ORIGINAL RESEARCH

Dislodging Force Resistance in Hemi-mandibulectomy Patients Rehabilitated with Acrylic Resin and 3D-printed Resin Prostheses

Ahmed N Elsherbini[1], Tarek K Alsharif[2], Nancy N Elsherbini[3]

Received on: 05 June 2023; *Accepted on:* 06 July 2023; *Published on:* 31 August 2023

Abstract

Aim: The aim of this crossover study was to compare dislodging resistance in hemi-mandibulectomy patients who had been rehabilitated with prostheses made of conventional acrylic resin (CA), conventional acrylic resin lined with a soft liner (CAS), and three-dimensional (3D)—printed resin.

Materials and methods: Patients were selected with hemi-mandibulectomy class III according to the Cantor and Curtis classification. Patients had a conventional acrylic denture for the upper arch with twin occlusion. For the lower arch, the patient received a conventional acrylic denture, after 3 months it was lined with a soft liner, and after 3 months, it was retrieved and they were given a 3D-printed denture for 3 more months. Resistance to dislodging force was measured using a force gauge at insertion and after 3 months.

Results: The resistance to dislodging forces was highest in the printed denture, followed by lined acrylic followed by the conventional acrylic with mean values of (3.72 ± 0.057) Newton (N), (2.696 ± 0.151) N, and (1.91 ± 0.089) N, respectively.

Conclusion: Three-dimensional (3D)—printed denture bases showed the highest resistance to dislodging forces, followed by the CAS, and finally the CA.

Clinical significance: Aiding patients with hemi-mandibulectomy with the best material to be used in their rehabilitation with dental prostheses.

Keywords: Dislodgment, Hemi-mandibulectomy, Three-dimensional printing, Twin occlusion.

World Journal of Dentistry (2023): 10.5005/jp-journals-10015-2265

Introduction

The mandible is a vital structure in the human body; it is involved in all essential functions. It is involved in mastication, speech, and deglutition. Besides the mandible forms one-third of the face, so it's an intriguing part of the facial appearance.[1]

Due to many reasons, such as tumors, infections, or accidents, some patients suffer from a partial or total loss of the mandible which is termed a hemi-mandibulectomy. Hemi-mandibulectomy results in speech problems, impaired mastication, compromised deglutition, rotation, and medial collapse of the mandible. Also, facial disfigurement, in control over saliva, and shifting of the lower occlusal plane of the intact side medially toward the defect side, due to the muscle pull and scarring of tissues.[1–5]

Prosthetic rehabilitation of a completely edentulous mandibular ridge is one of the most challenging management in prosthetic dentistry. The mandible has inherited problems due to the limited bearing area, which diminishes the functionality of lower dentures besides their retention.[5–7]

The prosthetic rehabilitation in hemi-mandibulectomy will be more challenging, as the bearing area is much smaller than the normal mandible. The diminished bearing area will worsen the support and the retention means of the lower denture. The prosthesis will be required not only to restore mastication and speech but also to restore facial appearance.[3–5] One of the proposed prosthetic solutions is using twin occlusion, in which two rows of upper acrylic posterior teeth are set on the maxillary complete denture in the case of completely edentulous patients. In the case of a dentulous upper arch, a row of acrylic posterior teeth is placed medial to the natural dentition to occlude with the deviated mandible's occlusal plane.[8]

[1,2]Department of Prosthodontics, Modern Sciences & Arts University, Cairo, Egypt

[3]Department of Prosthodontics, Cairo University, Cairo, Egypt

Corresponding Author: Ahmed N Elsherbini, Department of Prosthodontics, Modern Sciences & Arts University, Cairo, Egypt, e-mail: ahmed_elsherbini@live.com

How to cite this article: Elsherbini AN, Alsharif TK, Elsherbini NN. Dislodging Force Resistance in Hemi-mandibulectomy Patients Rehabilitated with Acrylic Resin and 3D-printed Resin Prostheses. World J Dent 2023;14(7):604–607.

Source of support: Nil

Conflict of interest: None

In addition, one of the problems in the rehabilitation of hemi-mandibulectomy patients is the lack of retention, which will be dwarfed when compared to the already limited retention of intact mandible dental implants with retention attachments inserted in the intact side of the mandible is one of the most effective ways to significantly improve retention.[9]

Other sources of retention are utilizing the remaining available physiologic retention means in the mandible such as saliva film, the peripheral seal of the denture borders and the vestibule, interfacial force, and oral and facial musculature. One of the physiologic retention means is the mechanical interlocking between the denture base and bony undercuts usually the distolingual undercut.[10] The magnitude of the retention force in such retention mean will be dependent on the degree of engagement between the denture base and the undercut, which can be affected by the material used in the fabrication of the denture base.[11]

Several materials have been used in the fabrication of lower dentures, such as conventional heat-cured acrylic resin, conventional heat-cured hard acrylic resin lined with soft liner, combination base of conventional heat-cured acrylic resin and chrome-cobalt base.[11,12] CA is one of the most used materials, due to its easy manipulation, acceptable esthetics, and easier repair. However, CA suffers from polymerization shrinkage, dimensional instability, and complicated processing. In CAS, the use of soft liners acts as a cushion, reducing the occlusal forces on the residual ridge, thus, reducing the rate of resorption. However, some soft liners harden and require regular replacement.[12] One of the recent materials used in fabrication in dental prostheses, is the three-dimensional (3D)—printed resin. 3D-printed resin decreases production time when compared with conventional heat-cured acrylic resin, and production errors are reduced. However, 3D-printed resin showed higher surface roughness, lower hardness, flexure, and bond and impact strength.[13]

Null hypothesis (H0)

There is no significant difference in the dislodging resistance among hemi-mandibulectomy patients rehabilitated with prostheses made of conventional acrylic resin (CA), conventional acrylic resin lined with a soft liner (CAS), and 3D-printed resin.

Materials and Methods

The aim of this crossover study was to compare dislodging resistance force [(Newton (N)] in hemi-mandibulectomy patients who had been rehabilitated with prostheses made of CA, CAS, and 3D-printed resin. These materials, CA and CAS, were selected as they are one of the most used materials. However, they have inherited drawbacks, as 3D printing can overcome some of (CA and CAS) drawbacks, and it was used and compared to them in this study. Patients will first receive a prosthesis fabricated from CA, after follow-up, the prosthesis will be lined with a soft liner, and then they will receive a prosthesis fabricated from 3D-printed resin.

A convenient sample of seven patients were selected in this study according to the following criteria:

Inclusion Criteria

- Skeletal class I.
- Completely edentulous upper and lower arch.
- Hemi-mandibulectomy class III according to Cantor and Curtis was chosen because resection of half of the mandible was done so the patients suffer from discontinuity of the mandible, and dysfunction of mastication.
- A surgical plate was used to repair the defect.

Exclusion Criteria

- Dentulous and partially edentulous patients.
- All other classes of hemi-mandibulectomy.
- Patients who had radiotherapy within the previous year, because prosthetic rehabilitation is not recommended.

Fabrication of the Dentures

Primary impression was done for upper and lower arches using irreversible hydrocolloid material Zhermack, Italy, pouring the impression with dental gypsum. Using polymethyl methacrylate (PMMA) special tray was made and the secondary impression was taken using elastomeric material. For the upper arch border molding was done using tracing compound Kerr, UK, then the impression was taken with Impregum from 3M, USA. For the lower denture, heavy-consistency elastomeric material was used for border molding and then light-consistency elastomeric material from Zhermack, Italy was used for the impression record. Light consistency was used to avoid exerting excessive pressure on the hemi-mandible. The jaw relationship was recorded and mounted on the SAM articulator, in Germany. Setting up of nonanatomic acrylic teeth in Acrostone, Egypt, to avoid the patient exerting biting force, teeth were set to the first molar on the intact side, and no teeth were set on the defect side in the lower occlusion block. In the upper occlusion block teeth were set to form twin occlusion on the intact side (Fig. 1). Try-in was tried intraorally. Then the upper and lower trial denture bases were flask and processed in a conventional way using heat-cured acrylic resin to form the acrylic denture (Fig. 1).

Scanning of the lower denture was done using an extraoral desktop 3D scanner (FREEDOM HD, South Korea) to form the standard triangulation language (STL) file.

The STL file was printed using photo-polymerizable PMMA liquid resin NextDent, Netherlands printed by 3D printer Mogassam Digital Dentistry, Egypt, to form the 3D-printed lower denture. Pink self-cure acrylic resin in Acrostone, Egypt, was applied on the polished surface to mask the 3D-resin color (Fig. 2).

Fig. 1: Lower denture fabricated from conventional acrylic resin

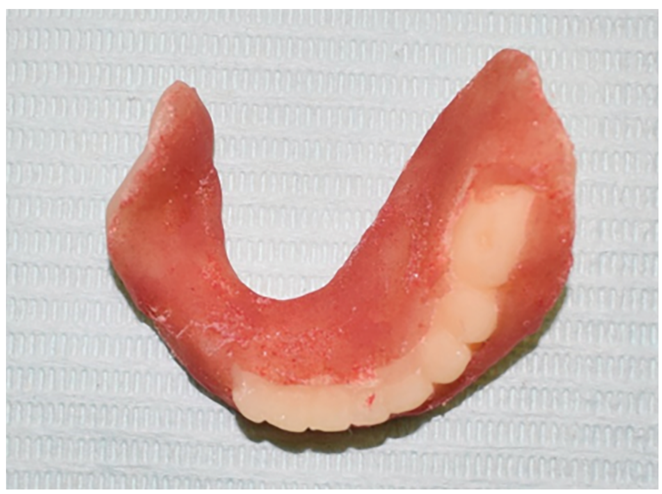

Fig. 2: Lower denture fabricated from 3D-printed resin

Dislodging Force Measuring Procedure

A conventional heat-cured acrylic resin denture, a conventional heat-cured acrylic resin lined with soft liner denture, and a 3D-printed resin denture were used in the research.

Push up dislodging force in N was applied and measurements were taken at denture insertion and after 3 months from insertion. Measurements were taken from three positions:

- Defect side
- Midline
- Intact side

Using force gauge Extech, USA, a pushing force in N was applied on the labial notch at the midline of the conventional acrylic denture, and then records were taken at the canine region on the defect side and on the intact side. After 3 months, measurements were recorded. Then the conventional acrylic denture was lined with a permanent soft liner Mollosil, Detax, Germany, and then measurements were taken. After 3 months, patients were recalled; measurements were taken for the lined denture from the three positions. Lined dentures were retrieved from the patients and they were given the 3D-printed dentures. Measurements were taken at insertion and after 3 months.

Statistics

Data was collected, and statistically analyzed using Statistical Package for the Social Sciences (Version 17, Chicago, IL) and represented in tables. Three-way analysis of variance test was used to detect the difference in the different types of denture bases and Tukey's *post hoc* test.

Results

Effect of the Prosthesis Material on the Resistance to Dislodging Force

The mean values of resistance to dislodging forces (N) were highest in the 3D printed (3.72 ± 0.057) N, followed by CAS (2.696 ± 0.151) N followed by the CA (1.91 ± 0.089) N (Table 1). Except for CA and CAS at immediate insertion, the difference in mean values between the groups was statistically significant *p* 0.001.

Effect of Time on the Resistance to Dislodging Force

The mean values of resistance to dislodging forces increased over the follow-up period for the three groups (Table 1). Except for CA and CAS at immediate insertion, there was a statistically significant difference of *p* 0.001 in each group over the course of the study.

Effect of Position of the Dislodging Force Application

The mean values of resistance to dislodging forces were highest in the intact side (3.72 ± 0.057) N, followed by midline (2.59 ± 0.074) N, followed by the defect side (1.896 ± 0.077) N (Table 1). At all three positions, there was a statistically significant difference of *p* 0.001.

Discussion

As a portion of the mandible has been lost, the structures available for retention have been reduced. Dental implants should be the first treatment option in such cases to restore retention. However, many patients reject implant placement because they have already suffered in the surgical procedure of mandible removal. Many patients don't want to enter any other surgical procedures even if it's a simple one. Another reason might be economic with high costs related to implant placement. Due to the complete edentulism of the upper and lower arches, we couldn't make a mandibular training flange or maxillary palatal ramp as suggested by Beumer et al.,[3] as making any of the two options will render the stability of the upper and lower dentures. Twin occlusion was fabricated to allow function, accompanied by physiotherapy to correct the deviation.[14]

All three denture bases, the CA, CAS, and 3D printed increased their resistance toward the dislodging forces during the follow-up period. This can be attributed to the settling of the dentures on the mucosa, better neuromuscular control, adaptation of the patient to the new prosthesis, and having more experience in using it. This result coincides with Behairy et al.[15] who compared conventional acrylic and 3D-printed dentures and there was an increase in the retention values. In addition, Ebrahim et al.[12] found that retention in CAS increased over the follow-up time.

The hypothesis was nullified as, when comparing the three denture bases, the 3D printed recorded the highest mean values of resisting dislodging forces, followed by the CAS, followed by the CA. The high mean values of 3D-printed dentures can be related to the fabrication technique. This technique layers resin layer by layer with a photosensitive resin, which is then polymerized by ultraviolet light, ensuring high accuracy and adaptation of the material on the supporting structures, as well as engagement of the available undercuts.[16] Also, 3D prints have higher water sorption than conventional acrylic, so more expansion of the material is expected which might result in more engagement of the undercuts.[17] This result coincides with Behairy et al.[15] and Heikal et al.[18] in which 3D-printed resin recorded higher retentive values than conventional acrylic resin. Naggar et al.[19] reported that 3D printing had higher retention than CA due to better dimensional stability, smoother surface, better wettability, and adhesion. Although encouraging retention values of 3D printed when compared with CA, 3D printing showed distortion of the incompletely polymerized resin during demounting of the denture base from the building platform reported Emera et al.[20] However, Faty et al.[21] found out there was no difference in the retention forces between 3D-printed resin and CA dentures.

When comparing CA with CAS, the latter showed higher retentive forces than the former denture this can be due to accurate adaptation on the tissues and better engagement of the available undercuts by soft liners. The low retention forces of the CA can be attributed to the errors of fabrication, and polymerization shrinkage which will result in a lack of adaptation and thus less accurate engagement of the undercuts.[12]

Table 1: Showing the mean values of the different prostheses over the follow-up period, the effect of time on the dislodging forces, and the mean values of the changing the dislodging force application in N

	Conventional acrylic		*Lined acrylic*		*Printed*	
Time position	Immediate	3 months	Immediate	3 months	Immediate	3 months
Defect	0.42 ± 0.13 N	0.98 ± 0.13 N	0.58 ± 0.109 N	1.402 ± 0.063 N	1.302 ± 0.067 N	1.896 ± 0.077 N
Midline	0.896 ± 0.107 N	1.52 ± 0.152 N	1.282 ± 0.069 N	1.8 ± 0.079 N	2.07 ± 0.083 N	2.59 ± 0.074 N
Intact	1.26 ± 0.083 N	1.91 ± 0.089 N	1.586 ± 0.061 N	2.696 ± 0.151 N	2.408 ± 0.054 N	3.72 ± 0.057 N

When comparing the mean values of the dislodging forces resistance in relation to the position of force application within each group. The defect side showed the lowest values, which can be related to the limited supporting area and limited retention sources on this side. Midline position followed with higher mean values, this can be due to the increase in retention sources such as anterior bony undercuts, adhesion, and saliva film. Due to the better supporting area, more contact area between the denture base and mucosa, and better adhesion due to the presence of the lingual undercut, the intact side had the highest values. The lingual undercut provides the highest mean of retention in diminished mandibular bearing areas, as demonstrated by Elsherbini[10] and Sheta.[11]

Conclusion

Within the limitation of the current research, it was concluded that 3D-printed denture bases showed the highest resistance to dislodging forces, followed by the CAS, and finally the CA. 3D printed dentures provide better retention than the other materials but still cost wise is expensive compared to other materials. Poor esthetics of 3D-printed denture base which requires masking with a tissue-colored material, with further added costs.

Future Suggestions

Lowering of the cost of the printed resin and the masking material should be considered. Complete digital workflow starting from scanning to designing and manufacturing can be investigated.

Ethical Consideration

The protocol and consent were approved by Institutional Review Board/Ethical Committees of Cairo University (IRB/ECs), Faculty of Dentistry) No: 30922 with respect to scientific content, compliance with applicable research, and human subjects' regulations.

References

1. Lingeshwar D, Appadurai R, Sswedheni U, et al. Prosthodontic management of hemimandibulectomy patients to restore form and function - a case series. World J Clin Cases 2017;5(10):384–389. DOI: 10.12998/wjcc.v5.i10.384
2. Taylor TD. Diagnostic considerations for prosthodontic rehabilitation of the mandibulectomy patient. Clinical Maxillofacial Prosthetics. Chicago: Quintessence Publishing. 2000;155–170.
3. Beumer J, Marunick MT, Curtis TA, et al. Acquired defects of the mandible: etiology, treatment, and rehabilitation. Maxillofacial Rehabilitation, Prosthodontic and Surgical Considerations 1996:184–188.
4. Marathe AS, Kshirsagar PS. A systematic approach in rehabilitation of hemimandibulectomy: a case report. J Indian Prosthodont Soc 2016;16(2):208–212. DOI: 10.4103/0972-4052.164914
5. Kataoka T, Akagi Y, Kagawa C, et al. A case of effective oral rehabilitation after mandibular resection. Clin Case Rep 2019;7(11):2143–2148. DOI: 10.1002/ccr3.2459
6. McCord JF, Grant AA. Identification of complete denture problems: a summary. Br Dent J 2000;189(3):128–134. DOI: 10.1038/sj.bdj.4800703
7. Elsherbini AN, Niedermeier W. Repercussion of conventional complete mandibular denture versus single implant over-denture on retention and biting force. Open Access Maced J Med Sci 2021;9; 186–189. DOI: 10.3889/oamjms.2021.6769
8. Agarwal S, Praveen G, Agarwal SK, et al. Twin occlusion: a solution to rehabilitate hemimandibulectomy patient-a case report. J Indian Prosthodont Soc 2011;11(4):254–257. DOI: 10.1007/s13191-011-0091-8
9. Goyal P, Manvi S, Arya S. Prosthodontic management of hemimandibulectomy patient: implants, a better solution. J Dent Implant 2016;6(1):37–40. DOI: 10.4103/0974-6781.190385
10. Elsherbini AN. Mini-poll coping as an alternative attachment in tooth supported over-denture prosthesis. Egypt Dent J 2019;65(1): 3671–3675. DOI: 10.21608/EDJ.2019.76000
11. Sheta NM. A comparison of the accuracy of the disto-lingual flange adaptation using two different dentures base materials in lower complete dentures: an in-vitro study. Egypt Dent J 2017;63(3): 2795–2802. DOI: 10.21608/EDJ.2017.76327
12. Ebrahim E, Abdel-Fattah A, Kabee S. The effect of two different denture base materials on retention of complete denture in severely resorbed lower ridge cases. Al-Azhar Dent J Girls 2016;3(4):287–292. DOI: 10.21608/adjg.2016.5182
13. Dimitrova M, Corsalini M, Kazakova R, et al. Comparison between conventional PMMA and 3D printed resins for denture bases: a narrative review. J Compos Sci 2022;6(3):87. DOI: 10.3390/jcs6030087
14. Ciuraj M, Lipowicz A, Graja K, et al. Physiotherapeutic methods of treatment of mandibular distal occlusion and the progress of therapy: a case report. J Bodyw Mov Ther 2022;29:26–32. DOI: 10.1016/j.jbmt.2021.09.026
15. Behairy NA, Kabeel SM, El-Sadany HF. Evaluation of retention for maxillary complete denture constructed by conventional and 3D printing techniques. Al-Azhar Dent J Girls 2022;9(2):245–250. DOI: 10.21608/ADJG.2022.102156.1423
16. Grande F, Tesini F, Pozzan MC, et al. Comparison of the accuracy between denture bases produced by subtractive and additive manufacturing methods: a pilot study. Prosthesis 2022;4(2):151–159. DOI: 10.3390/prosthesis4020015
17. Gad MM, Alshehri SZ, Alhamid SA, et al. Water sorption, solubility, and translucency of 3d-printed denture base resins. Dent J (Basel) 2022;10(3). DOI: 10.3390/dj10030042
18. Heikal MMA, Nabi NA, Elkerdawy MW. A study comparing patient satisfaction and retention of CAD/CAM milled complete dentures and 3D printed CAD/CAM complete dentures versus conventional complete dentures: a randomized clinical trial. Brazilian Den Sci 2022;25(1). DOI: 10.4322/bds.2022.e2785
19. Naggar SM, Helal E, Khalil MF, et al. Comparative study of maxillary denture-base retention between CAD/CAM (3D printed) and conventional fabrication techniques: a randomized clinical study. J Arab Soc Med Res 2022;17(1):46–51. DOI: 10.4103/jasmr.jasmr_7_22
20. Emera RMK, Shady M, Alnajih MA. Comparison of retention and denture base adaptation between conventional and 3D-printed complete dentures. J Dent Res Dent Clin Dent Prospects 2022;16(3):179–185. DOI: 10.34172/joddd.2022.030
21. Faty MA, Sabet ME, Thabet YG. A comparison of denture base retention and adaptation between CAD-CAM and conventional fabrication techniques. Int J Prosthodont 2022. DOI: 10.11607/ijp.7193