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Prevalence of pulp exposures during tooth preparation for fixed dental prosthesis

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Abstract
Purpose: The purpose of this study was to record the prevalence of pulp exposures occurring during preparation of vital abutment teeth.
Materials and Methods: 2527 patients (1495 female, 1032 male) who received metal-ceramic fixed partial dentures or single crowns were included in the study. Teeth were prepared using diamond burs in a high-speed hand piece under air and water coolant. If pulpal exposure occurred, data of the patient's gender and age, tooth number, tooth position (normal *vs* mal-positioned) and exposure time were recorded, and the patients were referred for immediate endodontic treatment. Data were analyzed using Chi-square test, with a confidence level set at 95% ($P < 0.05$).
Results: Pulpal exposure occurred in 80 teeth (0.66%), Chi-square demonstrated no difference ($P > 0.05$) male-female exposure ratio (1:1.5). The difference in exposure between maxillary and mandibular teeth was statistically significant ($P < 0.05$). Only 28.75% of exposed tooth was mal-posed. The majority ($n = 49$, 61.25%) of exposures occurred in mandibular teeth and this was statistically significant ($P < 0.05$). Overall the most frequently exposed tooth was mandibular canine (20%), followed by the maxillary central incisor (13.75%) and mandibular lateral incisor (10%).
Conclusions: Clinicians should undertake greater care in preparing teeth, especially mandibular canines, for fixed prosthetics. The majority (62.5%) of patients in which pulpal exposure occurred during tooth preparation were between 30-50 years old.

Keywords: immediate endodontics, prevalence, pulp exposure, tooth preparation

Introduction

The pulp is the part in the center of a tooth made up of living connective tissue and cells called odontoblasts. The dental pulp is a part of the dentin–pulp complex (endodontium). The vitality of the dentin-pulp complex, both during health and after injury, depends on pulp cell activity and the signaling processes that regulate the cell's behavior. The pulp is the neurovascular bundle central to each tooth, permanent or primary. It comprises a central pulp chamber, pulp horns, and radicular canals. The large mass of pulp is contained within the pulp chamber, which is contained in and mimics the overall shape of the crown of the tooth. Because of the continuous deposition of dentin, the pulp chamber becomes smaller with age. This is not uniform throughout the coronal pulp but progresses faster on the floor than on the roof or sidewalls.

Radicular pulp canals extend down from the cervical region of the crown to the root apex. They are not always straight but vary in shape, size, and number. They are continuous with the peri-apical tissues through the apical foramen or foramina.

Pulp acts as a security and alarm system for a tooth. Slight decay in tooth structure not extending to the dentin may not alarm the pulp but as the dentin gets exposed, either due to dental caries or trauma, sensitivity starts. The dentinal tubules pass the stimulus to odontoblastic layer of the pulp, which in turns triggers the response. This mainly responds to cold. At this stage simple restorations can be performed for treatment. As the decay progresses near the pulp the response also magnifies and sensation to a hot diet as well as cold gets louder. At this stage indirect pulp capping might work for treatment but at times it is impossible to clinically diagnose the extent of decay, pulpitis may elicit at this stage. Carious dentin by dental decay progressing to pulp may get fractured during mastication (chewing food) causing direct trauma to the pulp hence eliciting pulpitis.

The inflammation of the pulp is known as pulpitis. Pulpitis can be extremely painful and in serious cases calls for root canal therapy or endodontic therapy. Traumatized pulp starts an inflammatory response but due to the hard and closed surroundings of the pulp pressure builds inside the pulp chamber compressing the nerve fibres and eliciting extreme pain (acute pulpitis). At this stage the death of the pulp starts which eventually progresses to peri-apical abscess formation (chronic pulpitis).

The pulp horns recede with age. Also with increased age, the pulp undergoes a decrease in intercellular substance, water, and cells as it fills with an increased amount of collagen fibers. This decrease in cells is especially evident in the reduced number of undifferentiated mesenchymal cells. Thus, the pulp becomes more fibrotic with increased age, leading to a reduction in the regenerative capacity of the pulp due its loss of these cells. Also, the overall pulp cavity may be smaller by the addition of secondary or tertiary dentin, thus causing pulp recession. The lack of sensitivity associated with older teeth is due to receded pulp horns, pulp fibrosis, addition of dentin, or possibly all these age-related changes; many times restorative treatment can be performed without local anesthesia on older dentitions. Treatment of teeth can range in scope from the restoration

of a single tooth to the rehabilitation of the entire occlusion. Conventional complete crown coverage [1] and fixed partial dentures have recently come into extensive use for both their aesthetic and mechanical properties, which include reliability and durability [2] and given their reliability [3, 4].
However, despite the emphasis on conservative preparation methods and restorative procedures, undeniable threats to pulpal integrity exist during the construction of fixed prosthetic restorations [5]. The literature has shown each step in the fabrication of a fixed prosthesis to be a potential source of insult to the pulp [6, 7]. Complications may occur during or after properly performed fixed Prosthodontic-treatment procedures [8], whereas anticipated exposures of abutment teeth pulp during tooth preparation is included in a patient's treatment strategy regardless of whether or not teeth present with pulpal pathology, unanticipated exposure may create delays in treatment and necessitate reassessment of the treatment plan by the dentist and the patient. Vital pulp or endodontic treatments may be a valuable component of fixed Prosthodontic therapy whether the procedure provides an immediate solution for the exposed pulp [9].
Many studies have focused on the structural aspects of fixed partial prostheses [10], and long term follow-up studies have examined endodontic, periodontal, aesthetic and technical complications [11, 12]. However, very few studies in the literature have reported on immediate pulpal complications during tooth preparations [13]. Pulpal exposures involving crowns and fixed partial dentures can occur during preparation phase and the clinical skill of the dentists or dental students play an important factor in preparation towards success. Therefore the aim of this study was to record the incidence of pulp exposures occurring during preparation of vital abutment teeth.

Materials and Methods

This study was based on data obtained from the database containing information of all the patients treated for fixed partial denture (FDP.) 2527 were treated for fixed dental prosthesis (1495 female, 1032 male). The age distribution of the patients is shown in Figure 1 and table 1.

Table 1: Distribution of patients according to age group

Age group	21-30	31-40	41-50	51-60	61-70	>70
Men	104	121	318	310	172	7
Women	101	351	424	336	253	30

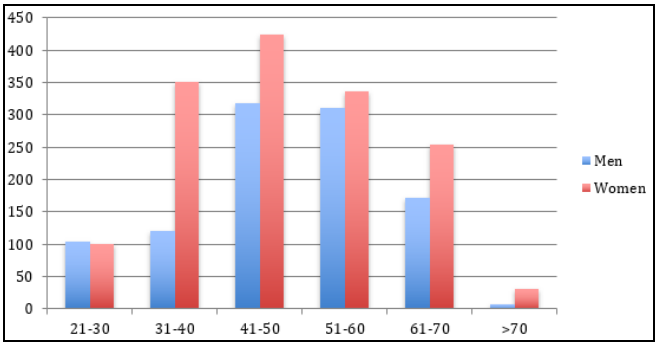

Fig 1: Distribution of patients according to age group

Only patients who received metal-ceramic FPDs or single crowns, had vital abutment teeth, and had not received any root canal treatment or filling prior to the FPD restoration were included in the study. Preoperative peri-apical radiographs were obtained, and all abutment teeth were evaluated prior to tooth preparation. All the members of the study group received metal-ceramic FPDs or single crowns. Teeth with pre-existing restorations, non-vital teeth and teeth with very deep caries were excluded from the study.
Teeth were prepared using diamond burs (Diatech, Heerbrugg, Switzerland) in high-speed hand piece under air and water coolant. The different dentists and dental students prepared teeth.
If pulpal exposure occurred, patients were informed of the study, and thereafter obtaining consent, data on patient's gender and age, tooth number, tooth position (normal vs. mal-positioned) and exposure time were recorded, and patients were referred for immediate endodontic treatment. The same clinician accomplished all of the endodontic treatments. All participants signed a written informed consent.
Totally, 80 pulp exposures were evaluated. Data were analyzed using Chi-square test, with a level of confidence set at 95% ($P < 0.05$). The analysis was performed with the Statistical Package for the Social Sciences software.

Results

Of the total preparations in 2527 patients, pulpal exposure occurred in 80 teeth (0.66%). A 1:1.5 male-female exposure ratio was observed, but the difference was not statistically significant ($P > 0.05$). The majority ($n = 49$, 61.25%) of exposures occurred in mandibular teeth. The difference in exposure between maxillary and mandibular teeth was statistically significant ($P < 0.05$). Overall, the most frequently exposed tooth was mandibular canine (20%), followed by the maxillary central incisor (13.75%) and mandibular lateral incisor (10%), [Table 2 & figure 2].

Table 2: Distribution of pulp exposure according to different teeth

Teeth with pulp exposure	n	Percentage
Maxillary central incisor	11	13.75
Maxillary lateral incisor	7	8.75
Maxillary canine	6	7.5
Maxillary first premolar	5	6.25
Maxillary second premolar	1	1.25
Maxillary first molar	0	0
Maxillary second molar	0	0
Maxillary third molar	1	1.25
Mandibular central incisor	6	7.5
Mandibular lateral incisor	8	10
Mandibular canine	16	20
Mandibular first premolar	4	5
Mandibular second premolar	8	10
Mandibular first molar	3	3.75
Mandibular second molar	4	5
Mandibular third molar	0	0
Total	80	100

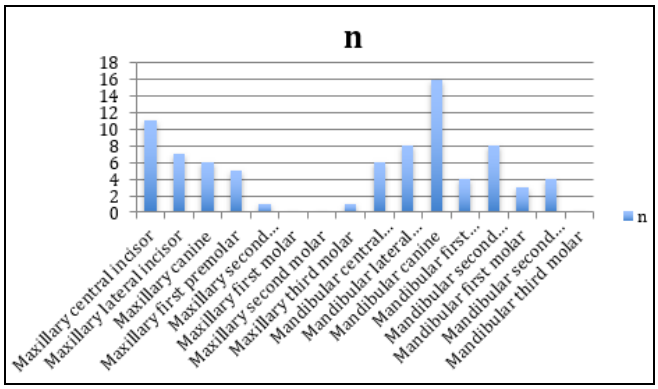

Fig 2: Distribution of pulp exposure according to different teeth

The central incisors accounted for the majority of pulpal exposure (35.5%) in the maxilla, whereas canines accounted for the majority of pulpal exposure (32.6%) in the mandible. In the maxilla, pulpal exposure occurred at a significantly higher rate in the anterior region when compared to the posterior region, whereas in the mandible there was only weak correlation between pulp exposure and region.

Pulpal exposure was found to increase significantly with the patient's age, among the age groups 31-40 and 41-50, each accounting for 31.25% of all exposures and as the age advances the chances of pulp exposure decreased [Table 3 & Figure 3].

Table 3: Pulp exposure according to age

Age group	21-30	31-40	41-50	51-60	61-70	>70
Pulp exposure	1	25	25	20	4	5

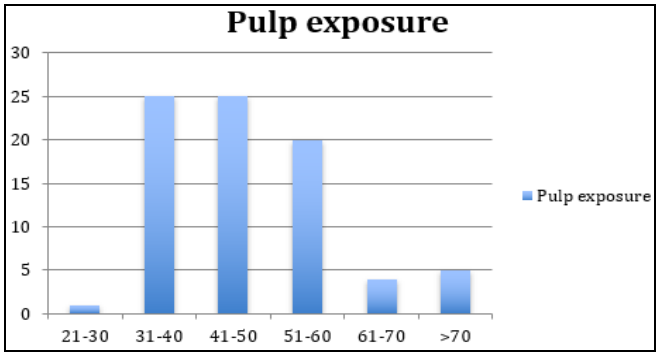

Fig 3: Pulp exposure according to age

A significant relationship was found between the pulp exposure and the treatment time with the majority (57.50%) of exposures occurring between 09:00-11:00 (26.25% between 9:00-10:00 and 31.25% between 10:00-11:00). A strong negative correlation had found between times of day and pulp exposures. Only 28.75% of exposed tooth was mal-posed.

Discussion

This clinical study examined the incidence of pulpal exposures during preparation of single crowns or FPDs. Although long-term prospective studies exist on endodontic treatment requirements in relation to crowns [5]. metal-ceramic restorations [15] and full ceramic restorations [16], few studies in the literature examine pulpal exposure during tooth preparation [14].

Al-Khreisat [14] evaluated the incidence of endodontic treatment required for vital abutment teeth during tooth preparation or immediately after the completion of the prosthetic treatment and found a rate of 0.7 percent (4 pulpal exposures/616 prepared abutments). Our study found a similar rate (0.6%).

the most frequently exposed tooth was the mandibular canine accounting for 20 percent of all exposed teeth. Usually last remaining teeth in the mouth are mandibular canines with periodontal diseases; prolonged clinical crown length and excessive preparation could be needed to compensate this situation.

Achieving the parallelism of abutment teeth required for FPD can sometimes be difficult and complications of this kind are unsurprising [14]. Preparing abutment teeth and achieving parallelism or preparation is more difficult when the teeth are mal-posed. In our study, 28.75 percent of exposed teeth were mal-posed. However, because the percentage of mal-posed teeth among all prepared teeth was not recorded, the statistical significance of the difference in pulpal exposure of normally aligned and mal-posed teeth could not be evaluated. This limitation will be corrected in future studies.

A study by Raustia *et al.* [17] evaluating primary failures and complications related to fixed metal-ceramic bridge prostheses prepared by dental students in 61 patients reported that pulp exposure during preparation was related to the students' lack of experience. In our study, rate of pulp exposure (0.6%) are similar to that of Al-Khreisat [14] (0.7%) despite the fact that a dentist, rather than dental students performed preparations in the earlier study. The similarity in findings between the two studies may be due to extra-attention paid by the dental students in preparation of our study.

Sivasithamparam *et al.*, [18] evaluated 'near and frank exposures' of the pulp in teeth with excessive wear and found 'near and frank exposure' constituted a small but significant percentage of all pulp exposures. The present study includes only frank exposures, although, clinical signs or symptoms of near exposure may be evaluated in further studies. Moreover, teeth with excessive wear were excluded from the study because dental students were not able to be expected to provide the improvements in occlusal dimensions and complex prosthetic treatment required by some of these patients.

The literature revealed that 3-38% of teeth prepared for complete coverage undergo pulpal necrosis [18-21]. However, the only clinical studies that have examined pulp exposures during teeth preparations are Al-Khreisat [14] and Raustia *et al*., [17] and the latter was a retrospective study.

In order to avoid damage to the pulp, tooth preparations should be kept to a minimum, especially in young patients [7]. An *in vitro* study by Davis *et al.*,[22] that used microtomography to measure residual dentin thickness following tooth preparation found sclerosed pulp chambers, especially in older individuals. 'Sclerosis of pulp chamber increases with age' forms part of the classic indoctrination of students during dental education and is supported by the literature. Contrary to expectations, in our study, the rate of pulpal exposure was lowest in the 21-30 age group and highest in the age group 70 and older. This may be due to the inexperience of dental students, who may have been more careful in treating younger patients than older patients. It is also possible that the small number of patients in the age group 70 and over affected the reliability of the results

The present study did not evaluate exposure by tooth localization. Follow-up studies with longer time periods are recommended.

Davis *et al.*, [22] suggested that pulpal response to tooth preparation is a major concern in fixed prosthodontics. Furthermore, research has suggested that 2 mm or more of remaining dentin is critical for protecting pulp, following tooth preparation [22]. The present study evaluated pulpal exposure rather than pulpal response or exposure. Moreover, when exposure occurred, patients were immediately forwarded to the Endodontic Clinic for tooth restoration, and despite admonitions that patients return if they experienced any signs of pain, none of the patients treated presented for follow-up. While the aim of the study was not to evaluate the success of single-visit root canal treatment, it is possible to conclude that immediate endodontic treatment is a good choice when pulp exposure occurs during tooth preparation.

Although the findings of this study may suggest that pulpal exposure is greater in the morning than at other times of day, this only appears to be the case because dentists and dental students generally schedule their patients for tooth preparation in the morning. Based on this study, it cannot be concluded that the rate of pulpal exposure is higher in the morning.

Because the present study did not utilize an experimental design, it is difficult to establish a causal relationship between the exposure of abutment teeth and the other clinical variables; therefore, it is also difficult to determine which clinical factors are most effective in either causing or preventing pulpal exposures.

Conclusions

- This study found 0.6 percent of all samples suffered from pulpal exposure during tooth preparation
- Clinicians should undertake greater care in preparing teeth, especially mandibular canines, for fixed prosthetics
- The majority (62.5%) of patients in which pulpal exposure occurred during tooth preparation were between 30-50 years of age
- Mandibular canines had the highest rate of pulpal exposure during tooth preparation (20%), followed by maxillary central incisors (13.75%) and mandibular lateral incisors, respectively (10%).

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