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DIGITAL EVALUATION OF ACCURACY OF REATTACHING FRACTURED DENTAL STONE TEETH WITH CYANOACRYLATE ADHESIVE.

Dental Science

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ABSTRACT

Aim: Aim of the study was to digitally evaluate accuracy of reattaching fractured dental stone (type III gypsum product) teeth to dental casts using cyanoacrylate adhesive.

Methods and Material: Ten mandibular dental stone casts were obtained using mandibular dentulous rubber cast mold. Dental stone casts were modified to make four teeth (one incisor, one canine, and two premolars) fracture prone by making them isolated and elongated. Modified gypsum casts were scanned using 3D scanner (Ceramill Map400, Amann Girrbach AG). Three out of four fracture prone teeth were fractured and reattached with cyanoacrylate. One unfractured premolar on each dental cast was used as control. After reattachment casts were again scanned in same position using 3D scanner. Scanned data was used to digitally evaluate dimensional changes in reattached gypsum teeth using 3D analysis software (PolyWorks, InnvoMetric).

Results: Mean displacement in X (mesiodistal), Y (occlussogingival), and Z (faciolingual) plane for measured points (n=120 points) on reattached teeth were 0.0268 mm (SD 0.0082), 0.0482 mm (SD 0.0113), and 0.0047 mm (SD 0.0020) respectively. Mean displacement in 3D for measured points on reattached teeth calculated as surface distance based on XYZ displacement was 0.0615 mm (SD 0.0162). Two-way ANOVA test revealed no stastically significant difference of dimensional change after reattachment of teeth with different morphology.

Conclusions: In the context of present study, it can be concluded that reattaching cleanly fractured dental stone teeth (type III gypsum product) with cyanoacrylate adhesive results in clinically insignificant dimensional change.

KEYWORDS

dental stone, cyanoacrylate, 3D superimposition.

Introduction

Fracture of dental gypsum cast may occur during its manipulation in the dental clinic and laboratory. Removal of impression from cast, accidental fall of casts to the ground, failure to block out undercuts in the cast are the reasons for fracture of vulnerable teeth on cast.[1,2] Also dentists often find it necessary to work with dental casts soon after they are poured. This results in to casts having inadequate strength and surface hardness to be manipulated without damage [3]. Lone standing teeth with elongated clinical crown due to periodontal disease and smaller diameter are more prone to fracture during manipulation of dental gypsum casts. It is possible to oppose fractured gypsum fragments and reattach them with some adhesive as gypsum casts fracture in brittle manner with minimal or no plastic deformation.[4]

An adhesive material for gypsum products should have ability to bond to calcium, low film thickness, ability to penetrate into the porous gypsum structure, and hydrophilicity. Out of different adhesives studied previously cyanoacrylate and polyacrylic acid solution were found to give adequate repairs of fractured gypsum casts based on height and tensile strength measurements of cylindrical gypsum specimens.[2]

Cyanoacrylate has also been used to improve the properties of gypsum models by applying a thin layer on the gypsum, thereby increasing fracture and abrasion resistance. [5,6,7] It also reduces the water absorption and when applied to the gypsum die preserves the margin of the preparation. [8] In addition, cyanoacrylate based adhesives are simple to use, polymerize upon reacting with air humidity, and commercially available at low cost. Cyanoacrylate also has an antimicrobial property and has been applied in sutures of the oral mucosa, which may simplify the surgical procedure in areas inaccessible for suturing, as it stabilizes and fixes the surfaces through haemostasis. [9,10,11] It can be used as a surface protector of graft material and as an adjunct to absolute insulation. [12,13]

Hanson et.al. based on computerized photographic image analysis of repaired teeth on gypsum dental casts showed that cyanoacrylate adhesive repair of gypsum casts will not result in any clinically significant dimensional changes. [14] Likeman, and Paolinelis investigated the accuracy of cyanoacrylate repair of fractured dental stone cast teeth using a contact scanner.

Results of their study revealed that there was significant angular displacement of cyanoacrylate repaired dental stone teeth. [4] Another study based on comparison microscope found no significant linear discrepancy in hexagonal gypsum models after repair with cyanoacrylate. [15] Hasan et. al. showed that cyanoacrylate repaired rectangular gypsum specimens showed good adhesion based on transverse strength measurement without any linear dimensional change. [16]

Properties of gypsum products varies with different brands and manufactures. [17] There are no studies related to three dimensional evaluation of accuracy of reattaching fractured dental stone teeth with cyanoacrylate adhesive for dental stone brands manufactured in India.

Literature lacks sufficient evidence regarding accuracy of reattaching fractured dental stone teeth, hence the purpose of the present study was to evaluate three dimensional accuracy of reattaching fractured dental stone teeth with cyanoacrylate adhesive.

Material and Methods

For the study purpose ten mandibular dental stone casts were obtained using mandibular dentulous rubber cast mold. Dental stone (Goldstone, Asian Chemicals, India) was mixed with water according to the manufacturer's instructions. Dentulous mandibular rubber mold was placed on dental vibrator (BEGO, Germany) and mixed dental stone was poured slowly into the mold to avoid entrapment of air bubbles. After final setting, dental stone casts were retrieved from the rubber mold and modified using sharp cutter. Cast modification involved isolation and crown lengthening of one central incisor, one canine, and two first premolars to make them fracture prone. Total forty teeth were modified four each on ten casts to make them fracture prone.

A 3 D dental scanner (Ceramill Map400, Amann Girrbach AG) was used to scan the casts before fracture and after reattachment. Ceramill Map 400 is fully automatic, compact strip light scanner with accuracy of 0.02mm. For scanning dental stone casts were affixed to no plast retainer provided with scanner. After aligning the cast in scan focus it was locked in position by tightening the knurled and allen screws. 3D scan was performed for each cast before fracture, unnecessary portion of the scanned image was cropped using scanning software and saved as stl – file. No plast retainer along with dental cast was removed from scan baseplate without changing position of the cast. Three out of four teeth excluding one premolar (identified as control) were fractured at gingival third without removing the cast from locked position on no

plast retainer. For reattachment thin film of cyanoacrylate (Fevi Kwik, Pidilite, India) was applied to fractured ends and fractured portion of tooth was carefully replaced in close opposition to unfractured portion of respective tooth on dental stone cast. Care was taken to avoid step deformity while reattaching the fractured portion of dental stone teeth. After reattachment of fractured teeth, cast along with no plast retainer was replaced in the scanner in the same position on scanning base plate. 3 D scan was repeated and scanned data was saved as stl-file. All the procedure of fracture and reattachment was performed by single operator. Stl files before fracture and after reattachment fractured teeth were imported in 3D metrology software (PolyWorks, InnvoMetric) superimposed. The discrepancies were mapped to the superimposed model using a color scale displayed in the 3D scene. Types of color scales used for comparison operations are configurable. Discrepancy above tolerance value of 0.02mm were represented with dark green color. Areas that have no discrepancy at set tolerance limit, were displayed with brick red color (Fig.1). Four points on occlussal third per tooth in the area of green color indicating discrepancy were measured for displacement along X (mesiodistal), Y (faciolingual), and Z (occlussogingival) axis. Software automatically calculated 3D displacement as surface distance in 3D, based on following geometric formula,

$$d = \sqrt{(x2-x1)2 + (y2-y1)2 + (z2-z1)2}$$

Where, d - Surface distance between two points in 3D i.e. 3D displacement

(x2-x1) - displacement along X axis (mesiodistal),
(y2-y1) - displacement along Y axis (faciolingual),
(z2-z1) - displacement along Z axis (occlussogingival).

Though control teeth showed no discrepancy based on tolerance limit of 0.02mm, four points on every unfractured control tooth (total 40 points) were measured for quantifying any errors in casts repositioning, scanning, and 3D software analysis. Discrepancy values at 120 points on 30 reattached teeth of ten dental stone casts were obtained and corrected for any errors in casts repositioning, scanning, and 3D software analysis based on discrepancy values for control teeth.

Mean and standard deviation values for displacement along X (mesiodistal), Y (faciolingual), and Z (occlussogingival) axis, and surface distance in 3D were obtained. Two-way ANOVA was applied to find out effect of tooth morphology on displacement of reattached teeth. All stastical analysis were performed using GraphPad Prism 7.02 stastical analysis software.

Results

Table.1 shows the mean, SD, median, minimum, and maximum values for displacement along X, Y, Z axis, and surface distance in 3D for 120 points on 30 reattached teeth.

Comparison of dimensional changes after reattachment of fractured incisor, canine, and premolar using two-way ANOVA showed stastically non-significant results with p value >0.05 and F=7.359 (Fig. 2).

Discussion

One of the concerns with the use of cyanoacrylate is its cytotoxicity. Short-chain cyanoacrylates (ethyl and methyl cyanoacrylate) are not suitable for medical use because of their rapid degradation with the emission of toxic products. However, long chain (octyl and butyl cyanoacrylate) are widely used in medicine in the different specialties, as they degrade more slowly, thus generating less toxicity. [10, 11] A short chain ethyl-cyanoacrylate was used in the present study, which is more toxic than the long chain ones. However, reported toxicity of cyanoacrylate is uncommon in the dental workplace, but may manifest as conditions such as urticaria, contact dermatitis and other dermatoses. Dental staff using cyanoacrylate adhesives should avoid direct contact with cyanoacrylate and use appropriate personal protective measures. Maintaining higher levels of humidity, optimizing room ventilation and using special air conditioning filters in the working environment may be useful in minimising the toxicity of volatile cyanoacrylate adhesives. [13]

Tolerance for dimensional change in reattached dental stone tooth depends on degree of accuracy required in fit of prostheses and physiologic mobility of natural tooth. Tolerance of 0.1mm in fit of cobalt chrome cast partial denture framework have been suggested in the literature. [4] Physiological mobility of natural tooth varies among different groups of teeth. Single rooted teeth exhibit higher mobility than teeth with multiple roots. Physiologic tooth mobility is measured in horizontal and vertical direction. The upper limit of horizontal tooth mobility has been reported to be T500 = 0.15 mm for single-rooted teeth and T500 = 0.10 mm for multirooted teeth, where T500 is the range of tooth movement under an occlusal force of 0.5 kg. Vertical tooth mobility ranges between 0.05and 0.10 mm, in which the tooth moves within the boundaries of the PDL under 100lbs force. [18]

Present study evaluated dimensional changes along X (mesiodistal), Y (faciolingual), and Z (occlussogingival) axis after reattachment of fractured dental stone teeth with cyanoacrylate adhesive. Also, surface distance in 3D between two points was calculated based on XYZ displacement. Mean displacement along X, Y, and Z axis for measured points (n=120 points) on reattached teeth were 0.0268 mm (SD 0.0082), 0.0482 mm (SD 0.0113), and 0.0047 mm (SD 0.0020) respectively. Mean displacement in 3D for measured points on reattached teeth calculated as surface distance based on XYZ displacement was 0.0615 mm (SD 0.0162). These values are within the tolerance limit for fit of cast cobalt chrome partial denture framework and physiological tooth mobility.

Results of present study are in agreement with study by Hanson et.al. [14] Discrepancy values obtained in the present study are very small as compared those obtained in the investigation by Likeman et.al. [4] In the present study no stastically significant difference was found in dimensional change after reattachment between incisor, canine, and premolar teeth. This is in agreement with observation by Hanson et.al. [14]

Mean displacement along Z axis i.e. in occlussogingival direction was significantly lower than along X (mesiodistal) and Y (faciolingual) axis. This observation is similar to previous studies by Likeman et.al. and Hanson et.al. [4,14] Very minimal change in occlussogingival direction could be attributed to low film thickness of cyanoacrylate and porous nature of dental stone permitting infiltration of adhesive along fractured surfaces further reducing film thickness. [19,20]

Fracture of dental stone teeth with narrow diameter and elongated crown height occurs commonly during removal from impression or during manual handling. Such fracture usually occurs at weakest point in cervical third. Manual fracture in present study also resulted in fracture at weakest point in cervical third similar to clinical and laboratory situation.

Points chosen for measurement were in occlussal third of teeth above height of contours of teeth where repeatability of scanner is not affected. Also to avoid any dimensional changes in dental stone casts due to manipulation, interval between two scans (before fracture and after reattachment) of same casts was 5 minutes and single operator manipulated all the casts.

In the present study all reattachments were performed by single operator. As reattachment could be influenced by operator's skill and experience, it is one of the limitation of present study.

Another limitation of present study is that it involved only cleanly fractured teeth with no or minimal micro fragment loss from fractured surfaces. Amount of dimensional change may be significant after reattaching fractured teeth with fragment loss on dental stone cast. According to Hanson et.al. it is possible for the natural dentition to compensate for the errors within physiological mobility range in reattached dental stone teeth. [14] However, validation of this statement is required by clinically evaluating removable partial dentures fabricated on the repaired casts.

Conclusion

Within the limitations of present study, it can be concluded that reattaching cleanly fractured dental stone teeth (type III gypsum product) with cyanoacrylate adhesive results in dimensional changes that are within the tolerance limit for fit of cast cobalt chrome partial denture framework and physiological tooth mobility and hence may be clinically insignificant.

Tables

Table.1 – Three dimensional changes in type III dental stone teeth reattached with cyanoacrylate adhesive after fracture.

	Mean (mm)	SD (mm)	Minimum (mm)	Median (mm)	Maximum (mm)
X	0.0268	0.0082	0.01	0.029	0.041
Y	0.0482	0.0113	0.021	0.049	0.060
Z	0.0047	0.0020	0.001	0.005	0.008
Surface Distance	0.0615	0.0162	0.023	0.061	0.092

Figures

Fig.1 Scanned images of dental stone model before fracture (B), after fracture and reattachment (A), and after superimposition of two models (AB). Green colored area in AB indicating discrepancy.

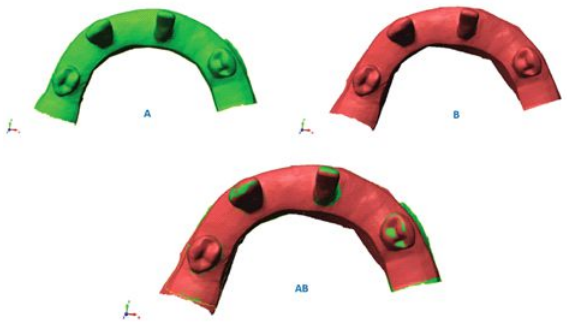
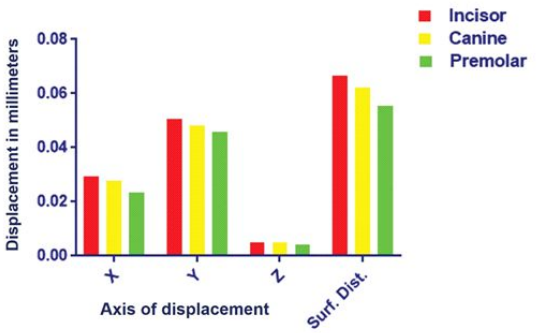


Fig. 2 Comparison of dimensional changes in reattached incisor, canine, and premolar teeth using two-way ANOVA. (P value > 0.05 non-significant, F =7.359)



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