

THE EFFECT OF USING DIFFERENT TECHNIQUES FOR FABRICATION OF TELESCOPIC COPINGS IN IMPLANT ASSISTED OVERDENTURE

Ahmed Amr Abd El-Moez Abu Sabaa*^{ID}, Abdelrahman Elsaid Abdraboh**^{ID}
and Hesham Samy Borg***^{ID}

ABSTRACT

Aim: This clinical study aimed to compare the effect of using two different techniques in fabrication of copings in telescopic overdenture retained by two dental implants in the anterior mandibular region on patient satisfaction and overdenture retention in a follow up period of one year. The secondary metal copings are either free hand casted or 3D printed.

Materials and Methods: In this clinical study, 20 patients who were treated with maxillary complete denture and mandibular overdentures retained by two implants over one year follow up period and met the inclusion criteria of the study. Each patient was asked to fill out a questionnaire to evaluate the general satisfaction with the implant assisted overdenture and force gauge was used to evaluate overdenture retention. Data were analyzed by SPSS software.

Results: Evaluation of overall patient satisfaction with overdenture revealed that, there was no significant difference between the two groups. Within each group, there was a significant difference in patients` satisfaction during all follow up periods. Regarding overdenture retention, there was no significant difference between both groups during follow up periods. However, within each group, there was a significant difference between all follow up periods except between baseline and 1 year in 3d printed group.

Conclusion: No significant difference between free hand and indirect 3d printing techniques. Future studies should be considered with larger sample size, different techniques and materials.

KEYWORDS : Implant overdenture, telescopic attachment, 3d printing, retention, patient satisfaction

* Lecturer, Prosthodontic Department, Faculty of Oral and Dental Medicine, Al-Salam University, Egypt

** Lecurer, Department of Removable Prosthodontics, Faculty of Dentistry, Beni Suef University, Beni Suef, Egypt

*** Assistant Professor, Prosthodontic Department, Faculty of Oral and Dental Medicine, Al-Salam University, Egypt

INTRODUCTION

Complete denture is considered the standard of care for edentulous patients. However, there are some well-known issues with such prosthesis². Mandibular denture has a major issue by its lack of stability and retention, as residual ridge continues to resorb over time the previously stable dentures may start to fit improperly¹. More than 50% of people with mandibular complete dentures may experience problems in stability and retention¹.

Patients complain of pain when eating and chewing, worrying that the denture will move during eating, speaking, or laughing, and have concern about how wearing dentures would affect their social interaction³. Patients usually complain that they had to modify their diet into soft less fibrous food because they were not able to bite or chew properly with their dentures because of lack of stability. These situations are very embarrassing and lower patients' self-esteem⁴.

Implant overdentures (IOD) offer the solution for such problems, they provided better retention and stability as well as enhanced chewing ability⁵. Also less visible movement of the denture significantly increased Patients' satisfaction with aesthetics as well as their confidence during speaking³. The use of dental implants to support the mandibular overdentures reduces the amount of bone resorption and provided long-term success rates⁶.

Many studies reported using two implants to support mandibular overdenture should be considered the first choice of treatment for edentulous patients^{7, 11}. Telescopic attachments are one of the most interesting and distinctive types of attachments used with implant overdentures, they provide the chance to install less number of implants with better aesthetic results and more freedom during implant placement⁸⁻¹⁰. In addition they allow more access for oral hygiene procedures. Their design provides better horizontal stability because of their parallel walls, less torque, and better load distribution on abutments⁵.

Telescopic attachments are composed of primary (inner) and secondary (outer) copings, these copings are fabricated by many ways, among the recent ways is using 3D printing technology in manufacturing of the outer coping. 3D printing is used for the fabrication of metal structures either indirectly by printing in resins or waxes for a lost-wax process, or directly in metals or metal alloys¹². From these alloys, Cobalt-chromium (CoCr) showed remarkable results for using in telescopic attachment for its precise fitting, high modulus of elasticity, mechanical strength, less weight compared to gold alloys, resistance to corrosion and high biocompatibility¹³.

Denture retention is the ability of the prosthesis to resist vertical (axial) displacing forces,

Retention of overdentures is of high importance clinically as it determines patients' satisfaction. Overall, patients are more satisfied with implant retained prostheses than with conventional complete dentures¹⁴.

MATERIALS AND METHODS

This clinical study was approved by the research ethics committee, faculty of oral and dental medicine, Al-Salam University, Egypt according to their guide lines which follows the principles laid down by the Declaration of Helsinki (World Medical Assembly, Helsinki, Finland).

Patient selection:

Patients selected in this study were completely edentulous who were rehabilitated by maxillary complete dentures and mandibular implant assisted telescopic overdentures. Those patients were selected for recall in prosthetic department, faculty of oral and dental medicine, Al-salam University on bases of commitment to regular follow up schedule, oral hygiene assessment at least one year since the overdenture delivery.

Patients selected had followed the following criteria: a) having maxillary complete denture with proper fitting and service. b) Mandibular implant assisted telescopic overdenture with two implants placed anteriorly in the canine lateral incisor area. c) Age range 45 – 65 years. d) Gender specification was not considered. e) Good general health with no history of heavy smoking or uncontrolled DM (Diabetes Mellitus). f) Acceptable oral hygiene and maintenance with no history of periodontal diseases. Patients came for follow up at least one time 6 months following delivery of the overdentures for evaluation of retention and patient satisfaction.

Sample size in this study was calculated based on the power analysis from the findings of a previous study¹⁵. Twenty patients were selected for this study and they were divided according to the technique of telescopic attachment fabrication into:

- a. **Group A:** Telescopic attachment secondary copings were made of Co-Cr by free hand technique.
- b. **Group B:** Telescopic attachment secondary coping were made of Co-Cr by 3D printing technique.

For both groups, the readymade Titanium abutments were considered the primary coping of the telescopic attachment. However some modifications were made in the lab during overdenture construction where, milling machine were used to ensure that all abutments has the 6° taper as well as 0.3mm occlusal space and 0.03 mm axial space were created between the two coping to allow somewhat of lateral movements^{9,28}. Fig. (1)

The secondary coping were made in group A by the conventional hand free technique, where wax patterns for the secondary copings were made on the previously milled abutment then casted into Co-Cr alloy⁹. While in group B copings were fabricated by indirect 3d printing technique, where primary milled copings was scanned using optical dental

laboratory scanner then 3d printed in castable resin which in turn casted into Co-Cr alloy²⁹. Fig. (2)



Fig. (1) Primary copings of telescopic attachments.



Fig. (2) Mandibular telescopic Overdenture

Evaluation of the implant assisted overdenture (IAOD):

This evaluation was carried out within the follow up period of patients 6 months and 1 year following IAODs delivery through:

a) Evaluation of IAOD retention:

Force gauge (Dillon GL digital Force Gauge Dillon® China) was used to measure mandibular IAOD retention by vertically pulling the denture from its geometric center. For measurement each overdenture had been prepared as follows.

The centers of areas covering the retromolar pads and the midline were marked on the polished surface of the denture. A triangle was formed by connecting these marks, center of which is considered the geometric center of IAOD. After placing the overdenture on a duplicate cast, three 18-gauge orthodontic wire loops were attached to lingual aspect of the denture, one at its midline and two posteriors at line, using self-cure acrylic resin. Three metallic wires were used to be joining in the center of the denture from which a loop was formed to be engaged by the hook of the force gauge³⁰.

Retention measurement was made while patients were sitting in an upright position and their heads supported by the head rest in order to keep their mandibular occlusal plane parallel to the floor. Upward pull was made while patient is in this position until denture dislodgement occurs. The force needed for vertical dislodgment was recorded in Newton, measurement was made three times and average was taken. Fig.3



Fig. (3) Measurement of retention by force gauge

b) Patient satisfaction:

Patients' satisfaction to overdenture was evaluated by allowing patient to answer a questionnaire in

Arabic language designed for Implant overdentures in order to evaluate their overall satisfaction about the prostheses. Patients were left by themselves after they took the questionnaires and they were informed to call the investigator after finishing them.

The questionnaire consisted of seven questions:

1. Question 1: How many times do you take out your prosthesis because of discomfort?
2. Question 2: How satisfied are you with your maxillary denture?
3. Question 3: How satisfied are you with your mandibular denture?
4. Question 4: How satisfied are you in general with your dentures?
5. Question 5: How satisfied are you with the functional comfort of your denture?
6. Question 6: How satisfied are you about eating with your denture?
7. Question 7: How satisfied are you about speaking with your denture?

Statistical analysis and data interpretation:

Data analysis was performed by SPSS software, version 26 (SPSS Inc., PASW statistics for windows version 26. Chicago: SPSS Inc.). Qualitative data were described using number and percent. Quantitative data were described using median (minimum and maximum) for non-normally distributed data and mean \pm Standard deviation for normally distributed data after testing normality using Shapiro Wilk test. Significance of the obtained results was judged at the (≤ 0.05) level.

- Kruskal Wallis test was used to compare between 2 studied groups for non-normally distributed data.
- Friedman test was used to compare between more than 2 studied periods.
- One Way ANOVA test was used to compare 2 independent groups for normally distributed data.
- Repeated Measures ANOVA test was used to compare 2 paired readings distributed data.

RESULTS

In this clinical study, 20 patients of age (45-65) were divided in to two groups; 3d printed and free hand technique for the fabrication of the secondary telescopic coping. After analyzing data of patients` satisfaction and overdture retention the following was found:

Regarding patients' satisfaction;

Comparing the two groups at each follow up appointment reveals that there were significant differences (p<0.001) between the two groups only in

term of general satisfaction with the overdture af- ter 1 year and in term of satisfaction in eating with overdture after 6 months. However, when using Friedman test to compare between different periods in the same group there was a significant difference (p<0.001) between data of all follow up periods in both groups except in P2 (difference between base- line and 1 year follow up) in some terms as shown in table 1. 3d printed group showed no significant difference in P2 (difference between baseline and 1 year follow up) in terms of all questions except question about the prosthesis discomfort

TABLE (1) Comparison of Overall denture satisfaction VAS (Visual Analogue Scale) between studied groups and during follow up.

Overall denture satisfaction VAS (Visual Analogue Scale)		3d printed n=10	Free hand n=10	P value#
How many times do you take out your prosthesis because of discomfort?	Baseline	8(5-12)	4(2-10)	0.119
	After 6 months	2(1-6)	0(0-5)	0.165
	After 1 year	3(1-7)	2(0-5)	0.218
Friedman test		p=0.001*	p=0.001*	
Within follow up significance		P1=0.005*	P1=0.007*	
		P2=0.005*	P2=0.009*	
		P3=0.005*	P3=0.01*	
How satisfied are you with your maxillary denture?	Baseline	5(5-6)	6(5-7)	0.240
	After 6 months	7(6-8)	7(6-9)	0.415
	After 1 year	5(5-7)	6(5-8)	0.09
Friedman test		p<0.001*	p<0.001*	
Within follow up significance		P1=0.004*	P1=0.004*	
		P2=1.0	P2=0.096	
		P3=0.003*	P3=0.002*	
How satisfied are you with your mandibular denture?	Baseline	5(4-6)	6(4-6)	0.194
	After 6 months	7(6-9)	8(6-9)	0.434
	After 1 year	6(5-7)	6(4-8)	0.935
Friedman test		p<0.001*	p<0.001*	
Within follow up significance		P1=0.01*	P1=0.005*	
		P2=0.132	P2=0.238	
		P3=0.003*	P3=0.003*	

Overall denture satisfaction VAS (Visual Analogue Scale)		3d printed n=10	Free hand n=10	P value#
How satisfied are you in general with your dentures?	Baseline	5(4-6)	5(4-6)	1.0
	After 6 months	7(6-8)	8(6-9)	0.206
	After 1 year	5(4-7)	7(4-7)	0.026*
Friedman test		p<0.001*	p<0.001*	
Within follow up significance		P1=0.005* P2=0.366 P3=0.003*	P1=0.004* P2=0.014* P3=0.004*	
How satisfied are you with the functional comfort of your denture?	Baseline	5(4-6)	5(4-6)	0.510
	After 6 months	7(5-9)	8(7-8)	0.341
	After 1 year	6(4-7)	6(5-7)	0.240
Friedman test		p<0.001*	p<0.001*	
Within follow up significance		P1=0.014* P2=0.357 P3=0.002*	P1=0.004* P2=0.01* P3=0.003*	
How satisfied are you about eating with your denture?	Baseline	5(4-6)	5(5-6)	0.453
	After 6 months	7(5-9)	8(7-9)	0.039*
	After 1 year	5(4-7)	6(4-8)	0.246
Friedman test		p<0.001*	p<0.001*	
Within follow up significance		P1=0.017* P2=0.163 P3=0.004*	P1=0.005* P2=0.04* P3=0.003*	
How satisfied are you about speaking with your denture?	Baseline	5(4-6)	6(5-7)	0.145
	After 6 months	7(6-10)	9(6-10)	0.639
	After 1 year	6(4-8)	7(5-8)	0.112
Friedman test		p<0.001*	p<0.001*	
Within follow up significance		P1=0.005* P2=0.191 P3=0.002*	P1=0.005* P2=0.028* P3=0.003*	

#Mann Whitney U test, *statistically significant

P1: difference between baseline and after 6 months follow up,

P2: difference between baseline and after 1 year,

P3: difference between 6months and 1 year follow up

Table 2 and fig. 4 Show the comparison between the two groups in total satisfaction by one way ANOVA during follow up periods. Free hand technique had better overall patients` satisfaction to overdenture at 6 months 48.20±4.18 and 1 year 39.30±4.34 and almost the same at baseline 38.20±1.23 freehand and 38.60±2.01 3d printed.

However, no significant difference between both groups during all follow up periods. Within each groups, significant difference (p<0.001) was found during all follow up periods.

Patient satisfaction increased significantly between baseline and 6 months, then decreased significantly between 6 months and 1 year.

TABLE (2) Comparison of total satisfaction between studied groups and during follow up.

		3D printed n=10	Free hand n=10	P value#
Total satisfaction	Baseline mean ±SD	38.60±2.01	38.20±1.23	0.598
	After 6 months	45.40±5.19	48.20±4.18	0.201
	After 1 year	36.20±3.68	39.30±4.34	0.102
	P value ##	p<0.001*	p<0.001*	
	P1=	0.001*	0.001*	
	P2=	0.001*	0.001*	
	P3=	0.001*	0.001*	
% of change between baseline & after 6 months follow up		17.6%	26.2%	0.357**
% of change between 6 months & 1 year follow up		20.3%	18.5%	0.758**

#Student t test, ##Repeated Measures ANOVA test ** z test for 2 independent proportions * statistically significant

P1: difference between baseline and after 6 months follow up, P2: difference between baseline and after 1 year, P3: difference between 6months and 1 year follow up

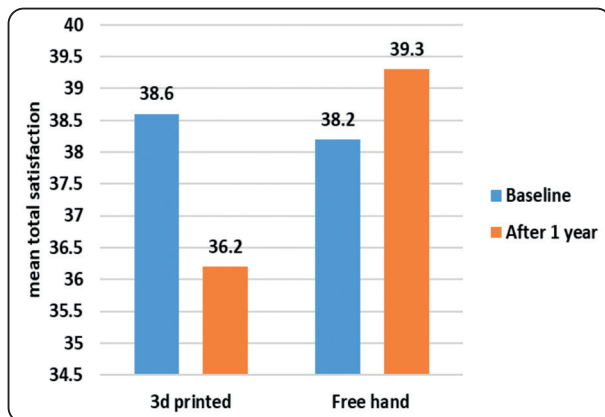


Fig (4) Mean total satisfaction values of study groups at baseline and after 1 year.

Regarding overdenture retention:

Evaluation of overdenture retention by force gauge revealed that, Free hand group recorded better mean overdenture retention at 6 months 53.19±10.22 and 1 year 47.64±9.77 and almost the same as 3d printed at baseline 41.15±7.19. Comparing the two groups using one way ANOVA at different follow up periods revealed that there were no significant difference between the two groups at all follow up appointments. However with in each groups

TABLE (3) Comparison of retention between studied groups and during follow up.

Retention	3d printed n=10	Free hand n=10	P value#
Baseline mean \pm SD	41.15 \pm 9.07	41.15 \pm 7.19	0.999
After 6 months mean \pm SD	51.63 \pm 14.24	53.19 \pm 10.22	0.783
After 1 year mean \pm SD	46.41 \pm 15.09	47.64 \pm 9.77	0.831
P value ##	<0.001*	<0.001*	
P1=	<0.001*	<0.001*	
P2=	0.052	<0.001*	
P3=	<0.001*	<0.001*	
% of change between baseline & after 6 months follow up	25.5%	29.3%	0.785**
% of change between 6 months & 1 year follow up	10.1%	10.4%	0.899**

#Student t test, ## Repeated Measures ANOVA test ** z test for 2 independent proportions * statistically significant

P1: difference between baseline and after 6 months follow up, P2: difference between baseline and after 1 year,

P3: difference between 6months and 1 year follow up

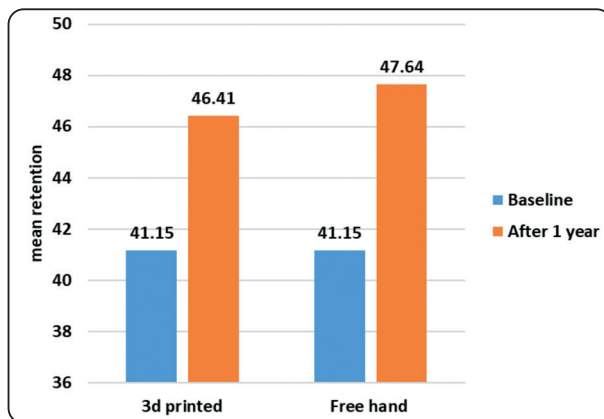


Fig (5) Mean retention values of study groups at baseline and after 1 year.

repeated measures ANOVA revealed that there was a significant difference ($p < 0.001$) during all follow up periods except in the period between baseline and after 1 year in the 3d printed group as shows in table 3 and fig.5

Retention increased significantly between baseline and 6 months, then decreased significantly between 6 months and 1 year in each group.

DISCUSSION

In this clinical study an attempt was made to evaluate the effect of changing the technique of telescopic coping fabrication on the overdenture retention and patient satisfaction. For each group ten patients were selected based on the power analysis of previous study of mandibular overdenture retained by telescopic attachment¹⁵. Selected patients were not heavy smokers or having history of periodontal diseases to avoid the risk of implant failure¹⁶. Diabetic patients were followed up regularly by encouraging them to keep HbA1c value under 7% to avoid hazardous effect of uncontrolled DM on bone metabolism¹⁷.

Mandibular implant overdentures were assisted by two implants in the canine-lateral incisor area opposed by maxillary complete denture as it was mentioned in many studies that it significantly improves the patients` quality of life²¹. Anterior position of the implants had a mechanical advantage of decreasing the seesaw effect that may be increased by placement of the two implants bilaterally in the premolar region²².

Telescopic attachment was used as retaining device for mandibular overdenture as it provides high level of patient satisfaction as well maintaining peri-implant tissue health^{8,18}. The two techniques for fabrication of secondary copings used in this study were, free hand techniques which is the long time used technique and 3d printing which was reported to result in better retention and higher patient satisfaction¹⁹. Co- Cr alloy was selected as the material of choice of the secondary coping as it has high modulus of elasticity, mechanical strength, lower weight, high biocompatibility and corrosion resistance²⁰.

Ensuring that all prefabricated abutment has the same 6° taper angle was a must to ensure that they provide the same amount of retention within the acceptable rang 4-8° as reported in the literature²³. Resilient design of telescopic attachment allow more freedom in vertical and rotational movements between copings lowering peri-implant stresses²⁴.

Although there was no significant difference between the two groups at follow up periods, Free hand technique had better overall patients` satisfaction to overdenture at 6 months and 1 year. This is mostly due to the complexity of the workflow and several steps and procedures of indirect 3d printing which might negatively affected the final copings` accuracy.¹²

Within each group, Patient satisfaction increased significantly between baseline and 6 months during all follow up periods, this is because of increased stability and retention. This finding coincides with a study that stated there was significant improvement in satisfaction with speaking, esthetics, comfort and the stability of the overdentures; these results are also consistent with another study that reported decreased difficulty in doing daily activities as smiling, speaking, and eating after using of implant-retained overdenture.²⁵

However, patient satisfaction decreased significantly between 6 months and 1 year. This mostly happened as a result of the decreased

retention. This is in line with Ramadan et al who concluded that the retentive force values for implant-retained telescopic overdentures significantly decreased after the simulation of 1 year of overdenture use⁵.

Retention increased significantly between baseline and 6 months, then decreased significantly between 6 months and 1 year in each group. This is due to the difference in hardness between the primary Ti coping material and the secondary Co-Cr coping material so wear for the secondary copings by the smooth primary copings happens slowly.²⁵ Also this is mostly attributed to the contact surfaces between the walls which shown to be enough for making friction points which with time, shifted from friction points into friction surfaces, requiring a greater force to separate copings.²⁶

After 6 months, the retention decreased significantly, this is mostly because wear happened between the two copings, even if minor, since they have different materials with different hardness values.⁵ Another point may be due to the resorption of bone in the posterior residual ridge and the need of relining to overcome the loss of overdenture fit posteriorly²⁷.

CONCLUSION

Within the limitations of this study, it can be concluded that,

- There is no significant difference between indirect 3d printing and free hand techniques for fabrication of secondary coping of telescopic attachment.
- Indirect 3d printing did not provide a valuable alternative to conventional free hand technique because of increased cost and complex workflow.
- Future studies should be considered with larger sample size, different techniques and materials of construction.

REFERENCES

- Hyland R, Ellis J, Thomason M, El-Feky A, Moynihan P. A qualitative study on patient perspectives of how conventional and implant-supported dentures affect eating. *J Dent*. 2009 Sep;37(9):718-23. doi: 10.1016/j.jdent.2009.05.028. Epub 2009 Jun 7. PMID: 19559515.
- Soboleva U, Rogovska I. Edentulous Patient Satisfaction with Conventional Complete Dentures. *Medicina (Kaunas)*. 2022 Feb 24;58(3):344. doi: 10.3390/medicina58030344. PMID: 35334520; PMCID: PMC8953744.
- Fueki K, Kimoto K, Ogawa T, Garrett NR. Effect of implant-supported or retained dentures on masticatory performance: a systematic review. *J Prosthet Dent*. 2007 Dec;98(6):470-7. doi: 10.1016/S0022-3913(07)60147-4. PMID: 18061741.
- Moynihan P, Varghese R. Impact of Wearing Dentures on Dietary Intake, Nutritional Status, and Eating: A Systematic Review. *JDR Clin Trans Res*. 2022 Oct;7(4):334-351. doi: 10.1177/23800844211026608. Epub 2021 Jul 2. PMID:34210202.
- Ramadan R, Elsherbeeney Y, Thabet Y, Kandil B, Ghali R. Retention of a telescopic overdenture on customized abutments after the simulation of 1 year in function. *Dent Med Probl*. 2021 Apr-Jun;58(2):201-206. doi: 10.17219/dmp/127963. PMID: 33915039.
- Al-Harbi FA. Mandibular Implant-supported Overdentures: Prosthetic Overview. *Saudi J Med Med Sci*. 2018 Jan-Apr;6(1):2-7. doi: 10.4103/sjmmms.sjmmms_101_17. Epub 2017 Dec 14. PMID: 30787808; PMCID: PMC6196685.
- Thomason JM, Feine J, Exley C, Moynihan P, Müller F, Naert I, Ellis JS, Barclay C, Butterworth C, Scott B, Lynch C, Stewardson D, Smith P, Welfare R, Hyde P, McAndrew R, Fenlon M, Barclay S, Barker D. Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients--the York Consensus Statement. *Br Dent J*. 2009 Aug 22;207(4):185-6. doi: 10.1038/sj.bdj.2009.728. PMID: 19696851.
- Sutariya PV, Shah HM, Patel SD, Upadhyay HH, Pathan MR, Shah RP. Mandibular implant-supported overdenture: A systematic review and meta-analysis for optimum selection of attachment system. *J Indian Prosthodont Soc*. 2021 Oct-Dec;21(4):319-327. doi: 10.4103/jips.jips_158_21. PMID: 34810359; PMCID: PMC8617439.
- ELsyad MA, Agha NN, Habib AA. Retention and Stability of Implant-Retained Mandibular Overdentures Using Different Types of Resilient Attachments: An In Vitro Study. *Int J Oral Maxillofac Implants*. 2016 Sep-Oct;31(5):1040-8. doi: 10.11607/jomi.4544. PMID: 27632258.
- ELsyad MA, Soliman TA, Khalifa AK. Retention and Stability of Rigid Telescopic and Milled Bar Attachments for Implant-Supported Maxillary Overdentures: An In Vitro Study. *Int J Oral Maxillofac Implants*. 2018 September/October;33(5):e127-e133. doi: 10.11607/jomi.6223. Epub 2018 Jun 12. PMID: 29894548
- Al-Magaleh WR, Swelem AA, Radi IAW. The effect of 2 versus 4 implants on implant stability in mandibular overdentures: A randomized controlled trial. *J Prosthet Dent*. 2017 Dec;118(6):725-731. doi: 10.1016/j.prosdent.2016.12.008. Epub 2017 Apr 4. PMID: 28389025.
- Dawood A, Marti Marti B, Sauret-Jackson V, Darwood A. 3D printing in dentistry. *Br Dent J*. 2015 Dec;219(11):521-9. doi: 10.1038/sj.bdj.2015.914. Erratum in: *Br Dent J*. 2016 Jan 22;220(2):86. doi: 10.1038/sj.bdj.2016.50. PMID: 26657435.
- Stock V, Schmidlin PR, Merk S, Wagner C, Roos M, Eichberger M, Stawarczyk B. PEEK Primary Crowns with Cobalt-Chromium, Zirconia and Galvanic Secondary Crowns with Different Tapers--A Comparison of Retention Forces. *Materials (Basel)*. 2016 Mar 10;9(3):187. doi: 10.3390/ma9030187. PMID: 28773311; PMCID: PMC5456689.
- Bayer S, Komor N, Kramer A, Albrecht D, Mericske-Stern R, Enkling N. Retention force of plastic clips on implant bars: a randomized controlled trial. *Clin Oral Implants Res*. 2012 Dec;23(12):1377-84. doi: 10.1111/j.1600-0501.2011.02312.x. Epub 2011 Nov 8. PMID: 22092547.
- Yunus N, Saub R, Bai Taiyeb Ali T, Mohd Salleh N, Rustum Baig MJIIJoO, Implants M. Patient-Based and Clinical Outcomes of Implant Telescopic Attachment--Retained Mandibular Overdentures: A 1-Year Longitudinal Prospective Study. 2014;29(5).
- Polymeri A, Loos BG, Aronovich S, Steigmann L, Inglehart MR. Risk factors, diagnosis, and treatment of peri-implantitis: A cross-cultural comparison of U.S. and European periodontists' considerations. *J Periodontol*. 2022 Apr;93(4):481-492. doi: 10.1002/JPER.21-0010. Epub 2021 Oct 19. PMID: 34390497; PMCID: PMC10138758.
- De Angelis P, Rella E, Manicone PF, De Rosa G, Gallottini S, Liguori MG, Papi P, Desantis V, Passarelli PC, D'Addona A. The Effect of Diabetes and Hyperglycemia on Horizontal Guided Bone Regeneration: A Clinical

- cal Prospective Analysis. *Healthcare (Basel)*. 2023 Jun 19;11(12):1801. doi: 10.3390/healthcare11121801. PMID: 37372917; PMCID: PMC10326814.
18. Ali S, El takawy D. Four Implant Supported Mandibular Overdentures With Rigid Telescopic Attachments. A Study of Circumferential Bone Resorption Using Cone Beam Computerized Tomography. *Egy Dent J*. 2020 Apr;66:1363-72 doi:10.21608/EDJ.2020.26166.1077
19. Tian Y, Chen C, Xu X, Wang J, Hou X, Li K, Lu X, Shi H, Lee ES, Jiang HB. A Review of 3D Printing in Dentistry: Technologies, Affecting Factors, and Applications. *Scanning*. 2021 Jul 17; 2021:9950131. doi: 10.1155/2021/9950131. PMID: 34367410; PMCID: PMC8313360.
20. Papathanasiou I, Kamposiora P, Papavasiliou G, Ferrari M. The use of PEEK in digital prosthodontics: A narrative review. *BMC Oral Health*. 2020 Aug 2;20(1):217. doi: 10.1186/s12903-020-01202-7. PMID: 32741366; PMCID: PMC7398079.
21. Burns DR. Mandibular implant overdenture treatment: consensus and controversy. *J Prosthodont*. 2000 Mar; 9(1):37-46. doi: 10.1111/j.1532-849x.2000.00037.x. PMID: 11074027.
22. ELSyad MA, Maryod WH, Mostafa AZ. Effect of Implant Position on Clinical and Radiographic Outcomes of Locator-Retained Mandibular Overdentures: A 1-Year Prospective Study. *J Prosthodont*. 2019 Feb;28(2):e699-e704. doi: 10.1111/jopr.12780. Epub 2018 Mar 6. PMID: 29508498.
23. Kamel A, Badr A, Fekry G, Tsoi J. Parameters Affecting the Retention Force of CAD/CAM Telescopic Crowns: A Focused Review of In Vitro Studies. *J Clin Med*. 2021 Sep 27;10(19):4429. doi: 10.3390/jcm10194429. PMID: 34640446; PMCID: PMC8509650.
24. Hakkoum MA, Wazir GJTodj. Telescopic denture. 2018;12:246.
25. Heydecke G, Thomason JM, Lund JP, Feine JSJJoD. The impact of conventional and implant supported prostheses on social and sexual activities in edentulous adults: results from a randomized trial 2 months after treatment. 2005;33(8):649-57.
26. Mishra SK, Chowdhary RJJOB, Research C. Patient's oral health-related quality of life and satisfaction with implant supported overdentures-a systematic review. 2019;9(4):340-6.
27. Fischer CAI, Ghergic DL, Vranceanu DM, Ilas SA, Comaneanu RM, Baciu F, et al. Assessment of force retention between milled metallic and ceramic telescopic crowns with different taper angles used for oral rehabilitation. 2020;13(21):4814.
28. Heckmann SM, Schrott A, Graef F, Wichmann MG, Weber HP. Mandibular two-implant telescopic overdentures. *Clin Oral Implants Res*. 2004 Oct;15(5):560-9. doi: 10.1111/j.1600-0501.2004.01064.x. PMID: 15355398
29. Kutkut A, Bertoli E, Frazer R, Pinto-Sinai G, Fuentealba Hidalgo R, Studts J. A systematic review of studies comparing conventional complete denture and implant retained overdenture. *J Prosthodont Res*. 2018 Jan;62(1):1-9. doi: 10.1016/j.jpor.2017.06.004. Epub 2017 Jun 27. PMID: 28666845.
30. Fromentin O, Lassauzay C, Abi Nader S, Feine J, de Albuquerque Junior RF. Testing the retention of attachments for implant overdentures - validation of an original force measurement system. *J Oral Rehabil*. 2010 Jan;37(1):54-62. doi: 10.1111/j.1365-2842.2009.02020.x. Epub 2009 Nov 11. PMID: 19912482.