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ORIGINAL ARTICLE

Evaluation of pre-alginate impression preparation methods in the surface accuracy of dental cast

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Abstract *Objective:* The aim of this study was to investigate the influence of pre-preparation technique (finger smearing and saliva ejection) of alginate impressions on the quality and accuracy of dental casts.

Materials and methods: Twenty mandibular impressions from 20 patients (10 males, 10 females) with an age range of 20–40 years were recorded using stock trays. A standard impression and pre-preparation technique for alginate were employed. This included removal of saliva with saliva ejector, smearing of alginate on occlusal surfaces of posterior teeth and smoothing of the material in the tray (Group-1: Test) and no drying and smearing or smoothing of the material prior to impression (Group-2: Control). Standardized disinfection, storage, pouring and removal from die stone techniques were used for all samples. Surface defects (nodules/blebs) on the occlusal surface of casts as examined with digital microscope, were classified according to their sizes and surface area into; Type-A (< 500); Type-B (> 500 < 100); Type-C (> 1000) in micrometers (μm). Data was tabulated and analyzed by SPSS using Anova and Tukey's test.

Results: Defects were significantly higher ($p < 0.01$) in samples in Group-2 (1225.51 ± 823.44 μm) as compared to Group-1 (783.68 ± 501.41 μm). All types of defects (Types A, B and C) were significantly higher in samples from Group-2 as compared to Group-1.

Conclusions: Use of pre-preparation technique of finger smearing and saliva ejector prior to alginate impressions resulted in significant reduction of surface nodules/blebs and enhanced the quality and accuracy of fabricated casts. Therefore, the use of saliva ejector, finger smearing on the occlusal

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surface of teeth and smoothening of alginate impression, immediately prior to intra-oral placement is clinically recommended.

1. Introduction

Alginate impression material is an elastic irreversible hydrocolloid most commonly used in dental applications (Ashley et al., 2005). Alginate consists of a chemical reaction which includes mixing of sodium alginate and calcium sulphate with water forming a calcium alginate gel (Carr and Brown, 2008). It is extensively used due to low technique sensitivity, hydrophilicity, pleasant taste and odor, ease of manipulation, low cost, long shelf life and compatibility with cast material (Carr and Brown, 2008). Alginate impressions are used to form dental gypsum and stone, study and definitive casts for the purpose of diagnosis and evaluation, record keeping, provisional and final restorations, mouth guards and bleaching trays (Nandini et al., 2008; Sedda et al., 2008).

Although alginate is universally employed for various applications, it appears to have poor dimensional stability due to imbibition and desiccation and must be poured within 10–12 min to avoid distortion (Donovan and Chee, 2004; Combe and Douglas, 1999; Fellows and Thomas, 2009). In addition, it has poor tear resistance, resulting in tearing when used in deep undercut areas or recording sub-gingival contours (Craig, 2002). Alginate dust in the form of components like silica, lead and cadmium are also present in its powder, which has toxic potential (Anusavice, 2003). Therefore, efforts to improve alginate impressions has received scientific attention and such attempts include extended pour alginates, to increase the pouring time up to 1–4 weeks (Jamani, 2002; Walker et al., 2010). Furthermore, to prevent alginate dust, de-dusting agents and minerals have been incorporated to inhibit toxic silica inhalation. Advanced alginates include, infection free, color changing, high viscosity alginates (Hiroshima, 2003; Taylor et al., 2002; Soares and Ueti, 2001). In recent times, CAD/CAM is used for digitization of the alginate impression material for precise impression taking to improve the outcome of the final prosthesis (Jin et al., 2018; Kim et al., 2015). These scanning softwares can be used to analyze and compare non-regular geometric shapes as those of teeth to check for dimensional stability in alginate material over a period.

Defects (nodules or blebs) on the occlusal surface of the casts are commonly observed on the occlusal surface of the stone casts fabricated from alginate impressions. These positive defects originate due to the air/saliva bubbles trapped between the impression material and occlusal surfaces of the posterior teeth. Along with improvements of the alginate material, improvements in manipulation of material and clinical techniques can also boost outcomes (McCullagh et al., 2005; Patel et al., 2010). These may include preparation of mouth, adequate storage and manipulation of impression, disinfection of impression, pouring and removal technique, use of cast materials and their compatibility to alginate. Preparation of mouth and impression technique is of particular importance, as presence of moisture and poor adaptation of material results in positive defects on the occlusal surfaces of the casts including nodules or blebs (Arora et al., 2015).

A study by Arora et al. in 2015 proposed finger adaptation of alginate on teeth, mouth rinse with astringents and smoothing the alginate material in trays, for improving the outcomes of impressions and cast quality. Therefore, the aim of this study was to investigate the influence of pre-preparation techniques of alginate impression (use of finger smearing, saliva ejector and smoothening of material) prior to intraoral impression on the quality and accuracy of the fabricated casts. The null hypothesis was that the use of pre-preparation techniques in the form of finger smearing, saliva ejection and smoothening of material prior to impression tray insertion would improve the quality of alginate impressions and dental casts.

2. Materials and methods

The study protocol was approved by the Research and Ethics Committee at the College of Dentistry, King Saud University (IR-0219) and all included subjects consented to the procedures. Twenty patients (10 females and 10 males) were included in the study, with an age range of 20–40 years. Subjects meeting the following criteria were included in the study: good oral hygiene, absence of caries, periodontal disease and oral infection, completely dentate arch with proper tooth alignment (no tilting, supra-eruption, impactions and imbrication) and absence of limited mouth opening. Mandibular non-reusable perforated stock trays of medium (M) and large (L) sizes were used to make a total of 20 mandibular impressions in 20 patients. In each patient, two impressions were recorded and were divided into two groups as following;

Group-1: Oral cavity was dried with saliva ejector and irreversible hydrocolloid (alginate) was finger painted onto the occlusal surfaces immediately before the impression tray with smoothed material was placed in the mouth (Fig. 1).

Group-2: Oral cavity was not dried and the impression was made directly without any painting or smoothing of the irreversible hydrocolloid (alginate).

After each impression, the oral cavity was rinsed with water and the mouth was closed for 20 min, prior to next impression being taken. A single operator took all impressions and a single operator was used for alginate mixing for all impressions. Mixing of alginate and water-powder ratio was standardized using measuring cylinders and scoops. Alginate was mixed for 45 s in tap water at room temperature (21 °C to 25 °C). Excess unsupported alginate outside the trays was cleanly severed using a disposable scalpel with No. 12 blade. All impressions were disinfected using 2% glutaraldehyde (spray) and rinsed under tap water for one minute and were stored in moist environment (wet paper tissue) for 10 min prior to pouring.

Fig. 1 Mouth preparation prior to impression using alginate finger smearing.

A standardized two-step pouring technique was used to pour all impressions using die stone with standardized water-powder ratio (W/P ratio) (0.24 mL of water per 100gm die stone). The stone was mixed in vacuum mixing machine and pouring was performed using a vibrator using a microbrush to prevent formation of air bubbles. Initial pour was made vertically and the casts were removed after 40 min from the impression with careful vertical movement. The second step included the base formation of using plaster of paris (Gypsum Type-II) in a rubber base, cast base former (Fig. 2).

The number of defects in the form of nodules or blebs on occlusal surface of each cast were noted and further assessed using a digital microscope (HIROX, KH-7700®, digital microscope system, Tokyo, Japan) at 100-x magnification (Fig. 3).

The number and size of defects produced on the occlusal surface of all the pre-molars and molars were tabulated. All these positive defects due to distortion in the impression were classified into the following three types:

Type-A: Nodules of 500 µm or less in diameter.
Type-B: Nodules between 500 and 1000 µm in diameter.
Type-C: Nodules more than 1000 µm in diameter.

The values for diameter of the nodules obtained from the casts (Fig. 4) were converted to micrometers using the following equation:

Fig. 2 Stone cast poured from the experimental impression.

Fig. 3 Hirox digital microscope for assessment of casts.

Fig. 4 Image from digital microscope showing assessment of defects.

$$\text{Micrometer} = \frac{\text{Number of units}}{\text{Eyepiece magnification x Zoom magnification}}$$

Eyepiece magnification = 100
Zoom magnification = 1

2.1. Statistical analysis

The mean and standard deviation of the test parameters were calculated using SPSS® (Ver. 21.0, SPSS, Chicago, IL, USA). The obtained data was subjected to independent T-test for comparison of groups 1 and 2. One-way Analysis of Variance test and Tukey's multiple comparisons test were performed to compare the different defect sizes in the 2 groups at a significance level of $p < 0.05$.

3. Results

The study demonstrated that there were defects (nodules/blebs) on the occlusal surface of the fabricated casts of the two groups (Group 1 and 2). Analysis of Variance computation showed that defects in µm were significantly higher ($p < 0.01$) in samples from Group-2 (1225.51 ± 823.44) as compared to Group-1 (783.68 ± 501.41). Tukey's Post Hoc test for multiple comparisons showed that all types of defects (Types A, B and C) were significantly higher in samples from Group-2 (control) as compared to Group-1 (Table 1, Fig. 5).

Interestingly, the number of Type-A defects as units was lesser in Group-2 as compared to Group-1, although statistically insignificant (Fig. 5). However, the number of Type-B and Type-C defects as units were higher in Group-2 (control) as compared to Group-1 (test) samples (Figs. 6 and 7).

4. Discussion

The present study was based on the hypothesis that the use of pre-preparation technique in the form of finger smearing, saliva ejection and smoothening the impressions prior to impression tray insertion will improve the quality of alginate impressions and fabricated casts. The pre-preparation impression technique (Test) was compared to non-preparation alginate impressions (Control). The hypothesis was accepted, as the positive defects (nodules/blebs) related to impression errors in μm were significantly higher in the control as compared to test group.

In the present study, saliva was removed using saliva ejector and not high volume suction. High volume suction potentially results in over-drying of teeth and causing the alginate to stick to teeth during impression (Arora et al., 2015). In addition, alginate's setting time decreases when mixed with warm water, therefore tap water was used (Harris, 1969). To prevent cast surface defects, glutaraldehyde disinfectant thoroughly washed off the impressions, which were stored in moist environment for 10 min to avoid desiccation and dimensional changes (Rentzia et al., 2011). Clinical setting of the material was determined with loss of surface tackiness and impressions were removed with a 2–3 min delay to allow for additional material strength (Harris, 1969; Ryu et al., 2002) for standardization and high quality of impressions, strict use of the water powder ratios for alginate and die stone was employed, along with vacuum mixing of die stone and two stage impression pouring using a vibrator (Rohanian et al., 2014; Azer et al., 2008).

The aim of using pre-preparation impression method is to minimize the incidence of voids and bubbles incorporated between the impression and tooth surface due to air/saliva

Table 1 Means and Standard deviations of the defects in micrometers (μm) for the study groups.

Group	Defects	N	Mean	Std. Deviation	ANOVA P value
1	≤500 μm	37	362.43	94.76	< 0.01*
	501–999 μm	46	703.41	131.61	
	≥1000 μm	27	1497.70	467.15	
	Total	110	783.68	501.41	
2	≤500 μm	32	367.18	90.64	
	501–999 μm	64	735.71	150.06	
	≥1000 μm	98	1825.64	752.78	
	Total	194	1225.51	823.44	
Total	≤500 μm	69	364.63	92.22	
	501–999 μm	110	722.20	142.90	
	≥1000 μm	125	1754.80	712.33	
	Total	304	1065.63	753.37	

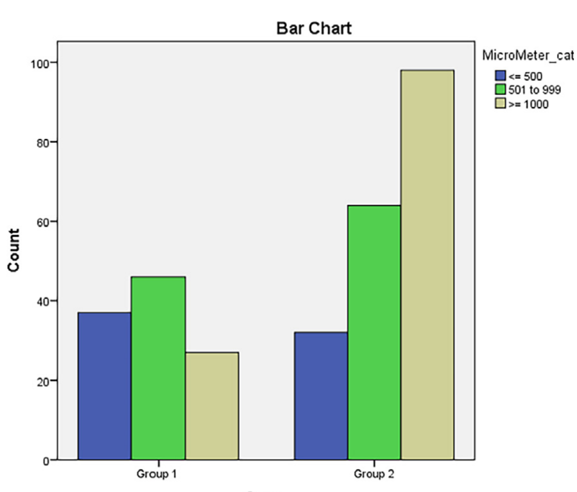

Fig. 5 Comparison of nodules counts among study groups.

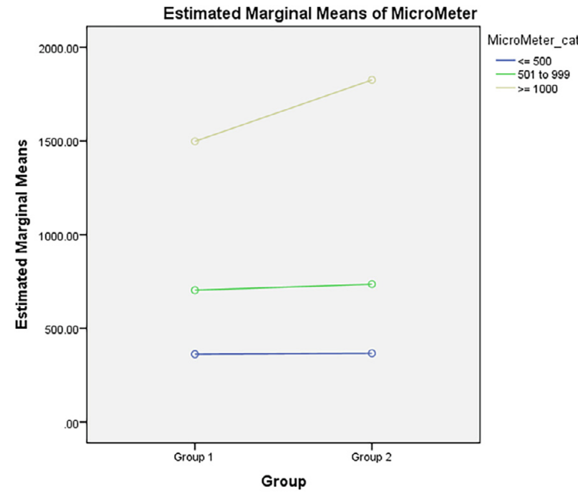

Fig. 6 Comparison of defects in micrometers among study groups.

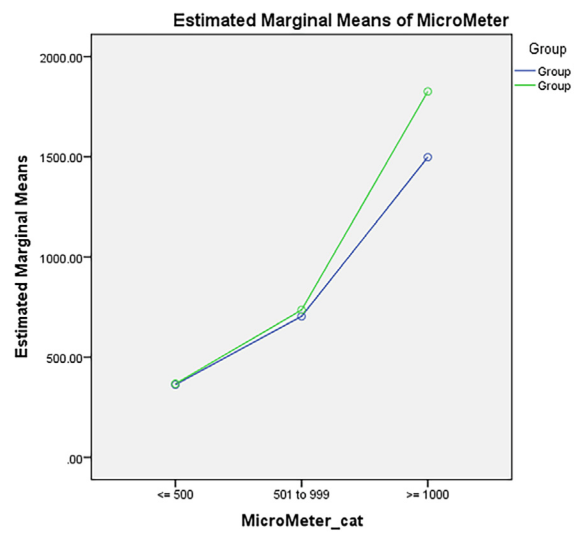

Fig. 7 Comparison of defects in study groups according to types of defects.

entrapment between the two. These negative impression defects such as bubbles results in positive defects (nodules/blebs) on the occlusal surface of the casts and the result is inaccurate mounting and assessment of dental casts. In addition, they impede correct cast intercuspation resulting in inaccurate diagnosis, treatment plans and prosthesis. In the present study, use of pre-preparation method of smearing of alginate prior to impression insertion showed significant reduction of these cast defects as compared to controls. A possible explanation for this reduction of defects is related to the improved adaptation of alginate on occlusal fissures of premolars and molars when manually smeared. This prevents incorporation of voids and bubbles introduced due to mixing of alginate and presence of intra-oral moisture and debris. These findings are in agreement with the observations of Arora et al, (2015).

The defects (nodules/blebs) on the occlusal surface of casts were classified into, < 500 (Type-A), $> 500 < 100$ (Type-B), and > 1000 (Type-C) in μm surface area. Interestingly, in the test group, Type-A defects were higher as compared to control group. However, Type B and C defects were significantly higher in control group. It is the authors opinion that Type-C defects (> 1000 μm) are mostly associated with occlusal inaccuracy and will interfere in correct articulation of maxillary and mandibular casts. In addition, Type-C defects are the most difficult to be removed accurately from casts and can compromise the outcome in a clinical case resulting in poor treatment planning. This further emphasizes the importance of implementing the pre-preparation methods to minimize the occlusal inaccuracies in the casts fabricated from alginate impressions.

A possible limitation of the present study is the use of operator mixed alginate technique. Newer techniques using alginate mixing under vacuum have already been introduced (Patel et al., 2010). In addition, incorporation of surfactants in alginate material to reduce surface tension and better adaptation to tooth surface has shown potential for use. However, a conventional Alginate material and impression technique was employed in the present study based on its common usage. Another limitation of the use of finger smearing of alginates on tooth surface for improving the quality is the extra time consumed with this process in the overall impression procedure. Other alternatives, such as smoothing the surface of alginate impression material with a wet finger without smearing on tooth surface prior to impression making have been proposed (McCullagh et al., 2005; Lim et al., 1995). This step does not add to the overall time of the procedure and improves the quality of impression by reducing bubbles (McCullagh et al., 2005; Lim et al., 1995). Therefore, this method can be compared to the test and control groups of the present study in future studies. Moreover, future studies investigating the use of vacuum mixed alginate and impression treatments to improve wettability (Milward and Waters, 2001) and its co-relation with pre-preparation methods in alginate impressions are recommended. Currently, CAD/CAM (Computer aided designing and computer added machining) scanning to monitor clinical tooth wear, for indirect restoration in primary teeth and digitization of alginate impression materials have shown promising results (Ahmed et.al., 2017; Simsek and Derelioglu, 2016; Jin et al., 2018; Miyazaki et al. 2009). There is also a need to compare these impression techniques with conventional alginate impression methods by using three dimensional CAD/CAM technology.

5. Conclusion

Within the limitations of the study it can be concluded that the use of pre-preparation technique of finger smearing, saliva ejector and smoothening of impression prior to alginate impressions resulted in significant reduction of surface nodules/blebs and enhanced the quality and accuracy of fabricated casts. Therefore, the use of saliva ejector, finger smearing of alginate on the occlusal surface of teeth and smoothening of impression immediately prior to intra-oral alginate impression placement is clinically recommended.

Conflict of interest

The authors have no conflict of interest to declare.

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