

The Fracture Pattern of Different Mandibular Over-Denture Designs.

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ABSTRACT

Aims: To evaluate the load at fracture for different mandibular over-dentures and the positions of the fracture area for these designs. **Material and methods:** Ten mandibular dentures were made, each of two designs. The first design consisted of acrylic resin over-denture supported by two dome-shaped 3 mm mandibular canines copings, the second design consisted of two dome-shaped copings connected with a rigid metallic bar. The mean and standard deviation were calculated in addition to the analysis of variance which showed a significant difference at $P < 0.05$. **Results:** Showed that the over-denture supported by two dome shaped mandibular canines were more fracture resistance than the over-denture supported with the bar. The fracture position depends on the denture design. **Conclusions:** The results indicated that the denture made entirely of acrylic resin was much more stronger than the denture with less thickness due to the incorporation on metallic rigid bar.

Key words: Fracture of denture, crack, acrylic resin, mandibular over-denture.

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INTRODUCTION

The most common problem of acrylic over-denture that, fracture is commonly encountered, especially with mandibular over-denture⁽¹⁾. The fracture usually occurs over, or adjacent to the abutment tooth which may be treated with metallic copings and /or some types of attachments such as bars, studs and magnets⁽²⁾.

Langer and Langer⁽³⁾ stated that, out of 18 over-dentures, nine mandibular over-dentures fractured within 11 months to 4 years.

The acrylic could be fractured in three ways, either due to impact, application of shearing or bending stresses, or due to dynamic fatigue failure⁽⁴⁾. It was postulated that the strength and stiffness of an acrylic resin denture are, generally adequate unless the denture is processed in very thin areas⁽⁵⁻⁷⁾. Morris *et al.*,⁽⁸⁾ found that, the increase in the base thickness increased the fracture load and energy. The over-denture is often thin in the region of abutments, especially if they are inadequately reduced and consequently increasing the possibility of fracture⁽⁹⁾. Fracture could occur over or adjacent to the abutment teeth⁽²⁾, or at the midline where areas of stress concentration are located⁽¹⁰⁾.

Eventual fracture of acrylic resin denture occurs due to the initiation and propagation of cracks from areas of high stress concentration⁽¹¹⁾. Sharp and thin edges and corners, deep frenal notches, pin holes, inclusions, deep scratches and residual processing stress may all cause stress concentration^(12, 13).

The type of load application may play a major role in crack propagation; tensile loads tend to pull cracks open, compressive loads tends to squeeze them shut⁽¹⁴⁾.

Different methods have been used to reinforce the acrylic over-denture⁽³⁾ which being a matter of controversy⁽¹⁵⁻¹⁷⁾. The improvement in denture fracture resistance was reported by Mathews and Smith⁽¹⁸⁾ through the use of mechanically improved material, Bowman and Manley⁽¹⁹⁾ through the use of carbon fibers while Ladizesky *et al.*,⁽²⁰⁾ suggested the use of polyethylene fiber in woven form to improve denture fracture resistance.

The aim of this study was directed to evaluate the effect of different mandibular over-denture designs on the fracture resistance of these dentures, and the way in which these dentures fracture.

MATERIALS AND METHODS

Two different over-denture designs were constructed in this study. The first design consisted of an acrylic resin over-denture supported by two dome-shaped copings of about 3 mm height, Figure (1). The second design consist of acrylic resin

over-denture with two metallic copings that was connected with a metal bar of about 2 mm thickness and width, the bar was away from the residual ridge of about 1 mm, thus the total height of the bar and the copings was about 3 mm, Figure (2).



Figure (1): The over-denture and the cast with two copings.



Figure (2): The mandibular over-denture and the cast with the two copings connected by the bar.

Cast preparation :

Acrylic mandibular cast with two dome shaped canines was constructed by taking an impression to an ideal plastic cast of two dome shaped canines with silicone-based rubber impression material (Major-prodotti Italy), after setting the cast removed from the impression. Cold cured acrylic resin (Medicus E.U) was

poured within the mould left from the cast, allowed to set under plastic cover and then the acrylic cast was removed which will be used later to support the different over-denture designs during testing. The oral mucosa was simulated using silicone rubber base impression material.

Coping and coping with bar preparation:

The acrylic mandibular cast with the two dome shaped canines was duplicated with agar-agar (Dentaram west-Germany), a refractory cast was poured into the mould with an investment material (Dentaram west-Germany), waxing then performed with 0.5 mm thickness wax (Dentaram west-Germany) on the refractory cast followed by spruing. Casting was performed followed by finishing and polishing in order to obtain the copings for the first design and the copings with the bar for the second design.

Mandibular over-denture preparation:

The modified acrylic cast with copings and the modified acrylic cast with copings and bar were duplicated into 20 stone casts using silicon based impression material (10 stone casts for each design). For the construction of the waxed up over-denture, a sheet wax of 1.5 mm (Major-prodotti, Italy) thickness was adapted to the stone cast, wax-rim was placed on it to form occlusion block. A medium size set of anatomic cross linked acrylic mandibular teeth were selected and set-up according to the roles of ideal arrangement, were the level of the occlusal plane is at the junction of the occlusal and middle third, the incisal edges of the lower anterior teeth was with the line emerging from the deepest point of the sulcus and the central fossa of the lower teeth passing through the line which originate lingual to the canine region to the lingual of the retromolar pad. Waxing up was then completed in such a manner that any undercuts were obliterated. Stone key in three sections was constructed for the duplication technique. The first and second sections were constructed for accurate positioning of the teeth on each side respectively. The third section was constructed for proper alignment of all the set up teeth as regards to their occlusal and lingual surfaces. For the duplication of the wax-up denture a sheet of wax was adapted to the stone cast of each design, a roll of softened wax was placed on the top of the base plate. The imprints of the teeth on the inner surface of the first section of the stone key were painted with separating material (isol Major prodotti dentari S.P.A., ITALY).

An identical set of teeth were accurately fitted in their imprints and the key was fitted to its position and immersed in water for few minutes then the key was removed. The same procedure was carried out on the other side of the arch to set up the remaining teeth with first section in position. Then the teeth with adjacent wax were flamed lightly and the three sections of the key were fitted in position with pressure for accurate alignment of the teeth to their imprints in the stone key. The waxed up dentures were then processed in heat polymerized acrylic resin (Quayl-dental England) by compression molding technique according to the manufacturer instruction. After bench cooling of the flask with the denture, deflasking was performed. Only excess flash were removed but without finishing and polishing and all the dentures were stored in distilled water for two weeks before testing.

By using a special constructed metallic applicator that mounted to the Engineering Test Equipment (Compression Testing Machine Model C.N. 472 USA), the load was applied bilaterally at the distal half of the second premolars and the mesial half of first molars with the denture supported by the modified acrylic cast. The load was applied at a cross-head speed of 1 mm/min. The load at fracture was recorded for every specimen. The proving ring sensitivity is 0.1173 Kg per division.

The statistical means of the load at fracture for different designs were calculated and tested for significant values using ANOVA test. The fracture position of the different over-denture design as was noted visually during the application of the load was recorded.

RESULTS AND DISCUSSION

The mean and standard deviation of the load at fracture for the different over-denture designs, showed in the Table (1).

However, in order to test whether there are any significant differences in the load at the fracture for the different over-denture designs, analysis of variance procedure was done Table (2), which showed that there was a significant difference at $p < 0.05$.

The positions of the over-denture fracture line were showed in Table (3).

Table (1): The mean and the standard deviation of the load at fracture for the two over–denture design.

Type of over–denture design	Number	Mean/Newton	Sd.
First design	10	2542.5	87.4
Second design	10	1853.6	60.7

Sd.: Standard deviation

Table (2): ANOVA of the load at fracture for the two over – denture design.

The acrylic over–denture	Df	SS	MS	f–value
The first and second design error	1	2372916	2372916	419.17*
	18	101899	5661	
total	19	2474815		

Df: degree of freedom; MS: mean square; SS: sum of square; *significant at $p < 0.05$

Table (3): The position of over–denture fracture line.

Over –denture type	Total No. of over–denture	No. of denture fracture over the abutment	No. of denture fracture over the midline	No. of denture fracture over other areas
First design	10	9	0	1
Second design	10	1	8	1

No.: number of specimen.

The acrylic resin as a brittle material was much weaker in tension than in compression, therefore failure of these materials during function is mostly due to tensile stresses ⁽²¹⁾, as these materials characterized by having low fracture toughness in tension ⁽²²⁾, therefore the fracture of the different over–denture designs were attributed to the induction of tensile stresses that lead to cracks initiation and propagation within the denture, this become on line with Smith ⁽⁶⁾ and Drabber *et al.*, ⁽¹¹⁾.

In this study the first design over–denture, showed the highest mean of the load at fracture, consequently the highest fracture resistance. This was in agreement with Fenton and Hahn ⁽²³⁾ in that the complete denture made entirely of acrylic usually much stronger with the advantage of cosmetics and flexibility.

The fracture position which was determined visually revealed that the first design over–denture was fractured over one of the two abutment, and the fracture line extended obliquely from the labial flange beneath the lateral incisor or the central incisor, crossing over one of the abutments, to the lingual flange on the other side. This was agreed with Brewer and Morrow ⁽²⁾ and Langer and Langer ⁽³⁾.

This fracture position of the over–denture could be attributed to the fact that during displacement of the denture downward due to the compression of the underlying rubber base material, the two abutments will function like a fulcrum. This fact is added to another fact that the denture thickness is reduced over this area in comparison to other parts of the denture this become on line with Fatih–Elbaab ⁽²⁴⁾.

The fracture resistance of the second over–denture design was significantly lower than the fracture of the first design, this was due to firstly the space occupied by the metallic bar which decreases the thickness of the denture base, secondly the rigid bar attachment used, that provide no stress–breaking action, could induce excessive stresses in the overlying denture base during their displacement under load which in this case may act as a fulcrum initiating denture fracture.

The fracture position (which was noted visually) of the second over–denture design occur approximately at the midline of the lingual flange and the fracture line extended to the labial flange, crossing over the bar rather than over the abutments. In this case the explanation is usually directed to the presence of the bar as a fulcrum

crossing the midline combined with reduced thickness of the acrylic resin in this area, this becomes on line with Fenton *et al.*,⁽¹⁰⁾ and others⁽²⁵⁻²⁸⁾.

CONCLUSIONS

The mandibular over-denture made entirely from heat-cured acrylic resin has the highest fracture resistance while splinting of the two over-denture abutments with metallic bar decreases the fracture resistance and the fracture position of the over-denture depends on the design incorporated.

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