Tooth Fractures in Fixed Full-Arch Implant-Supported Acrylic Resin Prostheses: A Retrospective Clinical Study

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Purpose: The aim of this study was to assess the influence of several variables in the frequency of prosthetic teeth fractures in fixed full-arch implant-supported acrylic resin prostheses. ***Materials and Methods:*** The influence of each variable was determined after analyzing the results obtained from 161 prostheses after a mean follow-up period of 39.69 months. All patients were treated with standard Nobel Biocare and Biomet 3i implants, and followed a strict prosthodontic protocol. ***Results:*** A total of 155 fractures were recorded, all of which took place in 60 prostheses (40% of the total). Statistically significant differences were found among several variables: the arch the prosthesis was on, patient sex, opposing arch characteristics, length of the cantilevers, and whether the structure had mechanical retention. The prostheses that suffered a greater number of fractures were those that had been placed in men, opposing a natural arch, with cantilevers shorter than 10 mm and without mechanical retention. Patient age and presence or absence of a cantilever were not determinants. ***Conclusion:*** Tooth fractures in fixed full-arch implant-supported metal-acrylic prostheses are a common complication. Several factors are linked more directly with the need for mechanical maintenance. The design and indications of this type of prosthesis should be carefully considered. *Int J Prosthodont 2016;29:161–165. doi: 10.11607/ijp.4400*

Fixed full-arch implant-supported acrylic resin prostheses (FFIMAPs) have been used successfully in patients with an edentulous arch since 1965 and continue to be used.[1] Follow-up periods of up to 24 years have shown a success rate of 95% of prostheses still present in the mouth at 10 years, and at 15 years, 92% for maxillary prostheses and 99% for mandibular.[2,3] Despite the high survival rates, considerable maintenance and repairs are required to keep these prostheses functional and stable in the mouth over time.[4,5] Johansson and Palmqvist[6] were the first authors to focus a study around the mechanical problems of FFIMAPs and found that the most frequent complication was the fracture of teeth (in 22% of the patients). In 1991, Jemt[7] published the results of a study of 380 FFIMAPs, which showed phonetic issues and fractures of the acrylic teeth as frequent complications; these occurred in 14% of the maxillary prostheses in the first year. This high fracture rate of teeth in FFIMAPs has also been recorded by many authors and continues to be found (Fig 1).[8–15]

There are several reasons behind the high fracture rate, including lack of mechanical retention for teeth and acrylic in the design of the metal structure,[16] the permanent elastic deformation that the structure suffers when there are cantilevers of different lengths,[11] and the influence of the characteristics of the opposing arch (especially if it is a prosthesis of the same materials).[12,13]

Different strategies have been recommended to reduce the incidence of fractures. Eliasson et al[12] suggested avoiding use of this type of denture if the opposing arch is restored with the same materials. Fischer et al[14] recommended using metal backings on the teeth of the upper anterior region. Gothberg et al[15] supplied his patients with soft mouthguards to wear at night, although the results were poor; it is unknown whether this was due to an inefficient system or lack of patient cooperation.

Different factors have been identified in the literature as possibly related to the incidence of fractures of acrylic teeth in implant-supported rehabilitations. Some of these factors were patient related, such as age, sex, edentulous arch treated, and type of opposing arch; others were related to prosthesis design, presence and length of cantilevers, existence of mechanical retentions in the metal structure for the acrylic and the teeth, and number of implants.

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Fig 1 Tooth fractures on a FFIMAP.

Fig 2 Mechanical retention for acrylic resin and teeth on the structure.

The aim of this study is to retrospectively evaluate the influence of each of these factors in the occurrence of tooth fractures in the FFIMAPs.

Materials and Methods

A total of 161 FFIMAPs placed between 2007 and 2013 were identified as suitable for inclusion in this study. The mean follow-up period was 39.69 months (range: 3 to 77 months).

All patients were treated with Nobel Biocare or Biomet 3i implants, following the same prosthodontic procedure, which was carried out wholly by the same operator. The prostheses had a minimum of 12 teeth and a maximum of 14. The structure was made of a cast nickel-chromium-titanium (Ni-Cr-Ti) alloy in 156 prostheses, mechanized titanium in 4, and cast gold in only 1. Different lengths of cantilevers were included in the design when needed.

The occlusal scheme was determined by the opposing arch: bilateral balanced occlusion in overdenture cases and full mucosa-supported dentures, and group function and/or mutually protected in cases where the opposing arch was either natural dentition or a fixed prosthesis.

Once the prostheses were in place, the patients were reviewed until it was confirmed that they were completely adapted and comfortable with the prosthesis and their hygiene was adequate. Finally, they were included in periodontal and/or peri-implant maintenance programs with reviews every 4 to 6 months depending on the risk factors of each patient.

All the tooth fractures that occurred during the follow-up period were registered and their frequency compared in relation to each of the factors previously mentioned, linked or not to the patient. Although bruxism may be a key factor in the incidence of mechanical complications, many of the patients were completely edentulous at the beginning of the treatment and there were insufficient clinical signs to establish whether parafunctional habits existed; therefore, this factor was not taken into account.

The data were analyzed with inferential statistics using nonparametric tests to determine whether there were differences in the number of prostheses with and without fractures for each of the variables previously mentioned. The chi-square test was used for this purpose. The statistical analysis was carried out using the software SPSS version 22 (IBM).

Results

A total of 161 prostheses were placed and reviewed for a mean follow-up period of 39.69 months. Of these prostheses, 80 were placed in men and 81 in women, with a mean age of 58 years (range: 42 to 87 years). Of the total, 80 prostheses were placed in the mandible and 81 in the maxilla.

A total of 922 implants were placed, with a minimum of 4 and a maximum of 8 per arch.

Of the prostheses, 71 did not have a cantilever on the right side and 68 did not have it on the left side. The length of the cantilevers ranged between 3 mm and 21 mm, with a mean length of 9 mm for both sides.

Of the metallic structures, 79 included mechanical retention for the teeth, while 82 did not (Fig 2).

In 57 cases, abutments were required in all of the implants under the FFIMAP. A total of 69 cases were restored with abutments only in those implants that were angulated, and 35 prostheses were placed directly over the implants.

The type of opposing arch varied between the cases: natural dentition (40 cases), mixed dentition fixed/removable (29 cases), full mucosa-supported denture (31 cases), other FFIMAP (49 cases), or metal-ceramic implant-supported rehabilitation (12 cases).

A total of 155 fractures were recorded during the follow-up period, 98 in the anterior region and 57 in the posterior. All the fractures occurred in only 65 prostheses, and there were no fractures at any point on 96 of the prostheses. Only one tooth fracture was seen in 25 of the prostheses, while 40 of them suffered two or more fractures with up to eight fractures on the same prosthesis. The overall relation of fractures with the different study variables can be seen in Table 1.

Statistically significant differences were found when comparing the number of prostheses that suffered fractures with the following study variables (Table 2):

- **Sex (*P* < .01):** Men suffered more fractures than women.
- **Arch (*P* < .05):** Maxillary prostheses fractured more than mandibular ones.
- **Mechanical retention (*P* < .01):** Prostheses that did not have mechanical retention for teeth and acrylic suffered more fractures.
- **Cantilevers (*P* < .01):** Prostheses with cantilevers 10 mm or longer fractured less than those with cantilevers shorter than 10 mm.
- **Opposing arch (*P* < .01):** Natural dentition caused a greater number of fractures than the full mucosa-supported denture, but there were significant differences between the other variables.
- **Number of implants (*P* < .01):** Prostheses supported by four implants fractured more than the others (five, six, or eight implants).

No statistically significant differences were found among the different age ranges or the presence or absence of cantilevers.

Table 1 Number of Fractures in Relation to the Variables

Variable	No. of fractures (no. of prostheses with fracture)
Arch	
Mandible (n = 80)	47 (24)
Maxilla (n = 81)	107 (41)
Sex	
Women (n = 81)	38 (22)
Men (n = 80)	116 (43)
Opposing arch	
Natural (n = 40)	68 (23)
Mixed (n = 29)	19 (10)
Full mucosa-supported denture (n = 31)	15 (5)
	46 (22)
FFIMAP (n = 49)	6 (5)
Ceramic implants (n = 12)	
Age	
40–49 (n = 22)	10 (5)
50–59 (n = 66)	68 (29)
60–69 (n = 50)	53 (22)
≥ 70 (n = 22)	22 (8)
Mechanical retention	
Yes (n = 79)	56 (23)
No (n = 82)	98 (42)
Abutments	
All (n = 57)	62 (29)
None (n = 35)	41 (15)
Angled (n = 69)	51 (21)
Cantilevers	
Left >10 mm (n = 31)	15 (6)
Left ≤ 10 mm (n = 60)	66 (26)
Right > 10 mm (n = 33)	13 (6)
Right ≤ 10 mm (n = 55)	63 (26)
No cantilever (n = 59)	55 (27)

Table 2 Pearson's Chi-Square Test Results

	Value	df	*P*
Sex	11,821	1	.001
Arch	7,107	1	.008
Mechanical retention	8,167	1	.004
Cantilever length	8,474	1	.004
Opposing arch	13,286	4	.010
Number of implants	14,205	4	.007
Age	3,616	3	.306
Presence of cantilever	.925	1	.336

Discussion

The 155 fractures recorded in this study confirm the high incidence of this type of mechanical complication, which has been described in other studies.[12,14,15,17,18] All the fractures happened in just 65 of the prostheses (40.4% of the total), 40 of which suffered fracture more than once. This suggests there might be conditioning factors that increase the incidence of these fractures, as has been shown in the inferential analysis of this study:

- **Sex:** Men fractured their prostheses more than women, which agrees with Gothberg et al[15] and could be due to the different amount of strength that men can apply compared with women of the same age.[19,20]
- **Arch:** Maxillary prostheses fractured more than mandibular ones, which also matches the findings of other studies.[7,13,15] This could be due to the different vectors of the occlusal forces to which teeth are subjected and the difficulty of avoiding interferences in the anterior guidance. The load the anterior teeth suffer increases when there is progressive wear of the posterior teeth. This is why more fractures occur in the maxillary arch and the anterior region, as they suffer forces perpendicular to the main axis of the tooth that lead to debonding it and/or breaks.

- **Mechanical retention:** Prostheses that included mechanical retention for teeth and acrylic on their structure fractured less than those that did not, matching the findings of Bergendal and Palmqvist[16] and Jemt and Linden.[21] Therefore, it is advisable to include these retentive elements in the design of metallic structures in the FFIMAPs, regardless of the alloy and fabrication method used.
- **Cantilevers:** Unexpectedly, fractures occurred more in prostheses with cantilevers of 10 mm or shorter than in those with cantilevers longer than 10 mm. There was no significant difference between having a cantilever or not. Several studies have associated a larger number of mechanical issues with prostheses that had long cantilevers due to the elastic deformation that the structure suffers.[11,22,23] However, in this study, cantilevers were required in cases with alveolar atrophy, where posterior implants could not be placed or were not advisable; this clinical condition requires bulkier prostheses with greater space for acrylic and teeth, thus increasing resistance and slowing down the damaging effects of progressive tooth wear. Therefore, the prosthetic space can be an equally relevant factor, one into which future studies should ideally look. A rigid alloy was used in most of the cases to elaborate the structure, which also increases the resistance to deformation in comparison with the precious alloys that were traditionally used in the past.
- **Type of opposing arch:** More fractures were recorded when the opposing arch included only natural teeth, compared with a full denture or an implant-supported overdenture. The reason for this is the greater force that these patients can apply, as well as the abrasiveness of the natural enamel or the fixed ceramic prostheses that could be part of the arch. Cases that had FFIMAPs in both arches also had a high incidence of fractures, which could be due to the reduced proprioception and occlusal discrimination these patients have; this matches the findings of Eliasson et al[12] and Davis et al.[13] The occlusal scheme was not studied statistically on its own, despite its direct link with the opposing arch in most cases; it should also be considered for further analysis in future research studies.
- **Number of implants:** Cases that were rehabilitated over four implants suffered more fractures than those that had five, six, or eight. This could be due to the greater elastic deformation the structure can suffer when resting over fewer abutments, but it should also be highlighted that 62% of these prostheses did not have mechanical retention elements on their structures, which could also increase the incidence of fractures.

Analysis of these factors can help select the most appropriate type of rehabilitation and material to reduce as much as possible the risk of suffering this type of mechanical complication. FFIMAPs placed on the mandibular arch are generally considered a low-fracture-risk option, especially in cases where there is sufficient space to rehabilitate and where mechanical retentions are added to the metallic structure for teeth and acrylic. However, in the maxilla it may be advisable to use ceramic over the metal, especially in men, with natural dentition or another implant-supported rehabilitation in the opposing arch. This is even more strongly suggested if the space for acrylic and teeth is reduced, as it will reduce further as time goes by, considerably decreasing its resistance.

Using porcelain in full implant-supported rehabilitations has shown a lower rate of fractures compared with resin teeth.[9,18] However, using a more rigid material leads to greater stress transmitted to the peri-implant bone, possibly overloading it,[24] and this should be assessed in each individual case.

Conclusion

The maintenance needs for this type of prosthesis are high. Tooth fractures are a very common complication, and patients should be made aware of this risk. Fracture incidence can only be reduced by carefully selecting cases for provision of FFIMAPs and designing them adequately.

Acknowledgments

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Literature Abstract

Oral Health and Blood Pressure: The IPC Cohort

This study investigated the association between oral health conditions and the risk of hypertension in an adult population. From 2002 to 2011, 102,330 subjects underwent medical and oral examinations. The oral examination used a simplified plaque index, a calculus index, and a simplified modified gingival index, and number of teeth was recorded. The medical examination included blood pressure measurement. The subjects were divided according to age (< 65 or ≥ 65 years). Logistic regression analysis was used to investigate the association between blood pressure and oral conditions. The authors found no significant association between oral condition and blood pressure for the subjects aged ≥ 65 years. For the subjects aged < 65 years, there was significant association between oral condition and blood pressure. Statistical analysis for this subset showed insufficient masticatory function, and missing teeth (> 10) showed odds ratio (OR) = 1.20 and OR = 1.17, respectively. Hypertension was also associated with high level of dental plaque (OR = 1.90), dental calculus (OR = 1.18) and gingival inflammation (OR = 1.56). The authors concluded that for subjects < 65 years, insufficient masticatory function, poor oral hygiene, and oral inflammation are associated with hypertension.

Darnaud C, Thomas F, Pannier B, Danchin N, Bouchard P. *Am J Hypertens* 2015;28:1257–1261. **Reprints:** Philippe Bouchard, Department of Periodontology, Service of Odontology, Rothschild Hospital, AP-HP, Paris 7-Denis Diderot University, UFR of Odontology, Paris, France. E-mail: phbouch@noos.fr. —*Sapphire Gan, Singapore*