that they promote stability, both with overjet and crowding. However, not all authors agree, and some view the possibilities of extractions with scepticism and say that, over time, the lower incisors tend to come together again, regardless of the treatment modality: conservative or not conservative[1]. Others point out that the key issue is the proper location of the teeth relative to the alveolar bone to maintain stability and periodontal health; such that the only thing that would ensure stability would be obtaining a proper interincisive angle (Figure 3).

One experience shared by orthodontists is that deep overbite in extraction cases tends to recur more than in cases where no extraction takes place[12].

5. Extractions and intrinsic pathology

Sometimes, in planning the treatment of a malocclusion that could be treated without extractions, removal of one or more teeth is included simply because they have intrinsic pathology or are periodontally compromised. If ignored, this condition can compromise medium- or long-term viability or hinder the treatment of the malocclusion itself. At other times, it is the requirement of an interdisciplinary treatment where other experts make the decision to extract. The most common pathology in this sense is partly periodontal (including recessions and severe dehiscence) and partly pulpar of an infectious or traumatic nature. Although morphological abnormalities and ectopic eruption are other reasons.

II. PATTERNS OF TEETH TO BE REMOVED IN ORTHODONTICS

1. Conventional or typical patterns

Table I Shows the most common tooth extraction patterns used and their main indications for treating malocclusions. It is open to multiple qualifications and exceptions but is basically an indicative scheme.

2. Atypical extractions

In practice, they are very common and, although they may be necessary in patients of all ages, their frequency has increased proportionally with the incorporation of adult orthodontic consultations. They have multiple indications, whether related to the pathology of the extracted tooth itself or unconventional malocclusion treatment demands. These extractions are very commonly indicated in adult patients because, after a certain age, dental mutilations, periodontal disease and other conditions that will affect the malocclusion treatment plan are a constant feature in our environment.

Table II contains examples of reasons for unconventional or atypical extractions. Particular atypical extractions worth a mention are extraction of a lower incisor and the first molars, so these are particularly referred to from the orthodontic treatment point of view[34,35].

2.1 Extraction of a lower incisor

The frequency of extraction of a lower incisor in orthodontic clinics is highly variable. Most authors put the figure at 1.1-6% of all patients treated for malocclusion[33,36]. For example, Proffit in the 1950s recorded the extraction of a lower incisor in 20% of all malocclusive patients treated with extractions[6].

The main indications for extracting a lower incisor are:

- *Malocclusion of Angle Class III, light – moderate, with little negative overjet or 0 overjet and decreased overbite.*

This is the fundamental indication, but has the limitation of not properly resolving the molar and canine classes. Extracting a lower incisor involves a reduction in arch length and extrusion and retrusion of the remaining lower incisors; thus increasing the overbite and overjet. As a result, extraction of a lower incisor is only recommended in patients with an Angle Class III malocclusion to resolve mild to moderate anterior crowding not accompanied by excessive overbite or large negative overjet.

- *Malocclusion of Angle Class I or II with Bolton discrepancy*

The extraction of a lower incisor may be indicated for an increase in the transverse dimension of the lower incisors (lower discrepancy excess), but also when the patient has microdontia, or even agenesis, of the upper ones (upper discrepancy defect). In these cases, extraction of the lower incisor is considered over other possible alternatives, as would be stripping in the anteroinferior sector for lower discrepancy excess or remodelling of the upper incisors in upper discrepancy defect.

Specifically in class II with Bolton discrepancy, the extraction of a lower incisor may be combined with the use of some distalisation mechanism, or with the extraction of two upper bicuspids. Skeletal class II cases can be treated with orthognathic surgery, with the extraction of a lower incisor possibly being part of a presurgical orthodontic treatment plan.

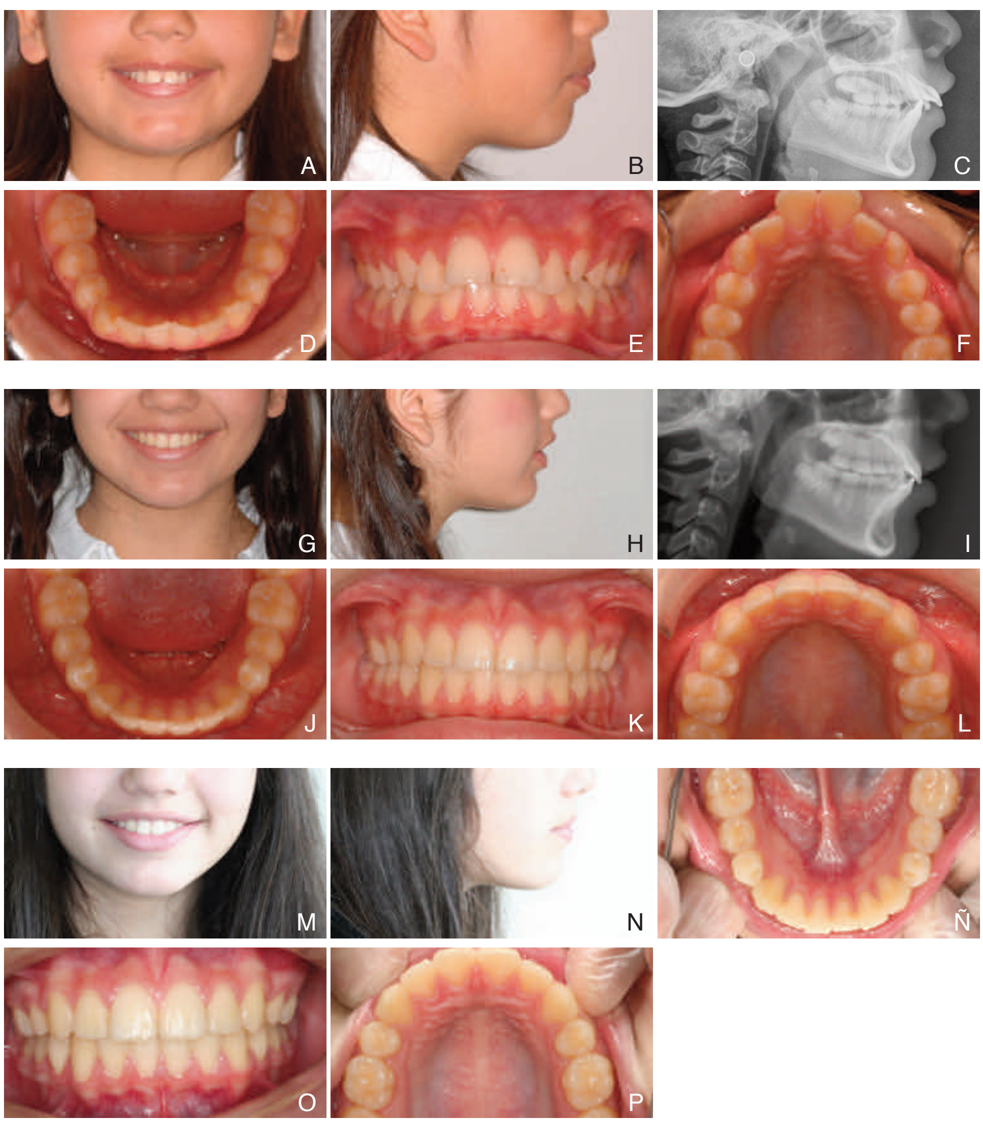

Figure 3: Patient with dentoalveolar biprotrusion treated by extracting first bicuspids. An improvement in the profile can be seen. a, b, c, d, e, f: Initially. g, h, i, j, k, l: After treatment. m, n, ñ, o, p: After one year of retention.

C. Temporomandibular dysfunction with mandibular retroposition

It has been suggested that the removal of a lower incisor facilitates the anterior reposition of the mandible in patients with TMJ dysfunction and Angle Class I malocclusions without residual growth.

Table III lists the undesirable effects and contraindications of therapeutic extraction of a lower incisor[36].

2.2 Extraction of the first molars

The functional significance of the first molars means they are rarely suggested for extraction in the conventional treatment of malocclusion. However, it is not uncommon to find first molars affected by severe pathologies, such that their removal is considered within an interdisciplinary therapeutic plan. Among these pathologies are those that involve significant destruction of the crown which makes restorative treatment difficult; particularly extensive decay and severe enamel defects (isolated hypoplasia and incisor-molar syndrome).

Therapeutic removal of first molars may also be considered for eruption disorders, whether due to ankylosis or ectopies of difficult renewal. Extracting the first molar with a pathology may be an alternative to a first premolar. When there is no indication to extract premolars, the space left by the removal can be closed by mesialisation of the second molars and eventually the wisdom teeth. In this case, the final occlusal position should be considered beforehand, depending on the molars remaining after extraction.

In adult patients, the most common cause of permanent molar extraction is periodontal disease of the tooth.

TABLE I: TYPICAL PATTERNS OF TOOTH EXTRACTIONS IN ORTHODONTICS: INDICATIONS

EXTRACTION PATTERNS	INDICATIONS
- First 4 bicuspids	- Angle class I with: - Crowding and/or - Biprotrusion and/or - Open bite.
- First 2 upper bicuspids	- Angle class II.
- First upper bicuspids and second lower	- Class II with: - Overjet and/or - Crowding.
- First 2 lower bicuspid	- Angle class III.

TABLE II. REASONS FOR ATYPICAL ORTHODONTIC EXTRACTIONS AND TEETH EXTRACTED

REASONS FOR EXTRACTION	TOOTH TO BE EXTRACTED
- Correction of the midline. - Asymmetric malocclusions	- Bicuspid
- Bolton Discrepancy - Lower crowding in Class III	- Lower Incisor
- Agenesis of a lateral incisor	- Upper lateral incisor (contralateral)
- Ectopy, impaction - Ankylosis	- Upper canines
- Intrinsic pathology	- Tooth affected

2.3 Extraction of temporary teeth

Temporary teeth extraction is an important prophylactic weapon in the development of certain malocclusions. However, it is a subject of constant debate and clashes between orthodontists, who indicate the extractions, and paediatric and general dentists who have to perform them and do not always understand the need for them. Removing temporary teeth can be prescribed in a timely and well located manner either or within the framework of a programmed eruption guide.

Specific indications for removal of temporary teeth without a predetermined pattern are very common; thus, only a few of the most frequent in orthodontic practice will be outlined.

Firstly, the prevention of permanent teeth impaction must be mentioned. Important in this area is the research by Ericson and Kurol on prophylaxis of the impaction of palatal maxillary canines in cases of eruptive deviation during the period of mixed dentition[40-41]. These authors showed that the extraction of canines, and eventually the first upper molars, in children with deviation of the permanent ones prevented their evolution to inclusion in 60-90% of

TABLE III: UNDESIRABLE EFFECTS AND CONTRAINDICATIONS FOR THERAPEUTIC EXTRACTION OF A LOWER INCISOR

UNDESIRABLE EFFECTS	- Excessive overjet and overbite. - Reopening of extraction space. - Inadequate posterior occlusion. - Loss of interincisor papilla with appearance of "black triangles". - Mesial inclination of the lower canines. - Excessive lingual inclination of the remaining lower incisors. - Inconsistency of midlines (inevitable).
CONTRAINDICATIONS	- Bolton Discrepancy, upper excess. - Increased overbite. - Triangular anatomy of lower incisors, especially with periodontal disease. - Increased overjet.

cases. This prophylactic extraction procedure of temporary canines deserves special consideration in patients with agenesis of the lateral incisors for its proven association with canines.

Another indication that is frequently suggested is the extraction of temporary second molars in cases of impaction of the permanent first with infraocclusion. In these cases, a distal reduction of the second temporary molar (slicing) can be performed; but if this is not enough, they must be extracted. Usually, the permanent molar erupts spontaneously afterwards, but is essential to control the loss of the space required for the premolar successor.

Finally, mention must be made of the extraction of the temporary incisors in the presence of eruptive alterations of the permanent successors. The etiology of their impaction is multiple: traumatic events with the incisor itself or its temporary predecessor; the presence of obstacles such as supernumerary teeth, odontomas or cysts; or jaw malformations, especially a cleft palate. In all these cases, when the temporary predecessor persists, usually removal is indicated, associated or not with other orthodontic or surgical procedures[28,42,43].

2.4 Guiding eruption

A programme of serial extraction of temporary teeth or, even better, a guide to eruption may facilitate the treatment of malocclusion in temporary or mixed dentition or prevent its full development[44].

However, many authors have pointed out the importance of extreme prudence and knowledge of the pathophysiology of the eruption when using this therapeutic tool. In inexpert hands, significant undesirable effects can occur by improperly handling the anchor and maintaining spaces, for example. In short, programmes guiding the eruption are far from being a rigid solution that apply in all cases; but must be tailored to each patient's pathology, ending or not in the removal of the first bicuspids[45].

CONCLUSIONS

Dental extractions are a highly useful weapon in the prophylaxis and treatment of numerous malocclusions. However, their use requires great caution and a thorough understanding of the pathophysiology of eruption, occlusion and facial aesthetics. The orthodontist is faced with numerous facial and dental deformities which cannot be managed by the rigid application of treatment plans; and this is particularly applicable to tooth extractions. Adult patients often have very complex pathologies which pose many challenges to the orthodontist, among which are the ability to remove or keep teeth and to manage this within an interdisciplinary approach.

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Case report

Periapical Microsurgery: An alternative in the treatment of persistent apical periodontitis: 2 case reports

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ABSTRACT

Endodontic microsurgery is an alternative in the treatment of periradicular lesions of endodontic origin which do not respond to conventional treatment. The use of surgical microscopy, surgical ultrasonic tips and new sealing materials, such as MTA, have improved the long-term prognosis of these treatments. Two clinical cases where surgery was the treatment of choice for persistent periapical lesions are described. The first was treatment of an injury due to foreign matter in the apical third of the mesiobuccal root. The second was due to a persistent extensive periapical lesion after conventional retreatment.

KEYWORDS

Periapical surgery; MTA; Operating microscope; Periapical periodontitis.

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BACKGROUND

Endodontic microsurgery is the branch of dentistry dedicated to the diagnosis and treatment of lesions of endodontic origin that do not respond to conventional endodontic therapy[1]. Faced with a periradicular lesion of endodontic origin, the use of a proper non-surgical technique with adequate cleaning, 3-dimensional conformation and sealing of canals achieves a success rate of 85%[2-4]. Among the causes of the persistence of these lesions are: Presence of intracanal biofilm, extraradicular Actinomyces infections, presence of cholesterol crystals and foreign body reactions[5]. In these cases, a therapeutic alternative may be endodontic microsurgery[6-9].

The main purpose of endodontic surgery is to prevent the invasion of bacteria and their bioproducts from the canal system to the periradicular tissues in teeth with periodontitis of endodontic origin[10-13]. Over time, endodontic surgery has had varying success rates and much lower than those of today. Ignorance of the root microanatomy, the use of rotating tungsten carbide burs for retropreparation and the use of silver amalgam as a filling material meant the prognosis was uncertain in most cases[14]. At present, the technological advances and knowledge of the microanatomy canal system have improved the long-term prognosis, achieving success rates close to 90%[15-17]. The use of Cone Beam Computed Tomography (CBCT) has improved the diagnosis, location and extent of periradicular lesions[18-19]. The use of the surgical microscope (Figure 1) has led to a substantial improvement in vision, by magnifying a work area as small as the root apex, and with the new lighting systems with xenon light or LED, which provide an intensity far superior to conventional halogen lighting. The better control of bleeding in the area of the bone crypt, thanks to proper anaesthetic technique and the use of local binding agents, improved management and vision of the operative field. The use of ultrasonic small size diamond tips and a specific design for various work areas (Figure 2) has facilitated the preparation of the cavity. The small size provides: a greater vision of the work area, due to not inserting

Figure 2. Surgical ultrasonic diamond tips reinforced with zirconium.

Figure 1. A surgical microscope provides better lighting and magnification in the work area.

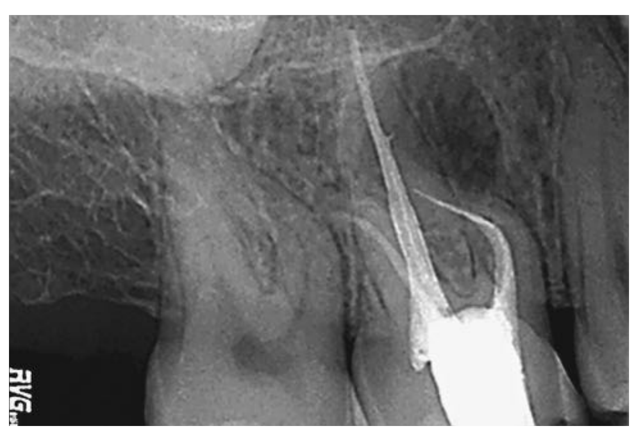

Figure 3. Radiograph of 16 showing the presence of a piece of material in the apical third of the mesial root.

the head of the handpiece, smaller osteotomies, apical bevels reduced by up to 10° and less aggressive and more accurate preparations[20].

Finally, the use of more biocompatible materials to provide better sealing, such as the mineral trioxide aggregate (ProRoot MTA, Maillefer, Ballaigues, Switzerland) and ethoxy benzoic acid reinforced cement (SuperEBA, Harry J. Bosworth, Skokie, IL, USA) have helped improve long-term prognosis of these cases[21-24].

CASE REPORT 1

Female patient, aged 28 years, referred to the consultation for reporting pain in the occlusion and swelling in the upper right vestibular region. The patient reported she had undergone a root canal treatment on tooth 16 two years earlier and was injured by a broken instrument. She had remained asymptomatic until recently. A clinical examination revealed inflammation in the vestibular area corresponding to 16 and tenderness after palpation and percussion of the tooth. The radiological examination revealed a root canal treatment in 16 with adequate condensation and extension of the sealing material, except in the mesiobuccal root, where a possible piece of material occupying the apical third (Figure 3) was detected. A radiolucent lesion associated with the apex of that root was also noted.

Since the fractured instrument piece was about 7mm in length and located beyond the angle of curvature of the mesial root, the possibility of success for a repeat treatment was considered low. The possibility of performing microsurgery to remove the lesion, removing the instrument piece and improving the sealing was proposed to the patient.

Infiltrative anaesthesia was performed with articaine with 1:100,000 epinephrine (Ultracain, NORMON, Madrid, Spain) to achieve adequate haemostasis of the operating areas to allow for proper vision. The use of the microscope during infiltration of the anaesthesia helped to avoid puncturing small blood vessels. A microfoil scalpel incision (Micro Blades, Hu Friedy, Zweigniederlassung, Germany) was performed to increase accuracy and minimise damage to the soft tissue. An incision was performed at 90° and not bevelled to promote proper repositioning of the flap; thus preventing scarring due to sliding. The

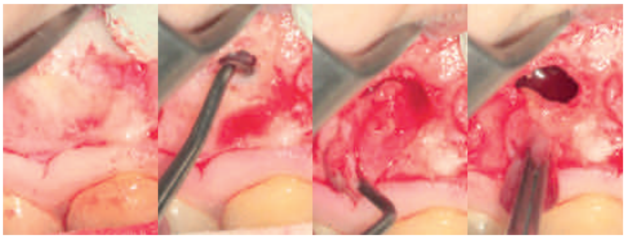

Figure 4. Removal of granulation tissue, curettage of the lesion and removal with the aid of toothed forceps.

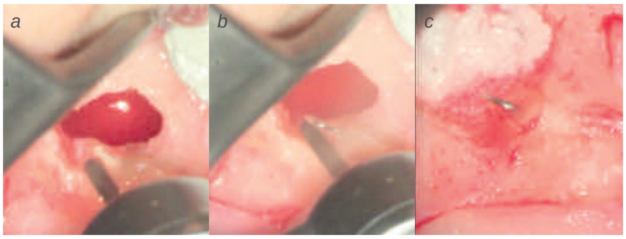

Figure 5. Elimination of 3mm of the root apex with surgical handpiece and abundant irrigation (a and b), exposing the fragment of foreign matter (c).

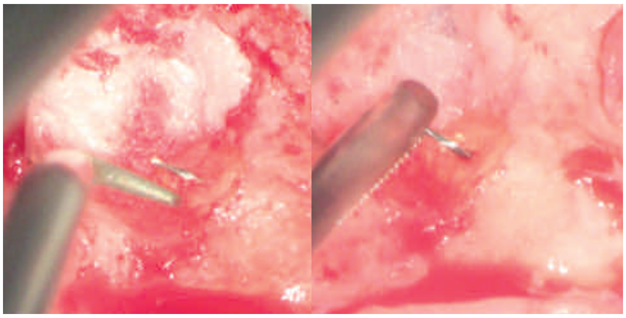

Figure 6. Ultrasonic surgical tip to dislodge fragment (a) before being removed with the straight forceps (b).

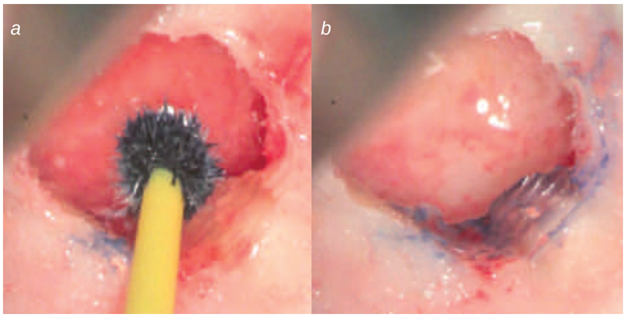

Figure 7. Staining of sectioned apical area with methylene blue (a) and detail of root section to see limits and possible untreated canals (b).

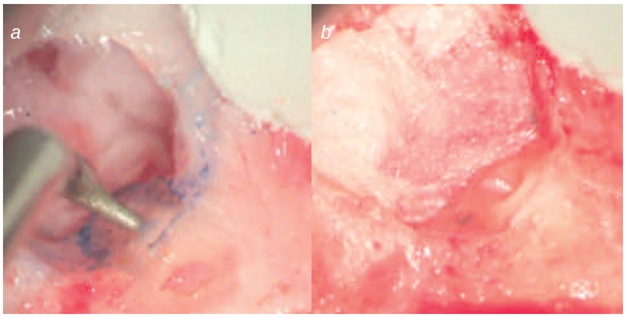

Figure 8. Preparation of retro cavity with ultrasound and abundant cooling (a). Close-up of retro cavity prepared and dry (b).

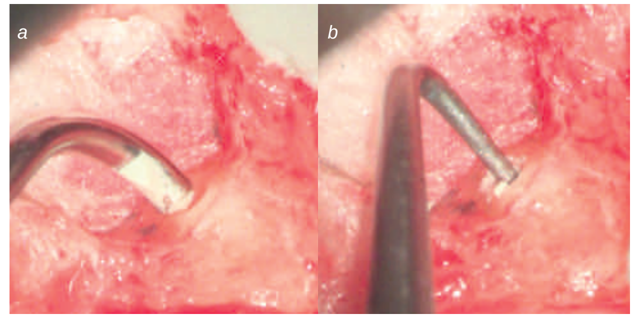

Figure 10. Close-up of MTA transport to the retrocavity with the MAP System syringe (a). Microrammer used to reduce the sealing material (b).

vestibular osteotomy was performed with a round surgical bur and a handpiece, copiously irrigated with saline. Part of the vestibular cortical bone had been lost due to the extent of the injury. After curettage of the tissue to remove granulation and the aid of toothed forceps, the instrument was removed in one piece from the lesion (Figure 4).

Next, 3mm of the apex root was removed, exposing the fragment of the file. This required a surgical NSK handpiece at a 45° angle (Ti Max A 450L, NSK, Shimohinata, Kanuma, Japan) and a surgical length tungsten carbide bur (Figure 5) was used. When the file fragment was exposed it was loosened by ultrasonic vibration with the surgical tip to disengage it from the root canal. Once it began to move, it was extracted with the help of a straight pair of forceps (Figure 6). After removing the file fragment, the apical area was dyed with methylene blue to better appreciate the periodontal limit, possible cracks and unsealed canals

Figure 9. Syringe MAP System for transporting MTA to the retropreparation.

Figure 11. Radiograph postoperatory to evaluate greater sealability.

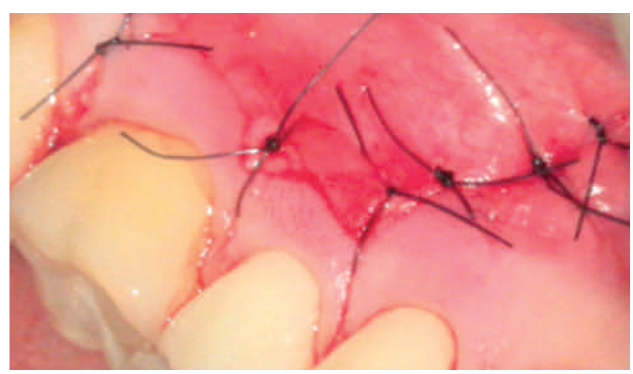

Figure 12. Surgical suture monofilament 5/00.

Figure 13. Follow-up radiographs at 6 months (a) and 9 months (b) where development of bone and complete regeneration of the injury can be seen.

(Figure 7). Then, the cavity was prepared to a depth of 3mm with an Ultrasonic Surgical diamond tip (ProUltra Ultrasonis tips, Maillefer, Ballaigues, Switzerland), by removing traces of potentially contaminated gutta percha. Ultrasound treatment was performed with ample cooling to prevent heating of the root and the appearance of cracks. The cavity was reviewed with micromirrors and dried using low pressure air with the Stropko air syringe (SybronEndo, Orange, CA, USA) (Figure 8).

Mineral trioxide aggregate ProRoot MTA (Maillefer, Ballaigues, Switzerland) was used as a sealing material, and transported with a MAP System syringe (Maillefer, Ballaigues, Switzerland), which had different angled terminals of different diameters and curvatures, suitable for the different areas of the arch (Figure 9). The sealing material was reduced with a microrammer and applied with a microspatula (Figure 10). After the sealing was finished and checked for possible remains of filling material which were removed from the bone crypt. A postoperative radi-

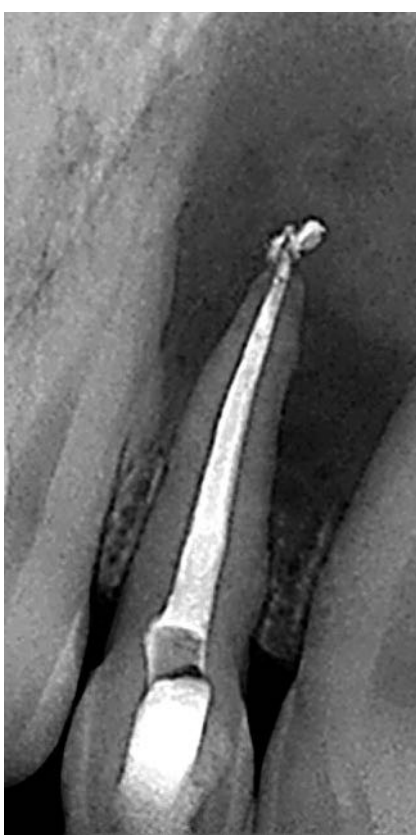

Figure 14. Root canal treatment of 12 with periradicular lesion reaching 11 and 13.

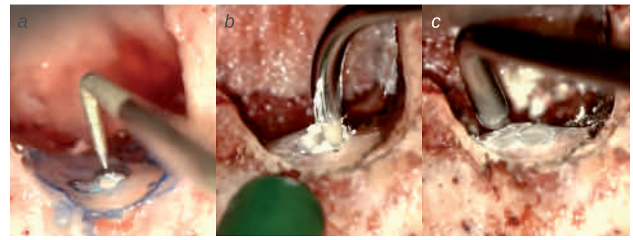

Figure 15. Close-up of the cavity preparation to retro with ultrasound tips (a) sealing with MTA (b) and condensation of the sealing material (c).

Figure 16. Postoperative radiograph to assess the quality of the seal and to serve as a reference to assess the evolution of bone growth during follow-ups.

Figure 17. Follow-up radiographs at 6 months (a) and 9 months (b). Almost complete regeneration of the bone defect can be seen.

ograph was taken to verify the adaptation of the sealing and to serve as reference in subsequent tests (Figure 11). The areas was curetted to stimulate bleeding and a clot established in the bone defect. No bone graft or resorbable membrane material was added as the vestibular cortical defect was reduced. A simple suture was performed with 5 zero monofilament suture points (Normon, Madrid, Spain) (Figure 12).

The patient was prescribed Amoxicillin 500mg, Ibuprofen 600mg and 0.2% chlorhexidine mouthwash for a week. The suture was removed after 48 hours. Radiographic controls at 6 months and 9 months were performed to check for the complete regeneration of the bone defect (Figure 13).

CASE REPORT 2

Female patient, 24 years, referred by her dentist to assess the periradicular injury on the 12 associated with an old canal treatment. The patient told us that the first root canal treatment was 3 years earlier and since then she had experienced periodic episodes of inflammation and pain. About 3 months previously, a retreatment was performed on the same tooth but the symptoms did not cease. Thus, the possibility of microsurgery was suggested. The clinical examination revealed a gum inflammation at the vestibular level 11, 12 and 13 and tenderness in that area. Probing the gingival sulcus 12 was negative and no mobility was appreciated. In the radiological examination a root canal in 12 was apparently of the correct extension and condensation, and an extensive radiolucent lesion around the apexes 11, 12 and 13 (Figure 14) was observed.

Pulp vitality tests were performed and it was observed that 11 and 13 had positive pulp vitality, so it was decided not to perform any treatment on these parts. The treatment suggested was periapical microsurgery on 12. All microsurgery phases were the same as described in clinical case 1 (Figure 15). Before the suture, a postoperative radiograph was performed to verify the quality of the sealing and the absence of foreign material in the crypt (Figure 16). The patient had clinical and radiographic follow-ups at 6 and 9 months (Figure 17). The patient was asymptomatic and the bone regeneration of the lesion was seen radiographically. A small radiolucent afterimage either showed that the injury had not completely healed or that there was non-pathological scar tissue present.

CONCLUSIONS

Periapical microsurgery may be an alternative predictable treatment in cases of persistent apical periodontitis.

The presence of insurmountable obstacles, such as fractured pieces of instruments, stepping, calcification, cast and core preventing access to the apical third are sometimes contraindicated for a retreatment. In these cases, periapical microsurgery may be a first therapeutic alternative.

The use of the operating microscope, ultrasonic terminals with diamond tips and new biocompatible retro sealing materials of greater sealability are some of the advances that have modified the surgical technique.

Careful treatment of the soft tissues, reducing the size of the osteotomy and precise suturing of the flap reduces inflammation and postoperative pain; thus possibly categorising this technique as minimally invasive.

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Case report

Endodontic and surgical management of invasive cervical resorption: Literature review and case report

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ABSTRACT

Background: Invasive cervical resorption (ICR) is a type of external root resorption, characterised by the loss of hard dental tissue by the action of odontoclasts. It appears most often in the cervical region of the root surface of the teeth.

Objective: To present a case report describing the protocol for dealing with an invasive cervical resorption, and literature review of the etiology, diagnosis and treatment.

Case report: Female patient, 19 years old, with no relevant medical history, who came to our clinic due to a pinkish colouration in the cervico-buccal surface of the right maxillary central incisor.

The tooth had no pain on percussion and palpation. The vitality of the tooth was negative. After rigorous analysis, treatment was performed which consisted of 2 phases: Firstly, a nonsurgical phase followed by a surgical procedure. The reconstruction of the defect was carried out using glass ionomer cement.

Conclusions: The endodontist needs to understand and manage the periodontal and restorative aspects of treating ICR. After treatment, the patient was satisfied with the aesthetic result.

KEYWORDS

External root resorption; Invasive cervical resorption.

BACKGROUND

Root resorption is the loss of dental hard tissue as a result of clastic activity. Reabsorption can be classified as internal or external according to its location relative to the root surface. Internal resorption occurs within the pulp canal, and tends to be asymptomatic; it is usually caused by a chronic infection or trauma[1]. Internal resorption is classified into surface, inflammatory and replacement resorption. While external root resorption can be divided into progressive inflammatory, cervical and replacement resorption.

Invasive cervical resorption (ICR) is a clinical term used to describe a rare form of external root resorption[2].

It is seen in most cases as a late complication of traumatic injuries to the teeth, but may also occur following orthodontic movements, periodontal treatments, whitening and reimplantation. In addition, there is literature supporting unknown etiology of ICR[3].

Clinical presentation of ICR varies considerably. Lesions can be identified during a routine conventional radiography (radiolucent area) or by performing a clinical examination, as in most cases it is asymptomatic. Cone Beam Computed Tomography (CBCT) is useful for the diagnosis and management of ICR, as the true extent of the defect cannot always be estimated by conventional radiography[4].

It is characterised by a progressive loss of cementum and dentine with replacement by fibrovascular tissue derived from periodontal ligament.

In early lesions, an irregularity can be seen in the gingival contour. In advanced lesions, the crown shows a pink colour, mimicking internal resorption[5]. This discoloration is due to vascular granulation tissue that shows through the thin residual enamel.

Heithersay[2,6-8] wrote what are now classic articles in the literature describing the features, possible predisposing factors and recommendations for treating ICR. He divided ICR into 4 categories depending on the degree of affectation of the mineral tissue.

- Class 1: Small resorption area located in the cervical zone with dentin surface penetration.
- Class 2: Well defined resorption, close to the root canal showing little or no extension to the root dentine.
- Class 3: Deep invasion into the dentine, which affects both the coronal dentine and extends into the cervical third of the root.
- Class 4: Extensive resorption which extends beyond the cervical third of the root.

For Heithersay, treatment[8] consisted of mechanical and chemical debridement of lesions followed by restoration. For class 1 and 2 lesions, he found a success rate of 100%; for Class 3 lesions, 77.8% and for class 4 lesions, a success rate of 12.5%.

Different approaches have been proposed to treat ICR. Nonsurgical treatment involves the application of 90% trichloracetic acid, curettage of the lesion, endodontic treatment, only if necessary, and restoration with glass ionomer cement[9].

Surgical treatment varies depending on the degree of ICR, and consists of lifting a mucoperiosteal flap, curettage of the lesion and restoration of the defect with composite resin[10,11], glass ionomer cement[5], ionomer cement with resin[12] or mineral trioxide aggregate (MTA)[13,14].

The aim of this article is to present a case report describing the action protocol for an invasive cervical resorption as well as a literature review of etiology, diagnosis and treatment.

CASE REPORT

Female patient, 19 years old, with no relevant medical history, who came to our clinic due to a pinkish colouration in the cervico-buccal surface of the right maxillary central incisor, 11 (Figure 1). The patient

Figure 1: Initial clinical appearance, where a pinkish colour is seen in the cervical region of the right central incisor.

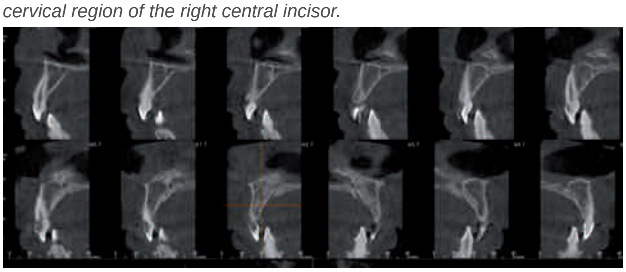


Figure 2: CBCT sagittal sections, where the resorptive extent of the lesion is seen.

had no memory of any history of trauma to the affected area.

The clinical examination showed the tooth had not been restored and there was no decay. A probe inspection detected a cavitation in the cervico-buccal surface enamel and bleeding in the area. The tooth was not painful to percussion or palpation. The vitality of this after the ethyl chloride test was negative.

Radiographic evaluation consisted of a CBCT (Figure 2) and periapical radiography, which revealed a well-defined radiolucent area in the radicular third cervical root of 11.

The diagnosis was invasive cervical resorption, Heithersay class 3, based on clinical and radiographic findings.

After studying the case, it was decided to perform treatment in two phases.

The first non-surgical phase consisted of opening and instrumentation of the root canal with manual K files to remove the necrotic pulp and disinfect the root canal. The second surgical stage was to expose and debride the resorptive defect, perform the root canal and posterior tooth restoration.

After signing the informed consent and local anaesthesia was given, the root canal was opened on the palatal face of 11. Heavy bleeding was seen, due to the link between the root canal and the resorptive defect.

The operation area covered 23 mm (Figure 3), and was determined by the apex locator Denta Port ZX (J. Morita Manufacturing) and confirmed radiographically.

The irrigation used was 1.25% sodium hypochlorite, with calcium hydroxide left as intracanal medication.

15 days later under local anaesthesia, the mucoperiosteal flap was opened to expose the entire lesion area for removal of the granulation tissue by curettes (Figure 4). Once all the granulation tissue was removed, the area was bevelled with a diamond handpiece bur.

The root canal was then irrigated with 1.25% sodium hypochlorite, before the final irrigation with 1mL of 17% EDTA and irrigation of the root canal with 1.25%

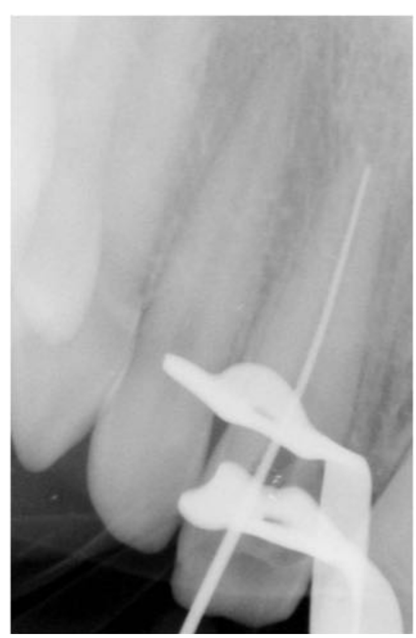


Figure 3: X-ray radiograph.

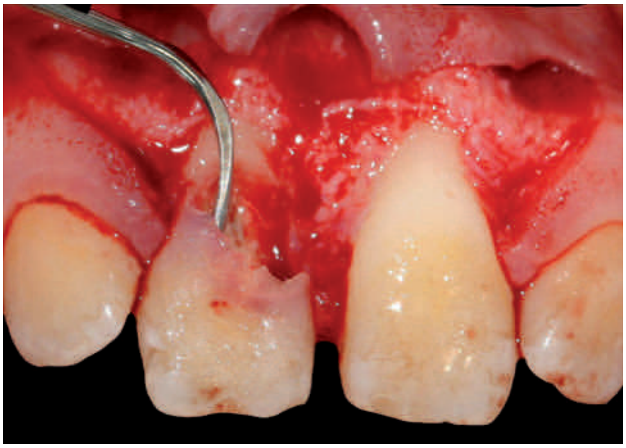
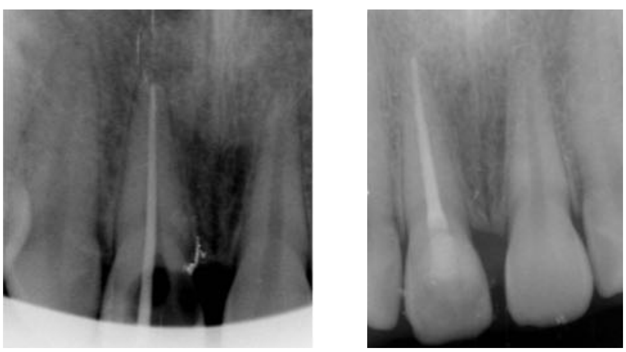


Figure 4: Intraoperative image removing granulation tissue.



Figures 5 and 6: X-ray conometry and final sealing.

sodium hypochlorite. The root canal was prepared using the Wave One® motor (Dentsply Maillefer) and Protaper® instrumentation system (Dentsply Maillefer) according to the manufacturer's instructions. The root canal was dried using paper points. The filling technique chosen was side condensation with the master cone # 50 (Figures 5 and 6). The cement used was AH plus (Dentsply). Once the root canal was finished, the resorptive defect was sealed using glass ionomer resin (EQUIA®, GC) (Figures 7, 8 and 9). After suturing the flap, the patient received post-surgical indications including a medication regimen (Augmentin 500/125mg 1/8 hours, 7 days; ibuprofen 600 mg 1/8 hours, 5 days; chlorhexidine 0.12%).

Follow-up checks were programmed at 7 (to remove stitches), 14 and 21 days (Figure 10) and 12 months (Figures 11 and 12).

DISCUSSION

Invasive cervical resorption (ICR) is an uncommon form of external root resorption, which is of interest due to the irreversible loss of the tooth structure.

In most of the studies reviewed, etiology of the ICR was not fully established. Although, trauma and orthodontic treatments top the list of factors causing this condition[15].

There was only one study published2 with a considerable number of patients with ICR. This study analysed the trigger factors in 222 patients with a total of 257 teeth undergoing different degrees of ICR. Several predisposing factors were identified, with orthodontics (24.1%) and trauma (15.1%) as the most frequent. Internal tooth whitening was a factor (9.7%) and some cases (16.4%) had no predisposing factor found.

Cement protects against root dentine resorption. It is widely accepted that there is a deficit in the protection of root cementum, as it is susceptible to colonisation by osteoclasts, which resorb the dentine[16,17]. The anatomical area most susceptible to ICR is the cementoenamel junction. Microscopic analysis of the cervical region of the teeth showed gaps in the cement, exposing the dentine and making it vulnerable to the action of osteoclasts[18].

The literature offers other theories to explain the etiology of this process. One suggested it is an inflammatory periodontal process which does not initially damage the root surface. However, after eruption of the tooth or because of gingival recession, inflammatory mediators attract resorbing cells to the root surface triggering this process[19].

However, there are counterarguments where ICR has been described as "aseptic resorptive process" which is secondarily colonised by microorganisms[9].

Von Arx[20] recently described a series of cases which shows that ICR occurs in both domestic and wild cats, where it is called Feline Odontoclastic Resorptive Lesions (FORL)[21]. Its etiology, as with ICR, is not

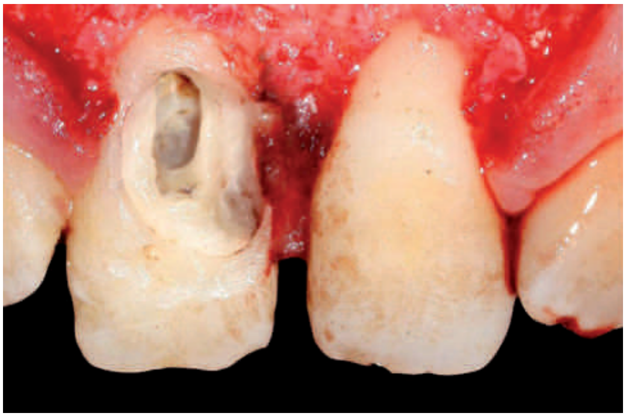


Figure 7: Situation after eliminating all granulation tissue and the cavity is prepared to receive the restorative material.

Figure 8: Restoration with glass ionomer.

Figure 9: Replacement and fixation of the flap.

entirely clear. Among the predisposing factors for FORL are stress, dietary nutrients, vomiting, irregular calcium homeostasis, viral infections, and excess vitamin D.

In all the clinical cases described by Von Arx, patients with ICR pathology had been in direct or indirect contact with cats. In addition, blood samples were taken for the neutralisation test for feline herpes simplex

Figure 10: Follow-up image after 21 days (note chlorhexidine staining).

Figure 11: Follow-up image after 1 year.

Figure 12: Pre-treatment and post-treatment images.

virus type-1 (FHV-1), indicating the transmission of the virus to humans.

To establish a good diagnosis of ICR, information about relevant background, such as trauma, orthodontic treatment and teeth whitening is required. Clinical and radiological findings must be considered as the main criterion. In our case, the patient did not remember having any trauma or orthodontic treatment.

For clinical manifestations, the so-called “pink spot" is a sign to consider for diagnosis. Clinically, it is difficult to differentiate the pink stain due to internal dentine resorption and external cervical resorption. Traditionally, the pink spot was considered pathognomonic of internal root resorption[22]; however, these stains are common in ICR and can also be found after intrapulpal bleeding. Thus, differential diagnosis cannot be based on only observing a pink stain.

Radiographic diagnosis especially using CBCT, is an excellent tool[23]. Using CBCT, the extent of the resorptive defect detection and classification of the apical periodontitis can be assessed more accurately, as well as evaluating root anatomy and detecting root fractures, among others. In our case, we used CBCT to observe the size, shape and size of the lesion and, in particular, the vestibular-palatal anatomy of the lesion.

Finally, treatment depends on the severity, location, if the defect has perforated the root canal and the restorability of the tooth. Different treatment options are found in the scientific literature, depending on the nature of ICR and especially in isolated case reports or case series. These alternative treatments may be intentional replantation, guided tissue regeneration[24], eruption with orthodontic forces and reconstruction of the lesion (using composite resin, MTA or glass ionomer).

Treatment generally consists of removing the resorption granulation tissue and restoring the defect. Endodontic treatment may be necessary in cases where the ICR has perforated the root canal.

Heithersay[6] classified the ICR types according to the extent of the lesion. He also recommended a careful diagnosis of the case for a good prognosis, and recommended that only classes 1, 2 and 3 should be treated for defects. Class 4 defects have a high probability of failure, due to the extent of the lesion. Our case was a Class 3.

To carry out our treatment, the mucoperiosteal flap had to be lifted to provide full access to eliminate the root injury by curette.

Heithersay[8] recommended the topical application of a 90% trichloroacetic acid solution, followed by curettage and restoration with glass ionomer cement. Topical application of trichloroacetic acid produces coagulative necrosis of the tissue.

In our case, the endodontic treatment had to be performed in 2 stages. As in our case, bleeding of the pulp and granulation tissue is normally profuse and it obstructs visibility in the initial stages. We left calcium hydroxide as intracanal medication[25].

After the root canal procedure is finished and all the granulation tissue is removed, a suitable material to properly seal the defect is chosen. The materials used in the scientific literature are glass ionomer cements, MTA, amalgam and composite resin[12-14]. We decided to use reinforced high viscosity glass ionomer EQUIA Fil®(GC) to seal the defect in our case. This system does not require stratification, is condensable and not sticky. EQUIA can be used both in small, medium and large class I, II and V cavities, for both the posterior and anterior segment of the oral cavity, and in abrasions, abfractions and erosions.

CONCLUSIONS

- A correct diagnosis is of vital importance, to choose the most appropriate procedure and thereby minimise the possible consequences of poor treatment planning.
- Early detection is fundamental to a better success rate; thus, more comprehensive reviews of

patients with one or more risk factors must be done.

- ICR treatment depends on the prognosis and extent of the lesion.

- Thanks to the use of different techniques in our case, the desired results were obtained. Thus, endodontic treatment is of little use if the lesion granulation tissue is not removed properly or the restoration appearance is managed poorly.

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