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DIGITAL EVALUATION OF THE EFFECT OF DIFFERENT IMPRESSION TECHNIQUES ON MUCOSAL DEFORMATION IN DISTAL EXTENSION RIDGES. A CLINICAL CONTROLLED TRIAL

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ABSTRACT

Aim: The purpose of this study is to compare the effect of different impression techniques for distal extension removable partial denture in achieving optimal tissue placement.

Material & methods: Eight patients were selected from a prosthodontics outpatient clinic with mandibular bilateral distal extension ridges. Four final impressions were made for each patient (Single-step full arch impression as reference, intraoral scan, elastomeric two-step, and altered cast impression). The produced casts were scanned and superimposed for comparison using Geomagic software. The 3D deviations were measured at different anatomical areas. The RMS, positive and negative gap distances of cast surfaces at each area were calculated. A Kruskal–Wallis test was performed to compare different casts in various areas.

Results: Significant differences were found in RMS. and -AVG. Overall data in IOS compared to other techniques. For +AVG., the altered cast technique showed significantly higher values at mesial half of the crest.

Conclusion: Intraoral scanning can replace mucostatic impressions in partially edentulous distal extension arches. The new 2-step elastomeric impression technique presents an acceptable alternative to the more complex altered cast impression.

KEYWORD: ??

INTRODUCTION

Mandibular distal extension removable partial dentures (DERPDS) present a challenge for dental professionals. An essential consideration in the use of partial dentures is their dual support, which is derived from two distinct supporting tissues: the teeth and the residual ridge. Functional impressions are critical to ensure the equitable distribution of applied forces to both the abutments and the tissues of the ridge. Failure to achieve this balance may result in the subsequent mobility of abutment teeth and resorption of the residual ridge. [1-3] Different functional impressions have

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been used to increase tissue support, such as the Hindel and McClean techniques, as well as the selective tissue placement technique. These traditional techniques are infrequently used due to their associated disadvantages, including increased time requirements, higher costs, and the potential for technical errors. The selective tissue placement method was recommended by Applegate [4]. This technique is widely regarded as one of the most acceptable and popular techniques. Studies by Holmes[1], Vahidi[2], and Leupold[3] have demonstrated that controlled tissue support is best achieved by this technique. Various surveys[5] show that if the framework is not completely seated during the clinical stage or the pouring of the altered cast, serious mistakes may be made. It also requires more time and effort to incorporate acrylic resin into the framework evaluation appointment.[6]

With advances in scanners and scanning technology, intraoral scanners can be used in partially edentulous cases. Multiple studies have demonstrated that there are no statistically significant differences between conventional impressions and intraoral scanning (IOS), and no clinically relevant effects have been observed in the fabrication of removable dentures.[7,8] The use of intraoral scanners eliminates patient discomfort associated with traditional impressions, reduces the risk of allergic reactions to impression materials, and minimizes errors related to impression distortion.[9] As IOS captures the static soft tissues, it is considered a mucostatic impression. Furthermore, digital pressurization can be employed to compensate for the discrepancy in tissue displacement between the residual teeth and the residual mucous membrane.[10]

A novel two-step impression technique using a spaced acrylic custom tray is introduced in this study, which applies selective pressure. The objective is to minimize the duration of chair time and the frequency of visits while ensuring sufficient accuracy, optimal tissue support, and proper adaptation of the denture base.

The null hypothesis in this study was that there was no difference between 3D deviation analysis in the three different impression techniques —i.e., intra-oral scan, Altered cast impression technique, and two-step impression technique —at different areas.

MATERIAL AND METHODS

The Ethics Committee of the Faculty of Dentistry at Tanta University accepted this study, reference number R-RP-4-24-3101. Eight patients, aged 35 to 65 years, were selected from the prosthodontics outpatient clinic at Tanta University, and they signed written informed consent to participate in this study. The criteria for inclusion in the trial were as follows: patients had lower bilateral free-end saddles (Class I Kennedy classification), with the premolar serving as the terminal abutment. The mucosa of the distal extension should be minimally compressible. Patients exhibiting flabby tissue were excluded from the study.

Sample size

The minimal sample size for each group in this investigation was eight samples. The sample size was determined utilizing the mean and standard deviation from a prior study[11] by a computer program. (G*Power version 3.1.9.7, Heinrich-Heine-Universität, Germany).

Primary Irreversible hydrocolloid impressions (Tropicalgin, Zhermack, Badia Polesine, Italy) were made for all eight patients. After surveying and design determination, mouth preparation was performed (rest seats and guiding planes preparation). Then, four types of final impressions were made for each case.

Irreversible hydrocolloid single-step mucostatic impression: a perforated custom acrylic tray with 3-layer wax as spacer was used, the impression was made with a loose mix of irreversible hydrocolloid (Tropicalgin- Zhermack - Badia Polesine, Italy), and the impression was poured immediately.

The obtained cast was scanned and used as a reference model.

Intraoral scanning: The Mandibular arch was scanned with an Intraoral Scanner (Primescan-Dentsply Sirona, USA) starting from the lingual surfaces of the teeth and then moving to the occlusal and buccal surfaces. The intraoral scan was exported as an STL file. (Figure 1)

Fig. (1) Intraoral scan

Altered cast impression [12]: The STL file of the reference model was imported into B4D software (Blender for Dental, Australia) to design the metal framework. The framework design consisted of a lingual bar major connector with direct retainers and additional rests on canines serving as indirect retainers, along with a grid work denture base connector. The frameworks were fabricated utilizing a selective laser sintering 3D printer. (Chamlion Laser Technology Co., Nanjing, China) using Co-Cr alloy powder (Shinseki International Inc., Korea). Upon completion of the metal framework, it was tried on both the reference model and the oral cavity. Self-curing acrylic resin was applied over the framework spacer. Holes were created corresponding to the crest of the ridge to allow for the escape of excess material. A thin layer of low-fusing compound was softened and applied to the fitting side of the tray. The operation was repeated until the framework was accurately aligned. The complete interior of the tray, except the buccal shelf area, was relieved by approximately 1 mm. The definitive impression was created utilizing zinc oxide eugenol impression material (Cavex, Haarlem, The Netherlands). Thereafter, the master cast was sectioned to remove the ridges. The metal framework was attached to the sectioned cast using sticky wax. Dental stone was used to pour the amended cast after boxing.

Elastomeric two-step impression: Using a 3-mm spaced perforated acrylic custom tray, putty condensation silicone impression (Silibest-BMS dental, Capannoli, Italy) was used to record the edentulous area only, with scraping of the impression surface at the crest of the ridge. The overall impression was recorded using light viscosity condensation silicone impression material (Sililight, BMS Dental, Capannoli, Italy). (Figure 2)

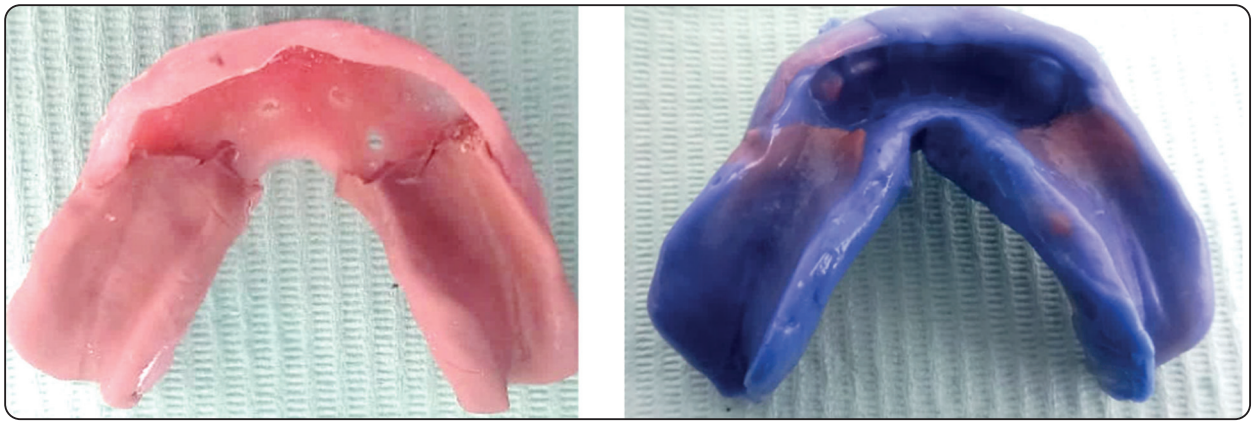

Fig. (2) Two-step elastomeric impression technique

All impressions were made and poured immediately by one investigator using Type 4 X-Hard Stone (Elite Rock - Zhermack SpA, Badia Polesine, Italy). All casts obtained from the impressions were scanned using a laboratory scanner (In Ecs X5: Dentsply Sirona, USA). The scans of each cast were exported as an STL file.

The 32 STL files were imported into an analytic program (Geomagic Control X 2020; 3D Systems, Rock Hill, SC, USA). For each patient, the irreversible hydrocolloid single-step mucostatic impression was used as the reference data. The STL files produced from the intraoral scan, altered cast impression, and two-step impression were used as separate measured data.

A best-fit alignment technique was used to align the reference and measured scan data. The 3D deviation was measured at the selected reference areas (Figure 3). Area 1,2 (at the mesial and distal halves of the crest of the ridge 4 mm in width; the crest of the ridge was determined then 2 mm on each side of the crest, then the distance between the distal surface of the last abutment to the midpoint of retromolar area was divided in two halves the mesial and distal), area 3: buccal slopes areas of the ridge (5 mm width), area 4: on lingual slope of the ridge (5 mm width), area 5 the remaining teeth**.**

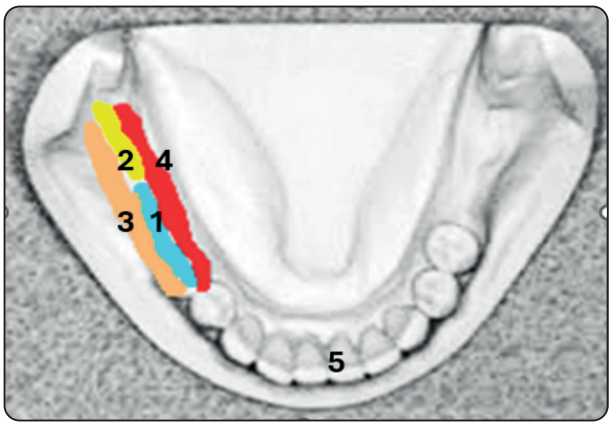

Fig. (3) Selected area for evaluation in distal extension mandibular arch

To achieve a more accurate best-fit alignment, the analytic software was instructed to use only area 5 of the casts for exact superimposition. In Geomagic software, "+AVG." refers to the average of positive gap distances when comparing a scan to a reference model**;** negative deviation "-AVG." means the measured point is below the reference surface, the root mean square RMS. Error determines the degree of matching between two scans.

To evaluate 3D discrepancies between the test data and the reference data, color maps were generated using the software's 3D comparison algorithm.

The measurements were collected. A statistical software program (IBM SPSS Statistics, version 24; IBM Corp.) was used for all statistical analyses. Normality testing of RMS, -AVG., and +AVG data was performed before the data analysis. Normality was tested using the Shapiro–Wilk test, which indicated that the data were not normally distributed; therefore, the Kruskal–Wallis test was conducted on the RMS. data, +AVG., -AVG., followed by Dunn's Test for post-hoc comparisons. All statistical testing was performed using a confidence level of 95% (α=0.05).

RESULTS

The median, minimum, and maximum of the RMS, +AVG. and -AVG. in each area for each technique are presented in Table 1. RMS values are maximum for the altered cast impression method, followed by the elastomeric 2-step method, and minimum for the IOS method. Comparison of RMS. in areas (1) and (2), as well as overall area showed a significant difference among three impression techniques. Post hoc test showed that IOS showed a significant difference when compared with the altered cast impression and 2-step techniques in areas (1) and (2), as well as overall area, as shown in Table 1. While there are nonsignificant differences in RMS. Between areas 3,4,5 of the three impression techniques.

AVG. values are maximum for the altered cast impression method, followed by the elastomeric

2-step method, and minimum for the IOS method. Comparison of -AVG. in all areas, the three impression techniques showed a significant difference. Post hoc test showed that IOS in overall area showed a significant difference when compared with the altered cast impression and 2-step technique, as shown in Table 1. While there are nonsignificant differences in -AVG. in areas 1,2,3,4,5 between the three impression techniques.

+AVG. values are maximum for the altered cast impression method, followed by IOS, and minimum for the elastomeric 2-step method. A comparison of the +AVG at area 1 among the three impression techniques showed a significant difference. Post hoc test showed that the altered cast impression showed a significant difference compared to the 2-step technique and IOS at area 1. While there are nonsignificant differences in +AVG. At areas 2,3,4,5, and overall between the three impression techniques groups.

For qualitative analysis, the 3D deviations were illustrated and color-coded. Figure 4 presents an example from each group. Green color indicates an exact fit between the original model and the test groups. However, a blue color indicated negative discrepancies, while a red color denoted positive discrepancies.

TABLE (1) Comparison of different impression techniques for RMS., +AVG., and -AVG. values at the different reference areas in each technique.

	Region	Intraoral scan			Altered cast technique			Two-step technique			
		Median	Min	Max	Median	Min	Max	Median	Min	Max	Sig.
RMS.	Mesial part of the crest	0.07a	0.03	0.12	0.48b	0.20	0.70	0.13ab	0.04	0.23	0.026*
	The distal part of the crest	0.15a	0.14	0.24	0.24b	0.22	0.75	0.17ab	0.06	0.21	0.041*
	Buccal side of the ridge	0.22	0.11	0.43	0.28	0.15	0.67	0.16	0.08	0.60	0.5
	Lingual side of the ridge	0.13	0.06	0.31	0.40	0.22	0.64	0.13	0.04	0.16	0.06
	Teeth	0.10	0.08	0.11	0.12	0.08	0.15	0.16	0.13	0.19	0.08
	Total	0.12a	0.03	0.43	0.23b	0.08	0.75	0.13ab	0.04	0.60	0.01*
-AVG.	Mesial part of the crest	-0.025	-0.05	-0.01	-0.315	-0.63	-0.03	-0.085	-0.18	-0.02	0.127
	The distal part of the crest	-0.03	-0.10	0.00	-0.15	-0.67	-0.07	-0.07	-0.17	-0.04	0.174
	Buccal side of the ridge	-0.07	-0.09	-0.01	-0.165	-0.60	-0.04	-0.08	-0.20	-0.06	0.331
	Lingual side of the ridge	-0.035	-0.08	-0.01	-0.22	-0.46	0.00	-0.075	-0.13	-0.03	0.497
	Teeth	-0.075	-0.08	-0.07	-0.025	-0.04	-0.01	-0.11	-0.09	-0.07	0.1
	Total	-0.06b	-0.10	0.00	-0.10a	-0.67	0.00	-0.09a	-0.20	-0.02	0.017*
+AVG.	Mesial part of the crest	0.06a	0.03	0.11	0.20b	0.16	0.29	0.05a	0.02	0.10	0.02*
	The distal part of the crest	0.14	0.13	0.22	0.20	0.10	0.22	0.08	0.05	0.13	0.06
	Buccal side of the ridge	0.20	0.10	0.37	0.22	0.05	0.32	0.08	0.05	0.82	0.6
	Lingual side of the ridge	0.12	0.03	0.26	0.39	0.10	0.79	0.08	0.03	0.12	0.1
	Teeth	0.05	0.04	0.05	0.05	0.05	0.05	0.09	0.07	0.11	0.1
	Total	0.11	0.03	0.37	0.19	0.05	0.79	0.07	0.02	0.82	0.06

There is a significant at P-value< 0.05 (*).

For each horizontal row, values with the same small letters indicate no statistically significant difference (P >0.05).

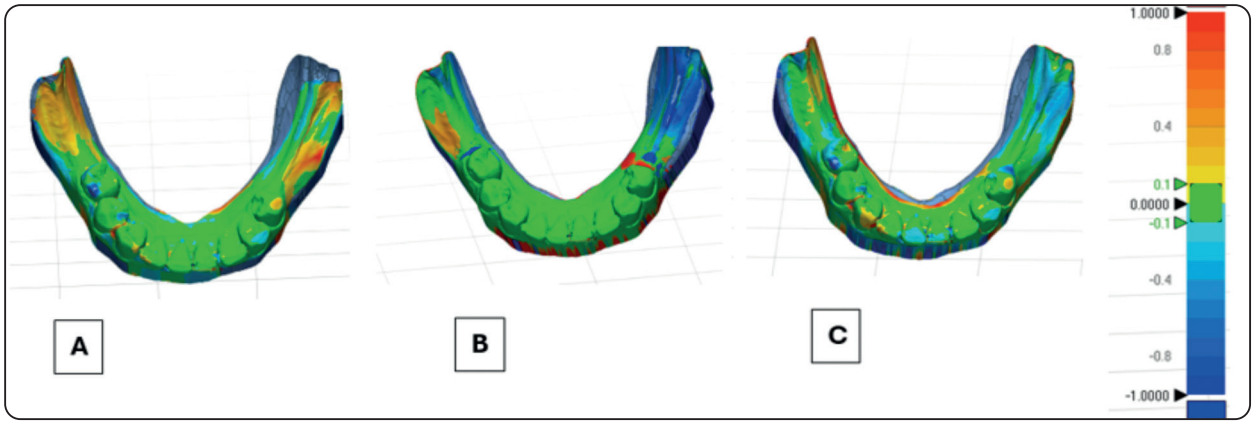

Fig. (4) Color coded 3D deviation for (A)-Intraoral scan (B)- Altered cast technique (C)- Two-step technique

DISCUSSION

The present study compared the accuracy of a newly developed two-step selective pressure impression technique with the conventional altered-cast method and an IOS for DERPD.

The dentist's issue in fabricating the distal extension denture is to balance the resilient support from the residual ridge with the non-resilient support from the teeth. Functional impressions provide one approach to attain this equalization.

Previous studies have measured the amount of tissue placement produced by different impression techniques using various methods. For instance, Lyte[13], Leupold[14], Vahidi[3], Wagle et al.[15], Holmes et al.[1], and Frank[16] measured the vertical movement of RPDs during loading. Hanna [17] measured the vertical displacement of the mucosa using direct measurements on plaster models, while more accurate analyses were conducted by Wang[18] and Al-Rawas [11] using 3D surface-matching software.

In this study, IOS was evaluated for its accuracy in recording distal extension ridges relative to alginate mucostatic impressions. RMS., +AVG., -AVG., and color maps of different areas of the IOS showed minimal deviation, indicating similar accuracy to physical mucostatic impressions in relatively short saddles. This suggests that IOS can replace conventional impressions in distal extension RPDs with acceptable results, [19-21]. However, IOS still faces challenges in capturing soft tissues in long saddles and complete residual ridges due to a lack of anatomical landmarks and soft tissue mobility.

The authors introduced a new selective pressure impression technique to record the supportive form of the residual ridge in distal extension cases. This technique is more straightforward and requires less chair time and laboratory steps than the more complex altered cast impression technique, reducing the potential for technical errors.

The RMS. results indicated that there was no significant difference between the altered cast impression technique and the newly developed technique across all evaluated areas in this study. This suggests that the newly developed technique could serve as a simpler alternative to the more complex altered cast technique.

The -AVG. results indicate no significant difference between the altered cast impression technique and the newly developed technique, suggesting that both methods exert similar compression. In contrast, IOS demonstrates a significantly lower level of compression compared to both techniques.

This result agrees with Vahidi[3], who revealed that ACIT presents statistically significantly more vertical displacement of tissue compared to

single-step mucostatic impression technique, and Leupold [14], who revealed a statistically significant decrease in vertical movement of denture bases constructed with altered cast impression. The difference may or may not be clinically relevant.

The null hypothesis that no difference would be found between the three impression techniques was rejected, as significant differences were observed.

Disadvantages of the altered cast technique included the possibility of errors in technical implementation, additional expense and time, and a perceived lack of value [22,23]. For this, the new selective pressure 2-step elastomeric impression technique presents an acceptable alternative to the more complex altered cast impression technique.

CONCLUSION

1. IOS can replace mucostatic impression in distal extension partially edentulous arches.
2. The new selective pressure 2-step elastomeric impression technique presents an acceptable alternative to the more complex altered cast impression technique.

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