

COMPARING THE RETENTION OF THE BALL ATTACHMENT RETAINED MINI-IMPLANT MANDIBULAR OVER DENTURE USING DIFFERENT RETENTIVE MECHANISMS. A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Objectives: The purpose of this study was to compare the retention of different three retention mechanisms (metal housing with nylon cap, PEEK and retention sil) in ball attachment retained mini-implant mandibular over denture.

Methodology: A total of fifteen completely edentulous male patients were selected from outpatient clinic of the prosthodontics department. the patients were then randomly divided into three groups as five patients per group. Group I: overdentures retained by conventional metal housing and nylon caps, Group II: overdentures retained by silicone housing retention sil, Group III: overdentures retained by PEEK housing. All patients were scheduled for retention evaluation in a regular follow up visits at time of insertion, 3 months and 6months.

Results: The results revealed there was a statistical significance increase in retention values in Group III : overdentures retained with PEEK housing when compared to Group I and Group II and the least retention values were recorded in Group II: overdentures retained with silicone housing retention sil at throughout the whole follow up period, While the comparison between different intervals revealed insignificant difference in all groups as $P>0.05$ (retention insignificantly decreased in all groups) at all intervals.

Conclusion: Retention sil silicon housing is no longer reliable technique for retaining implant mandibular overdentures. While the PEEK housing provided the highest retention values when compare with the metal housing and silicon housing in ball attachment retained mini-implant mandibular over denture.

KEY WORDS: Mini -implants, PEEK housing, Metal housing and Nylon caps, Overdenture.

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INTRODUCTION

Although conventional dentures are an opportunity for reestablishing aesthetics and physiological functions but lack of retention, stability and masticatory efficiency that may contribute to the residual ridge resorption⁽¹⁻³⁾. All those problems may compromise the complete denture as line of treatment for completely edentulous patients and make most of those patients unsatisfied with their final prosthesis, especially in mandibular dentures due to discomfort and limited stability of the prosthesis.⁽⁴⁻⁶⁾

Several studies have evaluated the patient satisfaction with implant-retained mandibular overdentures and compared to their satisfaction levels with conventional complete dentures. Thus, there were finding advanced satisfaction scores related to the implant-retained overdentures higher than conventional complete denture by 36%.⁽⁷⁻⁹⁾

Number, length and diameter of the implants were detected by the quantity and quality of the available jaw bones.⁽¹⁰⁾ Overdentures were retained by conventional implants showed better long-term results but also there was some restrictions such as: reduced buccolingual dimensions that increase the difficulty of insertion of the implant without the need for bone-grafting procedures. Also, the existence of chronic systemic diseases that might stop the progressive surgeries as bone grafts and lateralization of the inferior alveolar nerve moreover the financial limitation may affect the whole prosthetic treatment plan.^(11,12)

Mini-implants were introduced and became extensively used for a single and multiple replacement for tooth fixed, orthodontic anchorage, bridge repair and removable prosthesis retention.^(13,14) Also, the development of the dental implantology science creates scientific advances in the mini-implant design that contains improvement of the implant thread patterns, shape and its surface treatments, which have significantly improved the implant primary stability and lead to quicker osseointegration.^(15,16) they became a significant solution for several different conditions and minimized the invasive surgi-

cal procedure. Also became less complex, time saving when compared to conventional implants with wide diameter and naturally have a rapider healing period.^(17,18)

Moreover, the flapless approach enhances a minimal surgical trauma as the post operative pain and swelling related to the soft tissue this will improve the post operative healing and primary stability^(19,20)

Mini-implants serve as a retentive aid for overdenture with a high rate of success and satisfactory prosthetic result that enhance their use in edentulous arches. Also, provide a less time-consuming, excellent aesthetic with a minimal invasive technique to rehabilitate the oral cavity.^(21,22)

Additionally, the soft liner was recommended by many researches to incorporate with implant-retained overdentures as they proved that these liners showed high wear resistance so it may preserve the attachment retentive force, also, the silicone resilient denture liner materials used to allow easy insertion and removal of prosthesis especially in new denture wearer.^(23,24)

Since PEEK provide advanced mechanical properties when compared to Nylon, this study aimed to replace the Nylon cap of the ball attachments in mini-implant retained overdenture by the PEEK and retention sil and detect the loss of retention over time in order to improve the long life of the retention when exposed to repetitive cycles of insertion and removal.⁽²⁵⁾

METHODOLOGY

A total of Fifteen completely edentulous male patients were recruited for this study from the department outpatient clinic, Cairo university, with an age ranged around 50-60 years. **The inclusion criteria were as follows;** All patients with completely edentulous mandibles opposed by maxillary full set natural dentition with normal skeletal maxillary-mandibular relationship (Angle class I), Patients should be free from any medical conditions that might affect the implant insertion

and/or osseointegration. In addition, **the exclusion criteria were as follows:** Smokers, uncontrolled diabetic patient and patients with endocrinal disorders affecting bone quantity and quality.

The bone quality and quantity were evaluated before starting the implants installation and the implant treatment plan was performed using the CBCT

Sample size calculation:

Sample size was calculated depending on a previous study ⁽²⁶⁾ as reference. According to this study, the minimally accepted sample size was 5 per group, when mean \pm standard deviation of group I was (6.24 ± 0.6) , mean \pm standard deviation of group II was (2.47 ± 0.45) , when the power was 80 % & type I error probability was 0.05. Total sample size increase to 5 to compensate 20 % drop out. G. Power version 3.1.9.7 was used in sample size calculation.

The fifteen patients were randomly categorized into three groups:

Group I: overdentures retained by conventional metal housing and nylon caps

Group II: overdentures retained by silicone housing retention sil.

Group III: overdentures retained by PEEK housing.

For all patients the maxillary arches were occlusally adjusted in order to eliminate any super eruption or mal posed tooth that might interfere with occlusion and stability of the mandibular overdenture.

Then, all patients were scheduled to receive an adequate conventional mandibular complete denture that was constructed and evaluated regarding the retention, stability and adequate occlusal relationship pre-surgically. Then, all finished lower dentures were duplicated for the patients and surgical templates were constructed and the holes were drilled at the chosen implant sites.

According to precise surgical and prosthetic considerations implants sites planning were performed as the implant placement anterior to the mental foramen by minimum of 5 mm, and also, minimum of 5 mm was left between the implants to allow enough space for the housings.

Surgical protocol:

The surgical template was settled over the mandibular ridge and tissue marking probe was inserted through these holes.

Flapless preparation technique for implant insertion was completed by using the surgical template in order to guide the drilling depth through the soft tissue and the bone. The depth equal to two third of the implant length using a profile drill with one-step single perforation with 1.3mm in diameter. Then, the implants were inserted perpendicular to the ridge bone and at the midway bucco-lingual until attainment the optimum depth.

Finally, the four implants were installed parallel to each other and ensure to be placed inter-foraminally. Subsequently, Primary stability of each implant was measured using a torque wrench to establish the primary stability was beyond 30N/cm.

The mandibular denture was accurately seated over the implants and relieved to permit full seating on the implants without any contact between the balls and the denture. Then, the follow up sessions were scheduled every two weeks for possible complains and adjustment.



Fig. (1) A total four mini-implant placed inter-foraminally

Post-operative instructions

Patients were instructed for oral hygiene measures in order to control the dental plaque and avoid the tissue inflammation using a twice per day mouth wash.

Chair-side Pick-up Using the Existing Denture for Both Groups

For all groups, A direct pick-up technique (chair-side) was performed. Areas corresponding to the ball abutments were noticeable and relieved to accommodate the housings without interfering between the denture and the housings.

For Group I: overdentures pickup with conventional metal housing and nylon caps

A small vent was created at the lingual flange to permit the excess pick up material to escape. Then, small rubber dam pieces were applied beneath the ball attachment to block out the undercuts. Then, the black processing cap was oriented over the ball attachment then metal housing was placed directly over it , small amount of permanent self-curing acrylic resin was added at the recesses opposed to the ball attachment.

Finally, the mandibular denture was seated inside patient mouth and the patient was instructed to bite gently in centric position until the material had set completely. After which the denture was removed the occlusion and fitting surface of the denture were assessed and finished by using the pressure indicating paste to remove and trim any excess of the self-cure acrylic resin.

For Group II: overdentures pickup with silicone housing retention sil

Minimum relief of the fitting surface of the denture was done to create a minimum wall thickness of 1mm of the silicone material around ball attachment. Then, suitable thick coat of multi sil primer (Bredent medical GmbH &Co. KG,

Germany) was applied to the prepared site and allowed to dry for 3 minutes before application of the thin coat of retention Sil 600 in the fitting surface of the denture. The setting time of silicone housing material is almost 20 min. Then, patients were informed to close gently in the centric occluding relation until complete polymerization of the material was done.

For Group III: overdentures retained with PEEK housing.

The implant ball attachments were scanned using a laboratory dental scanner (Lab scanner; 3shape). Then, the design was carried out on dental software (Dental System 2016; 3Shape) and the PEEK retentive elements and housings were performed to be adapted to ball attachment.

After the PEEK retentive housing were designed the standard tessellation language (STL) file was performed and transferred to the CAM software (Zenotec CAM; Wieland Dental). The PEEK discs (DD peek MED: Dental Direkt GmbH) were milled using 5 axis milling machine (Zenotec Select Hybrid; Wieland Dental). Then, pick up of the PEEK housings was carried out conventionally.

Evaluation of denture retention

Retention was measured by digital force meter. Which is able to measure both pulling positive values up to 20 kg. It consists of universal sensing head to which a hook was attached.

Geometric center of the lower denture was relatively predicted and two wrought wires were prepared, first one was bent at the center of the arch and extended by 2 cm above the occlusal plane between the retromolar pad grooves of both sides. The second wrought wire, was also adjusted to extend from the groove at the lingual flange above the occlusal plane by 2 cm and the other end was molded to form a c shaped loop around the first wire, both wires were 1 mm in diameter. **(Figure 3)**



Fig. (2) A. Overdentures pickup with conventional metal housing and nylon caps. B. Overdentures pickup with PEEK housing/



Fig. (3) The digital force meter for retention measurement

Then, lower denture was checked inside the patient's mouth to evaluate the tongue freedom, denture stability and loop position. And patients were seated in upright position in order to adjust the floor of the mouth parallel to the floor with adequate head support.

The wire hook at the lower denture was hanged to the force meter device through a bar and engaged to the rigid loop. Then, the displacing force was applied to the denture until the denture was dislodged from its setting position and retentive force was measured from the initial separation of the overdenture. Wires were repositioned to measure the retention by detecting fixed tripod points in the lingual surface of the denture at each follow up session (at time of insertion, after

three and six months after implant loading).

The procedure was repeated five times and the mean value of these readings were tabulated and analyzed.

After the lower denture was removed from the patient's mouth. The wires were removed and the grooves were filled with self-cured acrylic resin.

Statistical analysis

All data were presented as mean & standard deviation. Data were presented (Table 1) & (Figure 4). Statistical analysis was performed with SPSS 16® (Statistical Package for Scientific Studies), Graph pad prism & windows excel.

TABLE (1) Mean and standard deviation of retention in all groups at different intervals:

	Metal		Peek		Silicon		P value (One Way ANOVA)
	M	SD	M	SD	M	SD	
At insertion	29.36 ^{Aa}	5.1	40.2 ^{Ba}	6.5	11.23 ^{Ca}	3.3	<0.0001*
After 3 months	27.02 ^{Aa}	4.8	38.4 ^{Ba}	5.4	10.45 ^{Ca}	3	<0.0001*
After 6 months	25.98 ^{Aa}	4.1	36.9 ^{Ba}	5.2	8.89 ^{Ca}	2.8	<0.0001*
P value (Repetitive One Way ANOVA)	0.45		0.61		0.41		

*M: mean SD: standard deviation *Significant difference as $P < 0.05$.*

Means with the same superscript letter (uppercase per row/lower case per column) were insignificantly different as $P > 0.05$.

Means with different superscript letter (uppercase per row/lower case per column) were significantly different as $P < 0.05$.

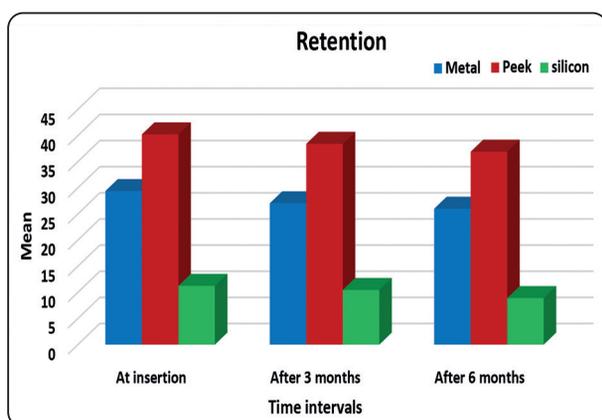


Fig. (4) Bar chart showing mean of retention in all groups at different intervals.

Exploration of the given data was achieved using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that the significant level (P-value) was insignificant at P-value > 0.05 which indicated that all data originated from normal distribution (parametric data) resembling normal Bell curve. Accordingly, comparison between different intervals was performed by using Repetitive One-Way ANOVA test followed by Tukey's Post Hoc test for multiple comparisons, while comparison between different groups was performed by using One Way ANOVA test followed by Tukey's Post Hoc test for multiple comparisons.

A. Effect of different materials

Comparison between different groups revealed significant difference between them at all intervals as $P < 0.05$ as:

- At insertion: PEEK group (40.2 ± 6.5) was significantly the highest, then metal (29.36 ± 5.1), while silicon was significantly the lowest (11.23 ± 3.3).
- After 3 months: PEEK group (38.4 ± 5.4) was significantly the highest, then metal (27.02 ± 4.8), while silicon was significantly the lowest (10.45 ± 3).
- After 6 months: PEEK group (36.9 ± 5.2) was significantly the highest, then metal (25.98 ± 4.1), while silicon was significantly the lowest (8.89 ± 2.8). Figure (4)

B. Effect of time (Lower case letters):

Comparison between different intervals revealed insignificant difference in all groups as $P > 0.05$ (retention insignificantly decreased in all groups) as all intervals have letter (a).

DISCUSSION

Deficiency of retention and stability in conventional denture wear is the main problem facing the edentulous patients especially with compromised alveolar ridge. For this cause the osseointegrated implants below the denture that improve this common problem specifically in mandibular ridge. So, using implant-retained overdenture was considered as an efficient treatment option.⁽²⁷⁾

Numerous factors such as bone quality, quality of the patient and patient's approval for surgery can affect the implant surgical technique to be used. Although conventional implant improved retention and stability but it needs a sufficient bone width and they not recommended to be place in thin wiry alveolar ridge unless ridge management was done.⁽²⁸⁾

Regarding the methodology of this study, the flapless approach not only provides superior advantage for the patient as it diminishes the trauma during the surgery and post operative complications but also provide gap free connection with best mucosal barrier that is free from bacterial accumulation that may attribute to protect the soft tissue and allow creation of a tissue collar overlapping the bone implant interface.^(17,18)

On the other hand, many studies reported that the flap reflection and suturing in conventional procedure may increase probing depth and increase soft tissue post operative complications that may affect the retention and stability of the prosthesis and lowering the overall patient satisfaction with the final prosthesis.^(6,11,29,30)

Moreover, the small rubber dam pieces were applied beneath the ball attachment to block out the undercuts that might prevent the removal of the denture during the direct pick up and also, to protect the soft tissue from the residual monomer.^(20,21)

Also, many investigations reported that the retentive values of the attachments were decreased

significantly after multiple pulls of the overdenture that may lead to increase wear of the attachment components and tearing of the nylon caps that may attribute to decrease the degree of retention and that required regular follow up and continuous maintenance for the retentive components of the attachment.⁽²⁹⁻³²⁾

On the other hand, the retentive qualities of the attachments should be relatively constant over a planned period of time due to most of the in-vitro study apply centric load only and ignore the eccentric load.⁽³³⁻³⁶⁾

Moreover, the silicon bases housing (Retention sil) was lately presented in prosthetic field and available in a pink color that improve esthetic with different degree of retention to accommodate the numerous patient's demands and improve denture retention.^(37,38)

Additionally, the main advantages of the silicon housing are the easily insertion and removal of the denture by old geriatric patients, allow minimal stress transfer to implants and not required for removing an excessive space from the fitting surface of the denture that may attribute to increase the availability of denture fracture.⁽³⁹⁾

The results of this study regarding the effect of the materials had shown that Group III: overdentures retained with PEEK housing was significantly the highest retention values followed by Group I: overdentures pickup with conventional metal housing and nylon caps while Group II: overdentures pickup with silicone housing retention sil was significantly the lowest retention values at all the intervals throughout the follow up period ,These results were in agreement with many studies which reported that the least amount of retention in a retention sil group that may attribute to reduced 66% loss of the retention due to incorporate of chemical solvent, saliva and air bubbles within the silicone housing by time.⁽⁴⁰⁻⁴²⁾

On the other hand, the result of this study was revealed that the highest retention values were recorded in PEEK housing group that may attribute to flexibility of the PEEK when compared to the nylon caps as the retention of the overdenture attachment depended primarily on the flexibility of the attachment system, although loss of retention of the PEEK housing as compared with nylon caps and retention sil groups is higher. This can be logically attribute to increase the friction and hence the wear of the caps over time.^(24,43)

While the result of this study regarding the effect of time was revealed insignificant difference in all groups (retention insignificantly decreased in all groups) after the whole period of the study which may recommend extending the follow up period.

REFERENCES

1. D.A. Felton, Complete edentulism and comorbid diseases: an update, *J. Prosthodont.* 2016; 25 : 5–20.
2. L.M. Seerig, G.G. Nascimento, M.A. Peres, B.L. Horta, F.F. Demarco, Tooth loss in adults and income: systematic review and meta-analysis, *J. Dent.* 2015; 43: 1051–1059.
3. M.C. Goiato, P. Ribeiro Pdo, A.R. Garcia, D.M. dos Santos, Complete denture masticatory efficiency: a literature review, *J. Calif. Dent. Assoc.* 2008; 36: 683–686.
4. Goodacre CJ. Implant overdentures: Their benefits for patients. *Saudi J Med Med Sci.* 2018;6(1):25-9.
5. Vi S, Pham D, Yian Y, Du M, Arora H. Mini-implant-retained overdentures for the rehabilitation of completely edentulous maxillae: A systematic review and meta-analysis. *Int J Environment Res Public Health.* 2021;18(8):4377-92.
6. Scarano A, Murmura G, Carinci F, Lauritano D. Immediately loaded small-diameter dental implants: Evaluation of retention, stability and comfort for the edentulous patient. *Eur J Inflamm.* 2012;10(1):19-23.
7. Thomason JM, Lund JP, Chegade A, Feine JS. Patient satisfaction with mandibular implant overdentures and conventional dentures 6 months after delivery. *J Prosthet Dent.* 2004;91(2):197.
8. Pan Y-H, Lin T-M, Liang C-H. Comparison of patient's satisfaction with implant-supported mandibular overdentures and complete dentures. *Biomed J.* 2014; 37:156-62.
9. Kucukkurt S, Tükel H. Does number of implants or type of attachment affect patient satisfaction with implant-retained mandibular overdentures? *J Osseointegration* 2020;12.
10. Mohammed S, Hamed H. Comparative study between conventional denture and bone expansion over denture in treatment of thin ridge. *Egypt Dent J.* 2012;2-8.
11. Zygogiannis K, Aartman I, Parsa A, Tahmaseb A, Wismeijer D. Implant mandibular overdentures retained by immediately loaded implants: A 1-year randomized trial comparing the clinical and radiographic outcomes between mini dental implants and standard-sized implants. *Int J Oral Maxillofac Implants.* 2017;32(6):1377-88.
12. Abdoel S.F., Haagedoorn S.S., Raghoobar G.M. et al. Implant-supported mandibular overdentures: a retrospective case series study in a daily dental practice. *Int J Implant Dent.* 2021;7, 64.
13. Van Doorne, L.; De Kock, L.; De Moor, A.; Shtino, R.; Bronkhorst, E.; Meijer, G.; De Bruyn, H. Flapless placed 2.4-mm mini-implants for maxillary overdentures: A prospective multicenter clinical cohort study. *Int. J. Oral Maxillofacial. Surg.* 2020;49, 384–391.
14. Di Francesco, F.; De Marco, G.; Carnevale, U.A.G.; Lanza, M.; Lanza, A. The number of implants required to support a maxillary overdenture: A systematic review and meta-analysis. *J. Prosthodont. Res.* 2019; 63, 15–24.
15. Sohrabi K, Mushantat A, Esfandiari S, Feine J. How successful are small-diameter implants? A literature review. *Clin Oral Impl Res* 2012; 1:1-11.
16. Kabbua P, Aunmeungtong W, Khongkhunthian P. Computerized occlusal analysis of mini-dental implant-retained mandibular overdentures: A 1-year prospective clinical study. *J. Oral Rehabil.* 2020; 47, 757–765
17. Oh TJ, Shotwell J, Billy E, Byun HY and Wang HL. Flapless implant surgery in the esthetic region: advantages and precautions. *Int J Periodontics Restorative Dent* 2007; 27:27-33.
18. Van de Velde T, Glor F, De Bruyn H. A model study on flapless implant placement by clinicians with a different experience level in implant surgery. *Clin Oral Implants Res* 2008; 19: 66-72.
19. Aunmeungtong W, Kumchai T, Strietzel F.P., Reichart, P.A., Khongkhunthian, P. Comparative Clinical Study of Conventional Dental Implants and Mini Dental Implants for Mandibular Overdentures: A Randomized Clinical Trial. *Clin. Implant. Dent. Relat. Res.* 2017; 19, 328–340.

20. Lemos, C.A.A.; Verri, F.R.; Batista, V.E.D.S.; Júnior, J.F.S.; Mello, C.C.; Pellizzer, E.P. Complete overdentures retained by mini-implants: A systematic review. *J. Dent.* 2017, *57*, 4–13.
21. Abou-Ayash, S.; Enkling, N.; Srinivasan, M.; Haueter, M.; Worni, A.; Schimmel, M. Evolution of in vivo assessed retention forces in one-piece mini dental implant-retained mandibular overdentures: 5-Year follow-up of a prospective clinical trial. *Clin. Implants Dent. Relat. Res.* 2019; *21*, 968–976.
22. Van Doorne, L.; De Kock, L.; De Moor, A.; Shtino, R.; Bronkhorst, E.; Meijer, G.; De Bruyn, H. Flaplessly placed 2.4-mm mini-implants for maxillary overdentures: A prospective multicentre clinical cohort study. *Int. J. Oral Maxillofac. Surg.* 2020; *49*, 384–391.
23. Rashid H, Hanif A, Vohra F, Sheikh Z. Implant overdentures: A concise review of the factors influencing the choice of the attachment systems. *J Pak Dent Assoc.* 2015; *24*:63-9.
24. Schweyen R, Beuer F, Arnold C, Hey J. Retentive characteristics of a vinylpolysiloxane overdenture attachment system. *Clin Oral Invest.* 2015; *19*:947–53
25. Salah A, Ahmed M , Shawky O. Evaluating the influence of different soft liners retaining mini implant supported mandibular over denture on the marginal bone height. *EDJ.* 2019; *65*:1549-58.
26. Karam AA, Helalay OA, Alhaddad DF. Evaluation of retention of the mandibular implant supported over denture with two types of low-profile attachment. *Al-Azhar Journal of Dental Science.* 2023; *26*(1): 27:32
27. Zygogiannis K, Aartman I, Parsa A, Tahmaseb A, Wismeijer D. Implant mandibular overdentures retained by immediately loaded implants: A 1-year randomized trial comparing the clinical and radiographic outcomes between mini dental implants and standard-sized implants. *Int J Oral Maxillofac Implants.* 2017; *32*(6):1377-88.
28. Park JB. Ridge expansion with acellular dermal matrix and deproteinized bovine bone: A case report. *Implant Dent.* 2007; *16*(3):246-51.
29. ELSyad MA, Denewar BA, Elsaih EA. Clinical and Radiographic Evaluation of Bar, Telescopic, and Locator Attachments for Implant-Stabilized Overdentures in Patients with Mandibular Atrophied Ridges: A Randomized Controlled Clinical Trial. *The International journal of oral & maxillofacial implants* 2018; *33*: 1103-1111.
30. Omran M, Abdelhamid A, Elkarargy A., Sallom M. Mini-Implant Overdenture Versus Conventional Implant Overdenture (A Radiographic and Clinical Assessments). 2013; *9*: 89-97.
31. Temizel S, Heinemann F, Dirk C, Bourauel C, Hasan I. Clinical and radiological investigations of mandibular overdentures supported by conventional or mini-dental implants: A 2-year prospective follow-up study. *J Prosthet Dent* 2017; *117*: 239-246 .
32. Emarah A A, Hamed M O, Aboulmagd I and Hassan S.S. Mini implants versus conventional diameter implants for 4- implant supported mandibular overdentures: One year randomized prospective clinical and radiographical study. *E.D.J.* 2022: *68* ;607-619.
33. E. Evtimovska, R. Masri, C. F. Driscoll, and E. Romberg, “The change in retentive values of locator attachments and hader clips over time,” *Journal of Prosthodontics*, vol. 2009 ;*18*(6): 479–483.
34. R. L. Ettinger and F. Qian, “Longitudinal assessment of denture maintenance needs in an overdenture population,” *Journal of Prosthodontics.* 2018; *28*(1) :22–29.
35. V. Rutkunas, H. Mizutani, and H. Takahashi, “Evaluation of stable retentive properties of overdenture attachments,” *Stomatologiia.* 2005; *7* :115–120.
36. M. Sharaf, E. Bakry, and M. Abdall, “A comparison of the retentive force of ball and socket attachment versus magnet attachment in mandibular overdentures: a randomized control trial,” *Journal of International Oral Health.* 2020; *12*(5): 420–426.
37. Ueda T, Kubo K, Saito T, Obata T, Wada T, Yanagisawa K, et al. Surface morphology of silicone soft relining material after mechanical and chemical cleaning. *J Prosthodont Res* 2018; *62*:422-25
38. Andreiotelli M, Att W, Strub JR. Prosthodontic complications with implant overdentures: a systematic literature review. *Int J Prosthodont.* 2010; *23*:195-3.
39. Evtimovska E, Masri R, Driscoll CF, Romberg E. The change in retentive values of locator attachments and hader clips over time. *J Prosthodont.* 2009; *18*:479-83.
40. Osman R and Abdelaal M. Comparative assessment of retentive characteristics of nylon cap versus retention. sil in ball-retained mandibular implant overdentures. A randomized clinical trial. *EDJ.* 2019; *65*:1787-94.

41. Schweyen RC, Arnold JM, Setz J H. Retention force of removable partial dentures with different double crowns. *Clin Oral Investing J.* 2019;21: 1641–49.
42. Rostom D A , Sheta NM. Evaluation of the Retention of Two Different Retention Mechanisms (Nylon Caps and Retention Sil) in Locators Retained Implant Mandibular Over-Denture. A Randomized Clinical Trial (Rct) ADJ-for Girls .2021; 8(1) :65-70.
43. Sharaf M. Y, Eskander A, and Afify M. Novel PEEK Retentive Elements versus Conventional Retentive Elements in Mandibular Overdentures: A Randomized Controlled Trial. *International Journal of Dentistry.* 2022, Article ID 6947756, 9 pages