

The Prevalence of Proximal Fractures of Dental Crowns with Amalgam Fillings

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ABSTRACT

The purpose of this paper was to determine the prevalence and impact of various etiological factors on marginal ridge fractures of teeth with amalgam fillings. 50 subjects participated in this research, 172 teeth restored with amalgam were examined out of which 28 premolars and 144 molars of both jaws. Data used in the research was obtained by nonaggressive exploration of oral cavity and by checking dental charts and radiographic charts of patients. Patients were divided in three gendered age groups. Etiological factors used in the research were: the position of teeth in jaws, classification of amalgam fillings according to Black, the duration of fillings, the presence of caries on proximal surfaces not included in restoration and tooth vitality. Also, Angle Class, habits and presence of fixed prosthetic appliances in opposite jaw were taken into consideration. Results for each patient were separately written in the questionnaire. Statistical analysis was carried out by Pearson's χ^2 -test. According to obtained results 51% of teeth with amalgam fillings have a fracture of marginal ridge. Statistically significant factors that influenced the occurrence of fractures of proximal surfaces in this research were classification of amalgam fillings according to Black, the patient's age and the existence of caries on proximal surface.

Key words: tooth crown, tooth fracture, dental amalgam, prevalence, etiology, Croatia

Introduction

Restorative dentistry is based on the replacement of hard dental tissue, most of which is often lost due to caries or trauma. Modern composite materials and dentin adhesive systems are used more frequently for restoration of dental crowns mainly because of high esthetic criteria and preservation of dental tissue during the cavity preparation. The fear of harmful effect of mercury, which is a component of amalgam, should not be ignored¹. A large number of teeth is restored with amalgam fillings, especially molars. Premolars are more often restored with esthetic composite materials, mostly because of their position in visible area. Assif et al reported that amalgam filling is an excellent choice especially for teeth with class I cavities, whilst for teeth with class II cavities the resistance to fracture is significantly lower². Nevertheless, in many clinical situations, amalgam still remains first choice material owing it to its positive characteristics, simple procedure, low price and long-term posi-

tive experience by its users^{3,4}. A good quality durable filling significantly reduces the price of dental treatment in the long run. Durability of the filling depends on many interchanging factors considering both dentist and patient.

Spears et al⁵ suggested that stress is distributed through anisotropic enamel on dentin, which significantly reduces enamel strain and the possibility of enamel fracture. Enamel is anisotropic due to its prismatic built. It has been proven that enamel with anisotropic characteristics has different strain distribution under pressure compared to isotropic enamel samples. So, with the application of pressure, the strain is transmitted through enamel parallel to the direction of enamel prisms directly on dentin. Due to anisotropic built, stretching and compressive forces, which would on the contrary cause the significant strain on enamel, are reduced and so diminish the possibility of enamel fracture^{5,6}. Arola et al pointed

out first lower permanent molars as teeth with greatest possibility of dental crown fracture because they are the masticatory centre where masticatory forces are the strongest⁷. Various authors have stated secondary caries as primary reason for amalgam fillings replacement. Other reasons for replacement were fracture of fillings' margins and tooth fracture^{8–10}. Kidd and O'Hara have proven that there was a small prevalence of caries on the outer surface of teeth with class I amalgam fillings, but caries was found on 54% of teeth on the inner surface of proximal, regardless of the presence of marginal gap¹¹. Ellis et al pointed out a connection between patient's age and the nature of tooth fracture. Fragmentary fractures, such as the fracture of the marginal ridge, more often appear in the case of older patients. Fractures appear on healthy and restored, especially endodontically treated, teeth with extensive fillings¹².

The purpose of this study was to determine the prevalence and impact of various etiological factors on fractures of marginal ridge of teeth with amalgam fillings.

Materials and Methods

The research was performed at the Department of Endodontics and Restorative Dentistry, School of Dental Medicine, University of Zagreb, Croatia. Informed written consent was obtained from all patients before they were included in this study. Ethics Committee of the School of Dental Medicine, University of Zagreb approved this study.

22 male and 28 female patients with at least one amalgam filling on permanent premolar or molar participated in the research, and attended our clinic from the beginning of research. The examination did not include any invasive methods but only inspection with dental mirror and explorer. The subjects were divided into three age groups: 15–30, 30–50, and over 50 years of age. 172 teeth restored with amalgam were examined, out of which 28 premolars and 144 molars of both jaws. Fillings were classified according to Black's classification. Tooth vitality was determined based on radiographic data and testing pulp vitality by using the cold test (Li Wa Cool, W+P Dental, Beveren, Germany). All fillings were divided based on age into three groups: up to 10 years old, 10–15 years old and amalgam fillings older than 15 years. Data concerning the age of the fillings was provided by patients, as well as the data whether the filling has ever been replaced. Carious lesions of proximal surfaces were diagnosed by inspection and palpation using explorer and dental mirror. Patients were questioned about the frequency of chewing gum. Angle Class as well as presence of fixed prosthetic appliances, which are in occlusal contacts with examined fillings were taken into consideration as possible etiological factors. The results for each patient were stated in the questionnaire. Statistical analysis was performed by Pearson's χ^2 -test and for the maximum level of significance the value of $p=0.05$ was decided.

Results

Amalgam fillings were found on 28 premolars (16%) and 144 molars (84%); total on 172 teeth. Distribution into groups of examined amalgam fillings is shown in Table 1.

Proximal fractures cannot occur on teeth with mesioocclusodistal (MOD) fillings because proximal surfaces are restored with amalgam. Therefore, MOD fillings were excluded from sample which was then used to establish the prevalence of fractures. Proximal fractures were found on 81 teeth with amalgam filling, which is 51%; 41 mesial, 19 distal and 7 mesial and distal fractures on the same tooth crown. Among 99 examined class I amalgam fillings, proximal fractures were found on 52 teeth. Out of 29 teeth with mesioocclusal (MO) fillings, 11 were fractured, and 18 teeth out of 30 examined ones with occlusodistal (OD) amalgam fillings had fractures (Figure 1). The difference in the prevalence of fractures according to class of preparation was statistically significant ($p<0.05$). The highest prevalence of fractures was found in OD class II. The level of significance showed that OD class II is significantly different from other classes according to prevalence of fractures (Table 2).

Among premolars with amalgam fillings on 50% of teeth fractures were found. Among molars fractures were found on 52% of teeth. Dependent on the type of

TABLE 1
NUMBER OF EXAMINED AMALGAM FILLINGS BY CLASS

Tooth	Class				Total
	I	II			
		MO	OD	MOD	
Premolars	7	2	15	4	28
Molars	92	27	15	10	144
Total	99	29	30	14	172

MO – mesioocclusal, OD – occlusodistal, MOD – mesioocclusodistal

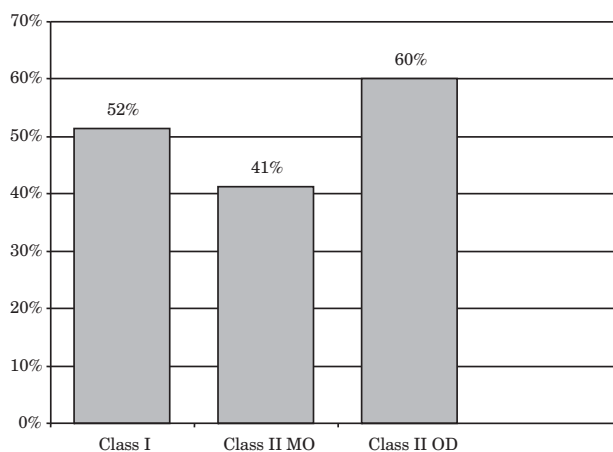


Fig. 1. Prevalence of the proximal fractures according to class type of amalgam filling. MO – mesioocclusal, OD – occlusodistal.

TABLE 2
PEARSON'S χ^2 -TEST FOR THE DIFFERENCE IN FREQUENCY OF PROXIMAL FRACTURES ACCORDING TO CLASS

	Class I	Class II MO	Class II OD
Class I		0.153	0.005
Class II MO	0.153		0.000
Class II OD	0.005	0.000	

MO – mesiocclusal, OD – occlusodistal, MOD – mesiocclusodistal, P – chi-square level of significance

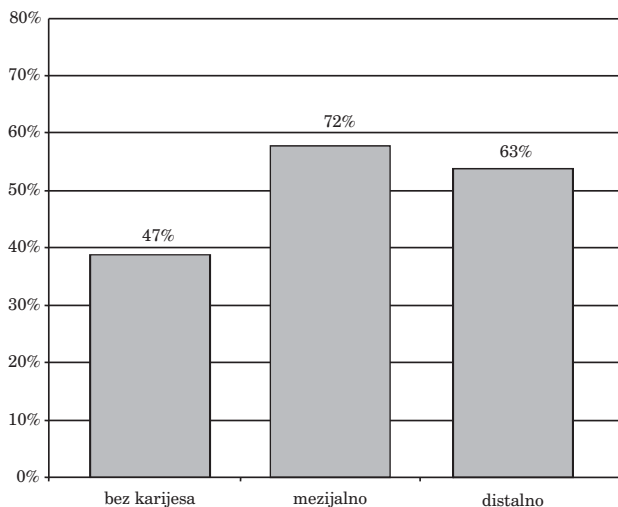


Fig. 2. Prevalence of the proximal fractures according to proximal caries.

tooth, Pearson's χ^2 -test did not show significant differences in the prevalence of fractures between premolars and molars.

Caries was found on 34 teeth with class I, class II MO or OD amalgam fillings, out of which 72% with mesial and 63% with distal caries had a fracture of the marginal ridge (Figure 2). In the group of teeth without caries, 47% of teeth had a fracture of the marginal ridge. The prevalence of fractures on teeth without caries and teeth with carious proximal surfaces statistically significantly differs ($p < 0.05$). There was no statistically significant difference regarding data whether caries is on mesial or distal proximal surface, but this effect can also be due to a small sample of such teeth.

The group 15–30 years of age encompassed 34 patients (68%), the group 30–50 years of age 6 patients and the group over 50 years of age included 10 patients. Differences in the frequency of fractures regarding age groups were statistically significant ($p < 0.05$). Greatest number of fractures was found in the 30–50 years of age group (Figure 3). Statistically, fracture appears more often in the 30–50 age group compared to the 15–30 age group. Regarding the over 50 age group, since there were less patients examined in that group, there were no statistically significant differences compared to the two prior groups.

151 teeth with amalgam fillings were vital, and 21 teeth were not vital. There was no statistically signifi-

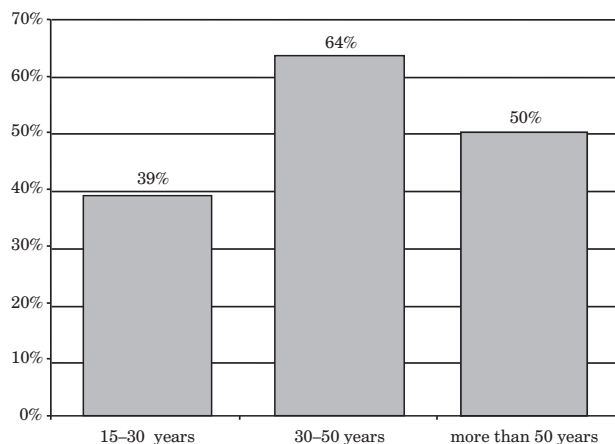


Fig. 3. Prevalence of fractures according to age.

cant difference regarding frequency of fractures on teeth with amalgam fillings dependent on whether the tooth is vital or endodontically treated. Regarding gender, more amalgam fillings were found with women (98 fillings) than with men (74 fillings). 54% of male teeth with amalgam fillings had a fracture of the marginal ridge and 44% of female teeth. The patients' gender was not significantly correlated to the prevalence of fractures.

Regarding the age of the fillings, 97 of them (56%) were less than 10 years old, 55 (32%) 10–15 years old and 20 (12%) were older than 15 years. Differences in prevalence of the fractures were not significantly connected neither to the age of the fillings nor to the amalgam filling ever being replaced.

The largest number of examined teeth with amalgam fillings was in class I according to Angle. Frequency of fractures regarding classes according to Angle is shown on Table 3. Differences in frequency of fractures regarding Angle Class were not statistically significant.

Differences regarding frequency of chewing gum were not statistically significant.

In regard to the presence of fixed prosthetic replacements with which the tooth with amalgam filling is in contact, there was not statistically significant difference in prevalence of fractures.

Discussion

Every material, when under pressure, changes its mechanical characteristics as a result of material strain. Enamel fractures are a consequence of enamel strain due

TABLE 3
TOOTH NUMBER AND PERCENTAGE OF FRACTURES ACCORDING TO ANGLE CLASS

Angle Class	% fractures	N
I	44%	132
II	56%	32
III	63%	8

N – number of teeth in Class

to constant and repeated pressure. When a certain pressure is applied to the compound of two materials of different stiffness, such as enamel and dentin, the strain is mostly transmitted through material of greater stiffness, because stiff materials attract stress⁵, onto the less stiff one, which absorbs stress. Enamel has a high elasticity module and that characteristic combined with flexible dentin, which it covers, reduces the possibility of fracture. Enamel is less resistant to fractures if the force is applied in a direction parallel to the direction of enamel prisms⁵. Dentin is, as well as enamel, of anisotropic built but Watanabe et al. have shown that anisotropy is minimal¹³.

Although opinions in literature about the connection of prevalence of dental fractures and age may differ^{12,14}, in this study, age influenced the occurrence of fractured teeth with amalgam fillings. Fractures were more prevalent over the age of 30 which is explained by the changes of hard tissue that occur with age. Due to the progressive deposition of secondary dentin and sclerosis of tubules, dentin becomes less elastic¹², and enamel more fragile, so that it breaks easily¹². There are additional contributing factors for teeth fracture at older age such as the number and size of fillings¹⁴, greater prevalence of endodontically treated teeth and fatigue due to long-term heat stress¹². Also, at older age, the loss of certain teeth increases the load on remaining teeth and therefore, increases the possibility of fracture¹². The connection between the bite force and age of dentulous patients has not been found¹⁵. Patients of second and third age group had less amalgam fillings probably because of their replacement with composites either for esthetic reasons or secondary caries and because of very common teeth loss in those age groups.

Some studies have shown that male patients have considerably stronger bite forces than female in correlation with patient's height and weight¹⁵. Although greater prevalence of fractures was expected in the male gender, this study, within its limitations, showed no significant difference between the two.

Since premolars are located in the visible zone, amalgam fillings are often replaced with composites so relatively small number of premolars with amalgam fillings was found. Starting hypothesis that fractures were more frequent in the molar area due to the strongest bite forces in the masticatory center was not proven since this study showed no statistically significant difference in prevalence of fractures between molars and premolars.

The form of cavity preparation was found to be an etiological factor which influenced the appearance of fractures of the marginal ridge. The prevalence of fractured teeth with OD fillings significantly differed from the one with class I and MO fillings. The depth and width of the restoration were not measured in the research. This result was consistent with the research conducted by Whal et al¹⁴, but it is not entirely consistent with the results of Purk et al¹⁶. It was assumed that the prevalence of fractures would be greater with class II fillings because the loss of hard tissue is greater compared to the loss of tissue during cavity preparation for class I fillings. It has

been stated in recent literature that shallow and smaller restorations are more resistant to fracture than wider and deeper restorations¹⁴. The cavity preparation for amalgam fillings requires the removal of unsupported enamel which often forces a dentist to remove a large quantity of healthy hard dental tissue and reduce resistance to fracture. Unsupported enamel prisms at excessive class I and class II restorations can be supported by glass ionomer cements or composite materials, so it would not have to be removed^{17,18}. Glass ionomer cement, as liner, also can diminish microleakage¹⁹. The remaining hard dental tissue, as well as the choice of restorative material, have an important impact on the success of therapy^{5,20}. It also became obvious that sharp edges of preparation and sharp angles contribute to appearance of fractures much more than round edges¹⁴.

Another factor that seemed to impact the prevalence of fractures of the marginal ridge was caries of proximal surface. Teeth with caries had significantly higher prevalence of fractures than teeth without caries. Carious dental tissues lack hardness and resistance to pressure so it was assumed that caries caused the fracture. However, fractured enamel presents open way for bacteria, so it could also be assumed that caries developed secondary. Many studies have stated secondary caries as one of the main reasons for replacement of amalgam fillings^{8,10,21–27}.

It was expected that numerous fractures would be found on endodontically treated teeth. Other researches have shown that, because of the loss of great quantity of healthy dental tissue during access cavity preparation, endodontically treated teeth are much less resistant to pressure^{2,14}. Since dentinal hardness and moisture of non vital are similar to vital teeth, the susceptibility to tooth fracture is increased due to cumulative loss of dentin during endodontic and restorative treatment²⁸. Since a relatively small number of endodontically treated teeth was involved in this study it was not possible to get representative result. Within the limitations of this study, there was no statistically significant difference in the prevalence of fracture between the group of endodontically treated teeth and the one of vital teeth.

The question that arises is when is it necessary to replace the old amalgam filling, as it is often difficult to differentiate marginal discoloration and carious lesion. Numerous studies state that survival time of amalgam fillings is 6 to 10 years. A justified reason for replacement of amalgam filling is filling or tooth fracture, clinically or radiographically proven marginal or inner caries, debonding of fillings, poor marginal adaptation with proximal caries or periodontal pockets and marginal gap²⁹.

The results of a statistical test showed that Angle Class did not influence the appearance of fractures of the marginal ridge, although the greatest number of fractures was found in Angle Class I. The frequency of chewing gum, as well as fixed prosthetic appliances in opposite jaw which is in occlusal contact with observed amalgam filling, did not significantly influence the appearance of fractures of the marginal ridge.

Conclusion

This study covered a large number of potential factors that could influence the appearance of fractures of the marginal ridge. Within the limitations of the present study, the prevalence of the marginal ridge fracture sig-

nificantly correlated to the cavity preparation and is the most common with OD class II preparations, to the age of the patient and to the presence of proximal carious lesions. Since a relatively small sample size is a limitation of the present study, a verification of the obtained results by a larger sample size is required.

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UČESTALOST APROKSIMALNIH FRAKTURA KRUNE ZUBA S AMALGAMSKIM ISPUNIMA U HRVATSKOJ

SAŽETAK

Svrha rada bila je utvrditi učestalost fraktura i djelovanje različitih etioloških čimbenika na frakture marginalnoga grebena zuba s amalgamskim ispunima. U istraživanju je sudjelovalo 50 ispitanika, pregledana su 172 restaurirana amalgamskim ispunima, od toga 28 premolara i 144 molara obiju čeljusti. Podaci korišteni u istraživanju dobiveni su neagresivnom inspekcijom usne šupljine te pregledom zubnih kartona i radiografskih zapisa pacijenata. Pacijenti su podijeljeni po spolu u 3 dobne skupine. Od etioloških čimbenika u istraživanje su uključeni: položaj zuba u čeljusti, klasifikacija amalgamskih ispuna po Blacku, starost ispuna, postojanje karijesa na aproksimalnoj plohi koja nije uključena u ispun te vitalitet zuba. Također, u obzir su uzeti klasa zagrizi po Angleu, navike te postojanje fiksno protetskih radova u antagonističkoj čeljusti. Rezultati su za svakog pacijenta zasebno upisani u upitni list. Statistička analiza izvršena je Pearsonovim χ^2 -testom. Prema dobivenim rezultatima, na 51% zuba s amalgamskim ispunima pronađena je fraktura marginalnoga grebena. Statistički značajnim čimbenicima koji utječu na pojavu fraktura aproksimalnih ploha u ovom istraživanju pokazali su se klasifikacija amalgamskih ispuna po Blacku, dob pacijenta te postojanje karijesa na aproksimalnoj plohi.