

RETENTION OF DIGITAL MANDIBULAR COMPLETE DENTURE IN FLAT RESORBED RIDGE WITH DIFFERENT IMPRESSION TECHNIQUES, A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Aim: This study aimed to evaluate the retention of digital mandibular complete dentures constructed from two different impression techniques for flat resorbed mandibular ridges.

Subjects and Methods: Sixteen completely edentulous patients with resorbed mandibular arch were selected. The patients were divided into two equal groups, group I (intervention group), in which the mandibular definitive impression was taken using all green impression technique, and group II (control group) where the definitive impression was taken using conventional impression technique. For both groups the master casts and the recorded jaw relation were laboratory scanned and the designed dentures were 3D printed. The retention of the mandibular complete denture was assessed at baseline (one week following denture insertion) and after 6 months using a digital force gauge. Statistics were done using Independent t test to compare retention in both groups. Significant difference was obtained when p value was set at < 0.05.

Result: It was found that at baseline there was statistically insignificant difference between both groups. At six months, there were also insignificant difference between them, yet greater values regarding the all green technique was observed.

Conclusion: Although there was insignificant difference between both impression techniques, printed complete dentures produced by final impression using all green technique could be beneficial for resorbed mandibular ridges regarding retention and ease of manipulation.

KEYWORDS: Severely resorbed ridge, 3D printed complete denture, definitive impression, digital force gauge, mandibular atrophied ridge.

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INTRODUCTION

Resorption of the alveolar ridge after tooth extraction is a pathophysiological process that affects both height and width of residual ridges.¹ The amount of resorption and its rate usually differs not only from one patient to another but also within the same patient at different times. Atwood attempted to categorize the main factors affecting residual alveolar ridge resorption into anatomical (such as size, shape and density of ridge), metabolic (such as nutritional, hormonal and factors related to cellular activity of osteoblasts and osteoclasts), functional (such as frequency, intensity, direction of forces) and prosthetic (such as myriad of techniques, materials used, concepts and principles incorporated into prosthesis) factors.²

The problem with residual ridge resorption is more exaggerated especially when patients lose all their teeth. According to reports, this resorption/atrophy peaks in the first year following tooth extraction and then progresses gradually over the next few years. By time, the resultant ridge may be severely depressed and atrophied compromising available treatment options for these patients.³ Moreover, implant placement or pre-prosthetic surgical correction of atrophied ridges could sometimes be contraindicated due to systemic conditions or financial related issues. Therefore, conventional complete dentures still remain a feasible treatment option for these patients.

Unfortunately, making an impression for these severely resorbed ridges especially mandibular ones maybe a nightmare because the tissues are displaceable and unsupported and the resultant denture made by conventional impression techniques may be unstable and affect patient masticatory efficiency and affect patients' quality of life.⁴

Theories of impression techniques include mucostatic, mucocompressive, functional and selective impression techniques. Conventionally, open mouth impression technique has been used for

decades to record edentulous arches. However, the main drawbacks of this technique were an unstable denture during function and difficult to obtain proper peripheral seal especially with atrophied mandibular ridges.⁵

Therefore, the proposal of modifications for impression techniques has been widely proposed in literature such as admixed⁶, functional, all green and cocktail techniques. These methods aim to capture the primary and secondary load-bearing regions without distorting the resorbed residual ridge. The primary benefits offered by these methods include their ease of control in achieving optimal coverage, their ease of correction, their accuracy in determining the extent of mucobuccal reflection, and their ability to concentrate pressure on the load-bearing areas, particularly the buccal shelf and the slopes of residual ridges in the mandible.⁷

Going in parallel with the digital dentistry, which has gained its popularity in the past few decades tremendously, the use of CAD/CAM dentures (computer aided design/ computer aided manufacturing) has provided some patients and clinicians with advantages as shorten treatment visits, eliminated errors of conventional processing (including denture warpage, volumetric shrinkage, porosity and crazing).⁸ Literature comparing digital dentures taken with different impression techniques are insufficient especially in atrophied mandibular ridges. Consequently, the purpose of this study was to assess the retention forces of digital mandibular full dentures made using various impression techniques.

METHODOLOGY

Following the consent of the Faculty of Dentistry's ethical committee, a two-arm, parallel, 1:1 allocation ratio randomised controlled clinical trial was carried out at Cairo University, Egypt. The study was conducted within the period of June 2023 till April 2024. The reporting of this study followed the Consort statement for reporting clinical trials.

Sample size was estimated depending on a previous study⁵ as reference. According to this study, the minimally accepted sample size was 6 per group, when mean \pm standard deviation of group I patients' satisfaction was 2 ± 0.7 while in group II mean \pm standard deviation was 3.4 ± 0.7 , with 2 effect size when the power was 80 % & type I error probability was 0.05. Total sample size increased to 8 per group to compensate for the 20% drop out. The t test was performed by using G. power3.1.9.7.

Patients were recruited according to the following inclusion criteria: age 45 years, completely edentulous patients with atrophied mandibular arch, Angle's class I maxillo-mandibular relationship with no history of recent extraction, normal salivary flow, healthy mucosa covering the ridge and normal size and position of tongue. On the other hand, temporomandibular disorders, any intra-oral pathological conditions that may jeopardize complete denture construction, patients with flabby or sharp knife edge mandibular residual ridges were excluded from the study. A written consent was obtained from patients fulfilling eligibility criteria and willing to participate.

Recruitment for the sixteen patients who were edentulous came from Cairo University's Faculty of Dentistry's Prosthodontic Department outpatient clinic. Allocation sequence was obtained using computer generated program (random.org) with allocation ratio 1:1. A researcher (MH), not involved in the trial procedures, kept the allocation sequence in her personal laptop and prepared sequential numbered, sealed opaque envelopes containing patients' allocation. Only the patient and the statistician were blinded.

Patients were assigned either to group I (intervention group), where the mandibular definitive impression was taken using all green impression technique, or to group II (control group) where the definitive impression was taken using conventional impression technique.

Maxillary and mandibular primary impressions were made for all participants using irreversible hydrocolloid impression material (Cavex CA37; Cavex, Holland). Using self-cure acrylic resin (Acrostone, Cairo, Egypt), custom made special trays were fabricated on the poured study casts and they were adjusted to be shorter than the depth of vestibule by 2 mm to allow for border molding. For maxillary secondary impression registration, green stick compound was used for border tracing and zinc-oxide eugenol impression material (Caxex outline BV, Holland) was used for impression making.

In group I, mandibular secondary impression was made using all green impression technique. The green stick (Hiflex Green Sticks, India) was softened by heating and kneading it into a homogenous mass. It was then loaded into the fitting surface and borders of the special tray and border molding movements were done. After that, final wash impression was made using zinc-oxide eugenol impression material. In group II, mandibular secondary impression was made in a conventional way, where green stick compound was used only for border tracing step and final impression was made using zinc-oxide eugenol impression material. (Figure 1)

In both groups, the definitive impressions were boxed, poured into extra hard stone (Zhermack, Zhermack elite rock Dye Stone, Italy) and jaw relation registration was performed using check bite technique. After that, the boxed master casts and the recorded jaw relation were scanned using lab scanner (Freedom HD scanner, DOF, Seoul, Korea) and exported as STL (standard triangulation language) files.

For thorough denture designing, the digital records were imported into the designing software (Exocad GmbH, Germany) and the scanned master casts were aligned using the jaw relation record scan. The Exocad software was used for detecting the alveolar ridge crest, midline, limiting structures and occlusal plane. After that, setting of artificial teeth was performed guided by the drawn crest of residual ridge and detected occlusal plane. (Figure 2)



Fig. (1) A: Mandibular primary impression, B: All green impression technique, C: final wash impression for all green impression technique.

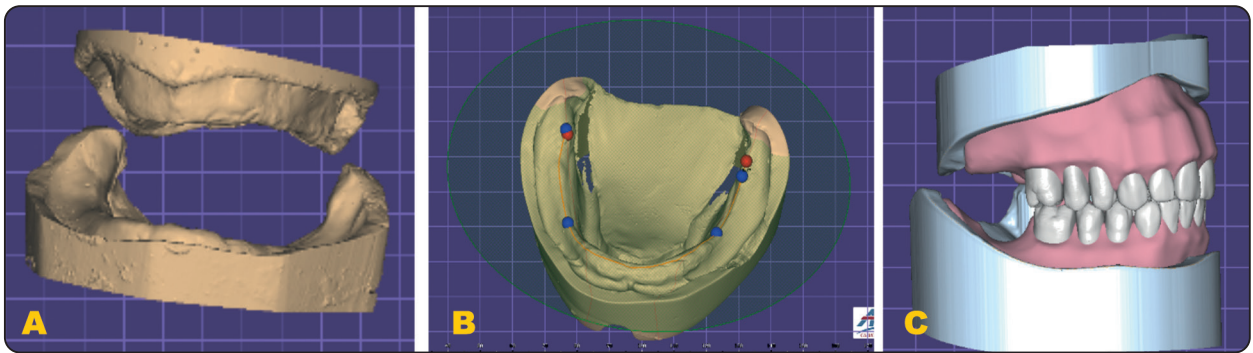


Fig. (2) A: The master casts after being scanned on lab scanner, B: detection of the alveolar ridge crest and occlusal plane using the Exocad software, C: final designed digital complete denture before printing.

The finished denture base design was exported as STL files to be 3D printed and the artificial polymethyl methacrylate (PMMA) teeth were cemented in the corresponding sockets of the printed denture base using resin cement (Nexus, Kerr, USA). The finished and polished complete dentures were inserted intraorally, adjusted for any pressure areas or occlusal disharmony and post-insertion instruction were given to the patients.

Denture preparation and retention assessment

One week after denture implantation, the retention of the mandibular complete denture in both groups was evaluated using a digital force gauge (Extech, U.S.A.) by pushing on a metal hook situated in the geometric centre of each mandibular denture. In order to identify the geometric center, the finished dentures were placed on their master casts and the midline and retromolar pad centers

were marked on the polished surface of the denture. Following the cutting of a cardboard triangle to fit the casts, the cardboard was traced with the three lines dividing the triangle's three angles. The geometric centre of the denture was determined by locating the intersection of these three lines.

To attach the hook in the lower denture, two holes were ground into the lingual side of the polished surface, bilaterally, just below the first molars, and one hole was ground into the midline area, just below the central incisors, using a small fissure bur. Self-cure acrylic resin was used to secure three 1 mm wires at the holes. The wires were then extended upward 2 mm above the occlusal plane and fixed with a metal hook at the geometric center with similarly self-cure acrylic resin.

Prior to using the retention gauge device, the patient was positioned upright with their head

securely resting on the dental unit headrest and the pointer was adjusted to zero. Once the patient’s mandibular denture was securely positioned on the supporting tissues, the tip of the tongue was to be passively rested in the floor of his mouth, adjacent to the anterior denture teeth. (Figure 3)

Three readings of retention (in Newton) were taken using the device, and the average of the three values was documented. After the readings, the hook was removed and sealed with clear, self-curing acrylic resin so that it would be in the same location for the subsequent follow-up period.

RESULTS

Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016. Exploration of the given data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that the significant level (P-value) was shown to be significant as P-value < 0.05, which indicated that data originated from normal data regarding both groups. Accordingly, comparison between them was performed by using Independent t test, while comparison between retention at baseline and after 6 months was performed by using Paired t test.



Fig. (3) Retention measurement by attaching the digital force-meter’s metallic probe to the hook

Retention evaluation

Intragroup comparison:

In both groups there was increase in retention. In group 1, there was a significant increase from (14.88 ± 3.52) at baseline to (16.81 ± 4.05) after 6 months with (1.94 ± 2.62) mean difference as P=0.03. In group 2, there was an insignificant increase from (12.94 ± 2.74) at baseline to (14.44 ± 3.39) after 6 months with (1.5 ± 2.61) mean difference as P=0.09, as presented in table (1) and figure (4).

TABLE (1) Descriptive results of retention at baseline and after 6 months in both groups, intragroup comparison:

		Minimum	Maximum	Mean	Standard Deviation	Paired Differences					P value
						Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
ALL green impression technique Group 1	baseline	10.00	22.50	14.88	3.52						
	At 6 months	11.00	24.00	16.81	4.05	1.94	2.62	0.79	0.18	3.70	0.03*
Conventional impression technique Group 2	baseline	10.00	18.50	12.94	2.74						
	At 6 months	10.50	20.00	14.44	3.39	1.50	2.61	0.79	-0.25	3.25	0.09

*Significant difference as P<0.05.

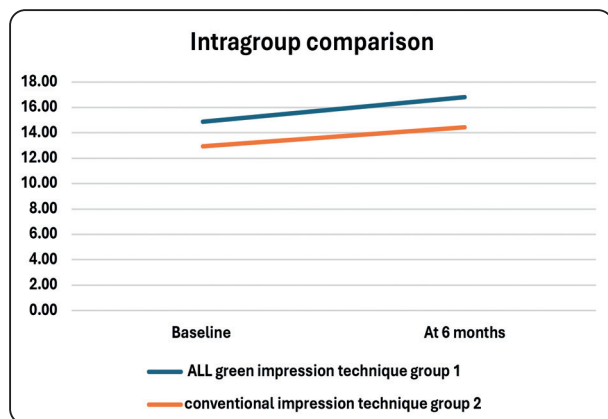


Fig. (4) Line chart representing retention at baseline and after 6 months in both groups.

Intergroup comparison:

Comparison between group revealed insignificant difference as , at baseline group 1 (14.88 ± 3.52) was insignificantly higher than group 2 (12.94 ± 2.74) with (1.94 ± 1.35) as $P=0.17$, while after 6 months group 1 (16.81 ± 4.05) was insignificantly higher than group 2 (14.44 ± 3.39) with (2.38 ± 1.59) difference between them as $P=0.15$, as presented in table (2) and figure (5)

TABLE (2) Comparison between groups using Independent t test.

	ALL green impression technique group 1		Conventional impression technique group 2		Paired Differences				
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
							Lower	Upper	
Baseline	14.88	3.52	12.94	2.74	1.94	1.35	-0.87	4.74	0.17
At 6 months	16.81	4.05	14.44	3.39	2.38	1.59	-0.94	5.69	0.15

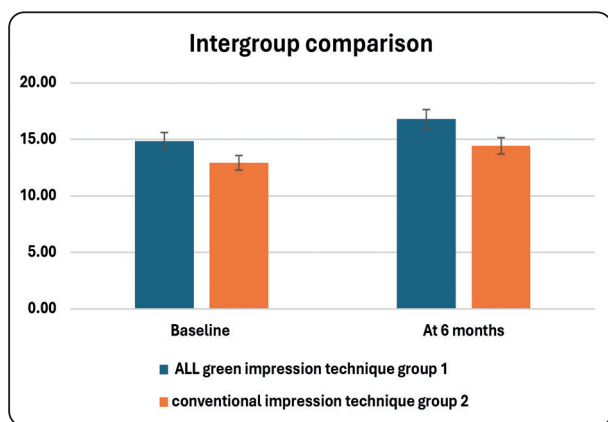


Fig. (5) Bar chart representing retention of group 1 and group 2 at baseline and after 6 months.

DISCUSSION

Providing a stable and retentive denture might be regarded as the primary objective of general dentists when treating complete dentures. According to research findings, patients' satisfaction is significantly influenced by the durability and retention of their mandibular full dentures, particularly in cases involving flat resorbed ridges^{9,10}

Resorbed mandibular ridges should be dealt with proper preparations as pre-prosthetic management could play a role to enhance stability, retention and support to the final denture. Massaging the gums to strengthen the tissues, using warm saline rinsing and discontinuing to use ill-fitting dentures could be highly useful. In certain cases, the use of tissue conditioning material could be very beneficial.^{9,11}

The use of CAD/CAM printed complete dentures was applied in this study, as some studies recommended its use and showed increased retention values when compared with CAD/CAM milled complete dentures or conventional methods for denture making. The use of CAD/CAM technology has been documented to provide improved fitting and retention of dentures fabricated using digital workflow, resulted in dentures with low polymerization shrinkage and facilitated the storage of 3D data for any future retrievals.^{12,13}

Another study compared the retention and adaptation of 3D printed dentures versus conventionally fabricated ones. The authors concluded satisfactory retention values for both groups, yet the difference was insignificant. However, there was insignificant increase in retention values over time which is consistent with the results of this present study. This conclusion could advocate the idea of replacing conventional dentures with digital ones to advantage from the digital workflow for complete denture construction.¹⁴

A highly qualified impression is critical in resorbed mandibular ridge to keep it stable and improve the patient comfort. The main objective for impression making in resorbed lower ridges is developing an impression that could exert uniform pressure over the stress bearing areas of denture foundation to reduce force per unit area.^{15,16}

Some surveys^{17,18} reported that modelling impression compound followed by zinc oxide and eugenol impression paste is the most commonly used material for complete denture impression-making maybe due to its capability to reproduce fine details, ease of handling, almost dimensionally stable after hardening.^{19,20} Yet, one of its main limitations is reduced manipulation time making it difficult to remain in the plastic stage till complete recording of functional movements of vestibular and lingual sulcular tissues. This is very obvious

especially when using sectional molding technique during impression making in completely edentulous patients.^{4,19-21} This limitation could be one of the reasons why the conventional method for final impression making could show reduced mean retention values. The results of our current study were consistent with a previous study comparing different materials for impression making for resorbed mandibular ridges and found that the conventional method to be the least retentive.⁷

The results of this current study also comes in accordance with a recent study that compared complete dentures fabricated from four impression techniques for resorbed mandibular ridges in a cross over study and concluded that the conventional method to be the least retentive.⁵

Another study reported that it took an average of 17 placements to obtain a final impression when using modeling plastic as a border molding material for completely edentulous arches.²² These increased number of placements may be accepted in cases when the denture foundation area is well developed as any error could be adjusted by re-warming and remolding the compound again. However, in cases of resorbed mandibular ridges -as included in our study- it would be difficult to reorient the tray every time correctly to mold each section of the lower arch separately. Therefore, the use the all green impression technique in such cases could be highly recommended as the number of customized tray placements could be decreased and could achieve optimal stability for the final denture.²³

A case report concluded that the use of all green technique was quick and simple, and the combination of both traditional and contemporary methods could lead to a prosthesis with better retention and stability. Yet, patient education remains mandatory both before and after treatment to make the patient understand the limitations of denture performance in such case.²⁴

Another case report recommended the use all green technique with proper positioning of teeth in the biometric denture space (neutral zone) especially in resorbed mandibular ridges as dentures produced by this technique showed reduced food trapping under denture, good esthetics as a result of proper facial support and proper positioning of posterior teeth which will allow sufficient tongue space.²⁵

Another study used all green technique in resorbed mandibular ridges and reported that the viscosity of low fusing impression compound removed any soft tissue fold and smoothed them over the mandibular bone and this reduced the potential discomfort that may arise from “atrophic sandwich” of the mucosa between the denture and the bone. This may explain the proper adaptation of denture base and improved retention over time. However, reported drawbacks of this technique was discomfort from heat used during functional loading and the brittleness of the material during scraping.²⁶

According to the authors’ knowledge, literature lack clinical randomized trials comparing conventional technique for impression making for completely edentulous patients versus all green technique combined with digital workflow to obtain printed complete dentures. The explanation of acceptable and reasonable retentive values for both groups could be attributed to documented reasonable adaptation of produced denture bases.²⁷ The increased retentive values for the final lower dentures over time produced by both techniques could be explained by the influence of the adaptive neuromuscular coordination of the patient that could be established with function. However, the significant increase in retention over time in the all green technique could be explained by the increased adaptation and fit of the denture base over the residual ridge.¹⁰

Finally, the present study has some limitations as reduced sample size and decreased period for follow up. Other factors could be analyzed as patient’s satisfaction and chewing efficiency of dentures produced by both techniques.

CONCLUSION

Although there was insignificant difference between both impression techniques, printed complete dentures produced by final impression using all green technique could be beneficial for resorbed mandibular ridges regarding retention and ease of manipulation.

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