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Original Article

Retention force of two different pickup strategies for Locator retained mandibular implant overdenture; an in-vitro study

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Abstract

Aim: This article evaluates the retention force of Locator metal housing attached to implant overdenture with two different pickup strategies.
Subjects and methods: Two dummy implants were inserted in the lower canine positions. The denture base was designed digitally with special parameters for both study groups (n = 5 each) with two different pickup strategies: without retaining material for the intervention group and with retaining material for the control group. Retention forces were tested by using the universal testing machine at 0, 135, 270, 405 and after 540 insertion/separation cycles respectively.
Results: The data was analyzed evaluating the effect of the time on the retention in each study group by using One-Way ANOVA test which revealed an insignificant difference between different intervals. To compare the two study groups with each other Independent t test was used which revealed insignificant difference between them in all intervals. Frequency and percentages analysis of detached and non-detached metal housings in both groups was performed by using Chi square test which also revealed insignificant difference between both groups.
Conclusion: Within the limitations of this study, the retention in both groups was nearly equivalent. Yet, by time, retention decreased in both study groups. This pickup technique may be a new application of digital dentistry reducing chair side corrections.

Keywords: Implant; Edentulism; Locator attachment; Overdenture pickup; Digital dentistry.

Introduction

Treatment of edentulous patients with implants has long been studied, from single implant overdentures to full arch fixed restorations (Gupta et al., 2019). Yet, in some situations, like limitations in the anatomical architecture, systemic condition of the patient or financial issues, increasing the number of implants may not be feasible. Limiting the restoration of the lower edentulous arch to two implants is still an acceptable treatment option as a standard of care (Lee and Saponaro, 2019).

Moreover, many attachment systems are present in the market to retain an implant retained overdenture. The choice of the attachment system depends on many factors like the jaw anatomy, antagonist arch status, available interarch space, amount of retention required, parallelism between implants and

finally cost. Among these attachments, the Locator system has recently gained popularity maybe due to its resiliency, self-aligning property, could be used in patients with limited interarch space, ease of placement and repair and can resolve/compensate problems for implant angulations up to 20 degrees (Alqutaibi et al., 2016; ELsyad, Elhaddad and Khirallah, 2018).

Traditionally, a pickup material is used to pick or attach the attachment system's metal housing into the prosthesis's fitting surface. Many dental materials were introduced in the literature to perform the pickup step before overdenture insertion. The perfect choice of adhesive or relining material depends mainly on ease of application and providing maximum durability in the intraoral environment. The conventionally used materials are under the category of resins, relining materials or adhesives. Although auto-polymerized acrylic resin denture relining material is the most commonly used pickup material, yet it is advisable to be chosen as a temporary solution owing to its low mechanical properties, the fact that leaching of monomers is inevitable which may cause irritation and burning sensations to the underlying mucosa, decreased color stability and poor bonding of the relining material to the denture base material (Zafar, 2020). On the other hand, heat-cured acrylic resin pickup material has been evidence-based to provide better mechanical and physical properties, increased longevity, show lower cytotoxic effects and provide better security of the attachment metal housing to the fitting surface of the denture base than auto-polymerized or visible light-cured acrylic resin (Dahl, Frangou-Polyzois and Polyzois, 2006; Nakhaei et al., 2020).

However, prosthetic or mechanical complications of implant retained overdentures may occur, which may increase the number of repairs and remakes, waste of chair-side time and financial resources, or even affect the patient's quality of life. One of the most common documented prosthetic complications associated with Locator attachment systems is the titanium housing debonding from the fitting surface of denture base resin over time. The process of reinserting the housing into the fitting surface of the denture may be costly and time-consuming and may affect the masticatory function and aesthetics of the patient until adequate clinical care is provided (ELsyad, Elhaddad and Khirallah, 2018; Irizarry, 2021; Sutariya et al., 2021).

Coping with the digital era, polymethylmethacrylate (PMMA) blocks were introduced, which have the same chemical chemistry of the heat-cured PMMA but are produced under pressure and are commercially pre-polymerized (Zafar, 2020). It was reported that complete dentures fabricated using computer-aided design/computer-aided manufacturing (CAD/CAM) technology provided simplified clinical and laboratory procedures, shortened the number of patient visits and established cost and time-effective protocols that would be favourable for edentulous patients (Goodacre et al., 2016; Lee and Saponaro, 2019).

Studies comparing milled dentures to conventional heat-cured acrylic resin reported that (CAD/CAM) PMMA showed superior properties in terms of hardness, ultimate strength, yield point, toughness, flexural strength, flexural modulus, more color stability and less microporosity. Moreover, CAD/CAM milled dentures could also be superior to rapidly prototyped ones in terms of strength allowing for thinner base designs, less surface roughness and increased trueness of the intaglio surface. Higher patient and clinician satisfaction in terms of aesthetic, retention and stability has also been reported with CAD/CAM milled dentures (Kalberer et al., 2019; Baba et al., 2021; Snosi et al., 2021).

So, the aim of this invitro study was to profiteer the advantages of digital technologies and mill overdentures to pick up the Locator metal housing without a retaining material and compare the retention force to conventional overdenture picked up using heat cure polymerized acrylic resin.

The null hypothesis is that there is no difference between the retention force of metal housing picked up without retaining material in milled overdentures compared to that picked up using heat cure polymerized acrylic resin.

Subjects and Methods

This in-vitro study was conducted in the Faculty of Dentistry, Cairo University, Prosthodontic Department. The study was divided into two groups; each group consisted of (n)=5 flangeless

denture bases. The first group was the intervention group in which a Locator metal housing was picked up in the fitting surface of a denture base without retaining material depending on the modification done to the prosthesis digital design on the software. The second group was the control group -comparator- in which a Locator attachment metal housing was picked up conventionally by using heat-cured acrylic resin material.

A reference model for odonatological practices was used for the assessment of both study groups. The osteotomies were drilled in the sites of the lower canines with the consideration of visual paralleling between both implants. The implant fixtures (NEOBIOTECH implant system, Korea) were screwed to the level with the model and the Locator attachments were inserted and screwed using the attachment driver.

The extraoral laboratory scanner (IDENTICO company, Kosovo) was calibrated and the study reference model with the Locator attachments (NEOBIOTECH implant system, Korea) and metal housing on their top was transferred into a digital file in the form of an STL file.

The geometric center was determined before designing the prosthetic part (Figure 1). ExoCAD dental designing software (VERSION 2.2 VALLETTA, made in the United States) was used to design the prosthetic part. The job order was chosen to design copings on the Locator metal housings position (canines' position). The design parameters were adjusted to be with intimate contact between abutment axial walls and the fitting surfaces of the coping (Figure 2). Surveying between the long axes of both metal housings and blocking out undesirable undercut was automatically performed by the software. On top of these copings, teeth with a flangeless base were waxed up in between copings and extended posteriorly to a line on the level of the geometric center. The last artificial teeth on both sides were connected by a bar and a rounded disc-shaped part was added to the bar on the midline; from which the pulling-out assessment would be done (Figure 3). The final design was exported again as an STL file.

This STL file was transferred to the CAM software and the prosthesis was imported to its proper position in the PMMA (YAMAHACHI DENTAL MFG company, Japan) and wax pucks (YAMAHACHI DENTAL MFG company, Japan) with sprues all around. Finally, the milling procedure was started according to the manufacturer's instructions. This milling procedure was repeated to mill 5 copies from PMMA pucks for the intervention study group and other 5 copies from wax pucks for the control study group (Figure 4). After the milling machine has finished its work, all prostheses were finished to be seated and checked for fit over the study reference model.

For the intervention group, the metal housings were seated in their positions with finger pressure. For the control group, the wax-milled copies of the prosthesis with the metal housing in their right positions were flasked in a conventional way by using heat-cured acrylic resin. After complete cooling and curing, the prostheses were extracted carefully from the surrounding dental stone and finished.

Finally, both study groups' samples were similar in design, final shape and color. The black processing caps were removed from all samples and replaced with blue ones (Figure 5). All samples were coded by alphabets randomly distributed between the intervention and control study group samples to be blinded to the outcome assessor (Figure 6). The key to this coding was known to the main investigator only.

The outcome assessment was measured by using a universal testing machine (INSTRON company, United States). The study reference model was fixed on the lower compartment of the machine. Each sample was placed in its proper position retained on the model by the Locator attachment assembly and attached to the upper compartment of the machine by a steel wire (Figure 7). Each sample was pulled out gradually till the detachment of the prosthesis from the study reference model occurred by one or both attachments (Figure 8). The first assessment was the baseline records for all samples for the two study groups. Then the assessment was repeated four times. Between each assessment, 135 cycles of manual removal and insertion were done - resembling a month and a half of clinical usage- with a total of 540 cycles. All these records were tabulated for statistical analysis.

Results

Statistical analysis was performed with SPSS 20, Graph Pad Prism and Microsoft Excel 2016.

The given quantitative data was extracted using the Shapiro-Wilk test and Kolmogorov-Smirnov test for normality, indicating that data originated from a normal distribution (parametric data) resembling normal Bell curve in both groups.

Comparison between both groups regarding the effect of retention by time was performed by using the Independent t test which revealed insignificant differences between both groups (Figure 9) (Table 1).

Regarding the evaluation of the denture bases detachment, the intervention group showed that 20% of the denture bases (Table 2) which equals 10% of the metal housings were detached. While in the control group no detachment occurred. Comparison between both groups was performed by using Chi square test which revealed that insignificant difference between both study groups.

The intervention group samples showed that they can withstand 492 cycles while the control group, samples showed that they can withstand 550 cycles.

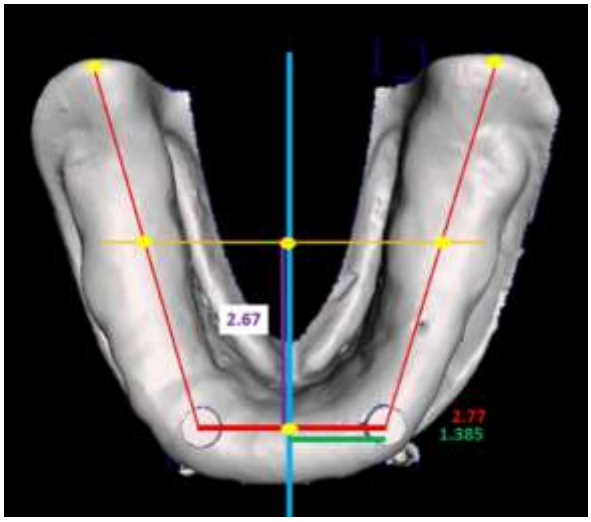

Figure 1: "Geometric center calculation steps": the heavy red line is the first line; the blue line is the second line and the orange line is the third line.

Figure 2: "Designing software setting": zero gap distance between the Locator metal housing and the fitting surface of the prosthesis.

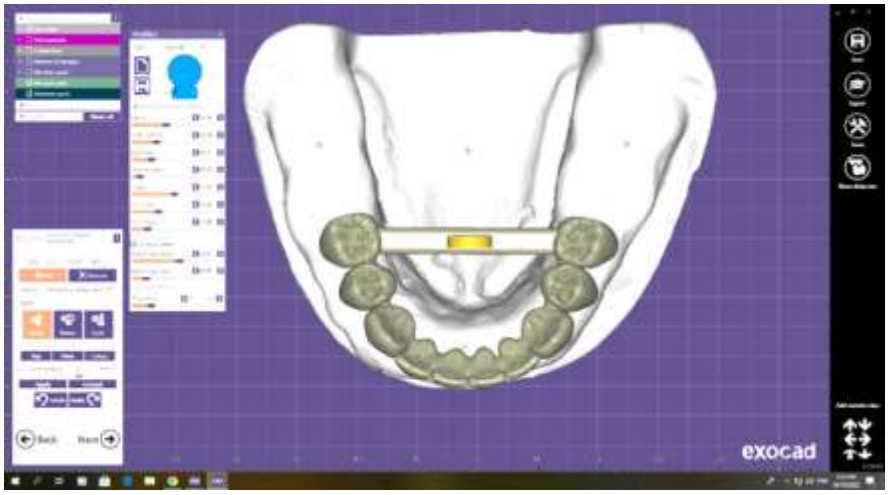

Figure 3: “Designing software setting” rounded disc-shaped part for outcome assessment preparation.

Figure 4: "Milling procedure”: A sample in puck after milling completion.

(a) **(b)**

Figure 5: "Processing cap replacement”: (a) Removal of the laboratory processing retention cap and (b) Seating of the blue clinical retention cap.

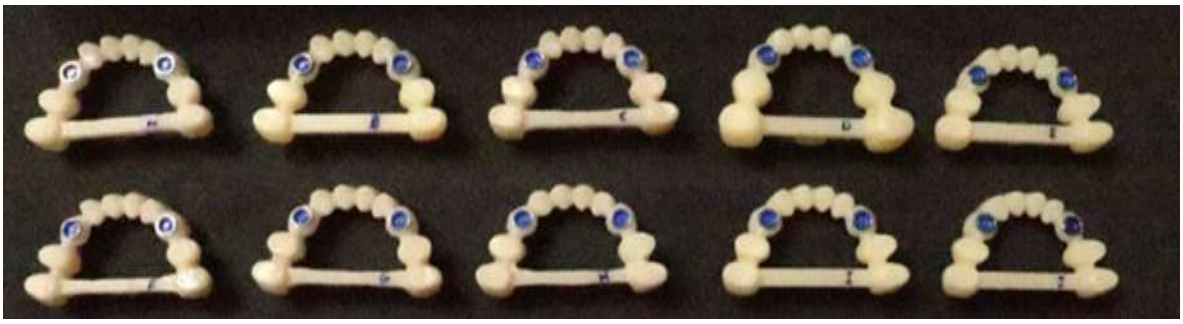

Figure 6: "Study samples": All study samples after coding and exchanging the retention caps to be ready for outcome assessment.

(a) **(b)**

Figure 7: " Sample- assessment machine fixation": Sample fixation within the testing machine, (a) Long shot for the setting of the assessment and (b) Close shot for the model fixation index and the sample hanging by a wire.

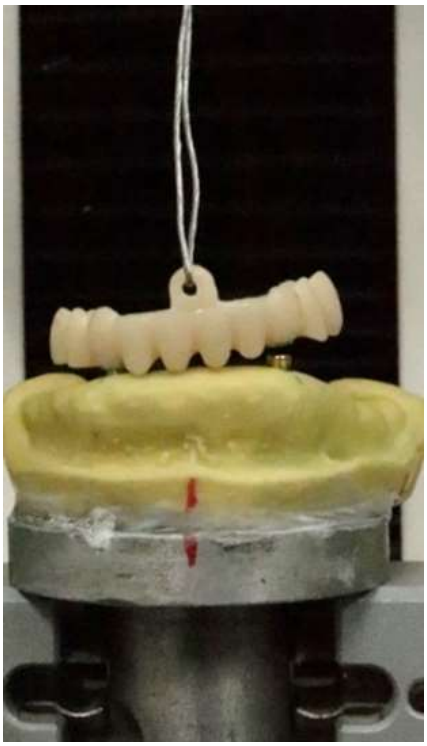

Figure 8: "Study sample assessment": Sample was pulled out during testing until a detachment of the base from the Locator abutment occurred.

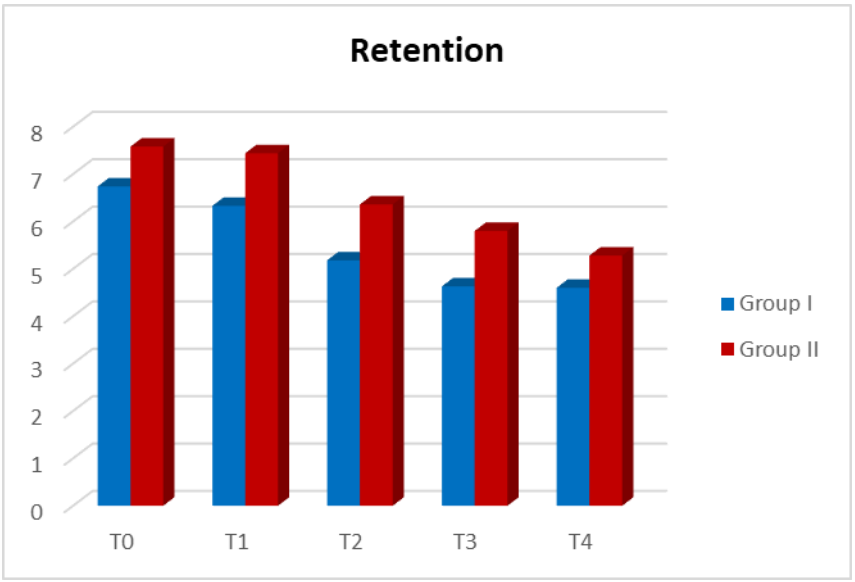

Figure 9: "Comparison between the two study groups regards the effect of the time on the retention": bar chart showing the mean of both study groups at all intervals.

Table (1): Mean and standard deviation of both study groups at all intervals and comparison between them to evaluate the effect of the material:

Interval	Group I (Intervention)		Group II (Control)		Difference				
					MD	SEM	95%CI		P value
	Mean	Standard Deviation	Mean	Standard Deviation			L	U	
T0	6.74 N	0.80 N	7.58 N	2.97 N	0.84	1.3	-2.3	4.02	0.55
T1	6.33 N	1.64 N	7.44 N	1.73 N	1.11	1.06	-1.3	3.5	0.32
T2	5.18 N	1.46 N	6.36 N	1.50 N	0.18	0.93	-0.97	3.33	0.24
T3	4.63 N	0.72 N	5.80 N	1.61 N	0.17	0.78	-0.64	2.98	0.17
T4	4.60 N	1.17 N	5.28 N	1.17 N	0.68	0.74	-1.02	2.36	0.38

Table (2): Frequency and percentage of denture base detachment in both study groups:

	Detached		Non detached		P value
	N	%	N	%	
Group I (Intervention)	1	20	4	80	0.07
Group II (Control)	0	0	5	100	------
P value	0.31		0.31		

Discussion

The idea behind this study is to evaluate the retention resulting from the friction between the intaglio surface of the denture base and the external surface of the Locator metal housings.

The prosthesis was also designed with a special configuration; not to touch the model for the research purpose to eliminate other confounding factors that might affect the outcome assessed.

The outcome assessment was achieved by using the universal testing machine with a 500 N load cell at a crosshead speed of 50 mm/min which represents to the estimated speed of denture removal during chewing until complete separation (abdelaziz et al., 2021; Mostafa, Mohammed and Thabet, 2021). The removal assessment cycles were performed in a vertical direction to prevent sample distortion.

In each interval between the assessment times, each sample was subjected to 135 cycles of the removal and insertion of the prosthesis which simulate a month and half of the patient usage; considering average three removals per day (Reda, El-Torky and El-Gendy, 2016). Since each sample was assessed five times with four intervals in between, the total cycles that were done for each sample were 540 cycles. These 540 cycles resemble six months of the patient usage. It was chosen to end the outcome assessment after usage period simulation of six months as after the 500 cycles the retention quality of the nylon caps specially in the presence of inclined implants was found to differ from the first 500 cycles (Sultana, Bartlett and Suleiman, 2017).

According to the statistical results, both study groups reported retention decrease, this is most probably due to wear of the nylon caps surface during insertion/separation cycles. This finding is in context with previous studies which reported that the Locator attachment showed a decrease in its retentive potential gradually after a period of usage (Shastry et al., 2016; Guédat et al., 2018).

It was observed according to the results of the present study that the Locator metal housing detachment from the denture base was one of the attachment's clinical complications which is in accordance to a recently published systematic review (Sutariya et al., 2021). Hence, from this observation, researchers attempted to find new strategies to overcome this type of complication. One of these attempts, which was published, was to expose the Locator metal housing to sandblasting before conventional direct pickup (Sipahi and Ezmek, 2020).

The intervention strategy of pickup resulted in the detachment of only one of the Locator metal housings from one sample of the intervention group. The detachment occurred in 10% of the total study Locator metal housings and 20% of the total study denture bases which was considered an insignificant percentage of mechanical complication. This may be explained due to the fine manual finishing during the seating step to eliminate the interference friction that arose from slight excess denture material intruding the space of the Locator metal housing entry.

Another probability of Locator metal housing detachment may be due to the weaker interfacial bond in the metal-resin contact area than the retention forces between the nylon cap and the attachment abutment in this sample. Although all nylon caps used in the study are ready-made with the same retention quality and manufacturer source and material, this can never eliminate the factor of manufacturing error tolerance like other implant components reference (Ma, Nicholls and Rubenstein, 1997).

From the same point, milling machine error tolerance may be considered a factor that resulted in designed cavity in the fitting surface of the denture in a sample may be slightly larger in diameter than other samples (Budak, 2006).

Another explanation for attachment maintenance, and in correspondence to a previous study, is that the polymer surface (denture base) friction against a metallic counterface (the Locator metal housing) which

makes the polymer tend to deposit wear debris. These wear debris on the counterface result in an intermediate film that adheres on the counterface through molecular interactions, thus decreasing the interfacial gap (e.g., van der Waals force attraction, chemisorption) (Sun et al., 2022).

Within the limitations of this study, it could be concluded that:

1. The retention in both study groups was nearly equivalent.

2. By time, the retention decreased in both study groups.

3. The pickup strategy without retaining material can reduce additional clinical and laboratory steps and may create a new application of digital dentistry.

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Conflict of Interest:

The authors declare no conflict of interest.

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Ethics:

This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo university on: 29 March 2022, approval number: 22-3-22

References

1. **Abdelaziz, Medhat et al.** (2021) 'Retention Loss of Locator Attachment System Different Retention Caps for Two Implant Retained Mandibular OverdentureMedhat', future dental journal, 7(2), pp. 120–126. doi:10.54623/fdj.7029.

2. **Abibe, A.B. et al.** (2016) 'On the feasibility of a friction-based staking joining method for polymer-metal hybrid structures', Materials and Design, 92(0264–1275), pp. 632–642. doi:10.1016/j.matdes.2015.12.087.

3. **Alqutaibi, A.Y. et al.** (2016) 'Attachments used with implant supported overdenture', Article in International Dental & Medical Journal of Advanced Research, 2, pp. 1–5. doi:10.15713/ins.idmjar.45.

4. **Baba, N.Z. et al.** (2021) 'CAD/CAM Complete Denture Systems and Physical Properties: A Review of the Literature', Journal of Prosthodontics, 30(S2), pp. 113–124. doi:10.1111/jopr.13243.

5. **Budak, E.** (2006) 'Analytical models for high performance milling. Part I: Cutting forces, structural deformations and tolerance integrity', International Journal of Machine Tools and Manufacture, 46(12–13), pp. 1478–1488. doi:10.1016/j.ijmachtools.2005.09.009.

6. **Dabrowa, T., Dobrowolska, A. and Wieleba, W.** (2013) 'The role of friction in the mechanism of retaining the partial removable dentures with double crown system', Acta of Bioengineering and Biomechanics, 15(4), pp. 43–48. doi:10.5277/abb130406.

7. **Dahl, J.E., Frangou-Polyzois, M.J. and Polyzois, G.L.** (2006) 'In vitro biocompatibility of denture relining materials.', Gerodontology, 23(1), pp. 17–22. doi:10.1111/j.1741-2358.2006.00103.x.

8. **ELsyad, M.A., Elhaddad, A.A. and Khirallah, A.S.** (2018) 'Retentive Properties of O-Ring and Locator Attachments for Implant-Retained Maxillary Overdentures: An In Vitro Study', Journal of Prosthodontics, 27(6), pp. 568–576. doi:10.1111/jopr.12534.

9. **Goodacre, B.J. et al.** (2016) 'Comparison of denture base adaptation between CAD-CAM and conventional fabrication techniques', The Journal of prosthetic dentistry, 116(2), pp. 249–256. doi:10.1016/J.PROSDENT.2016.02.017.

10. **Guédat, C. et al.** (2018) 'Clinical performance of LOCATOR® attachments: A retrospective study with 1–8 years of follow-up', Clinical and Experimental Dental Research, 4(4), pp. 132–145. doi:10.1002/CRE2.122.

11. **Gupta, A. et al.** (2019) 'Rehabilitation of Edentulism and Mortality: A Systematic Review', Journal of Prosthodontics, 28(5), pp. 526–535. doi:10.1111/JOPR.12792.

12. **Irizarry, A.N.** (2021) Success and Complications on Implant-Retained Prostheses at a US Advanced Education Program in Prosthodontics: A Cross-Sectional Study, ProQuest Dissertations and Theses. The University of Texas, School of Dentistry at Houston. Available at: https://www.proquest.com/dissertations-theses/success-complications-on-implant-retained/docview/2570551293/se-2?accountid=17242 (Accessed: 20 August 2022).

13. **Kalberer, N. et al.** (2019) 'CAD-CAM milled versus rapidly prototyped (3D-printed) complete dentures: An in vitro evaluation of trueness', The Journal of prosthetic dentistry, 121(4), pp. 637–643. doi:10.1016/J.PROSDENT.2018.09.001.

14. **Kamel, A. et al.** (2021) 'Parameters affecting the retention force of cad/cam telescopic crowns: A focused review of in vitro studies', Journal of Clinical Medicine. Multidisciplinary Digital Publishing Institute, p. 4429. doi:10.3390/jcm10194429.

15. **Lee, D.J. and Saponaro, P.C.** (2019) 'Management of Edentulous Patients', Dental Clinics of North America. Elsevier, pp. 249–261. doi:10.1016/j.cden.2018.11.006.

16. **Ma, T., Nicholls, J.I. and Rubenstein, J.E.** (1997) 'Tolerance measurements of various implant components.', The International journal of oral & maxillofacial implants, 12(3), pp. 371–5. Available at: https://pubmed.ncbi.nlm.nih.gov/9197102/ (Accessed: 13 April 2023).

17. **Mostafa, N., Mohammed, S. and Thabet, Y.** (2021) 'Effect of Different Materials of Primary Telescopic Crowns on The Frictional Fit of Pekkton Partial Denture Frameworks in Kennedy Class I', Ain Shams Dental Journal, 22(2), pp. 105–111. doi:10.21608/asdj.2021.71094.1038.

18. **Nakhaei, M. et al.** (2020) 'Bond strength of locator housing attached to denture base resin secured with different retaining materials', Dental Research Journal, 17(1), pp. 34–39. doi:10.4103/1735-3327.276233.

19. **Reda, K.M., El-Torky, I.R. and El-Gendy, M.N.** (2016) 'In vitro retention force measurement for three different attachment systems for implant-retained overdenture', Journal of Indian Prosthodontist Society, 16(4), pp. 380–385. doi:10.4103/0972-4052.191284.

20. **Shastry, T. et al.** (2016) 'An in vitro comparative study to evaluate the retention of different attachment systems used in implant-retained overdentures', Journal of Indian Prosthodontist Society, 16(2), pp. 159–166. doi:10.4103/0972-4052.176520.

21. **Sipahi, C. and Ezmek, B.** (2020) 'An Alternative Incorporation Technique for Minimizing Complications in Attachment-Retained Implant Mandibular Overdentures: Technical Report', Journal of Prosthodontics, 29(9), pp. 814–817. doi:10.1111/jopr.13279.

22. **Snosi, A.M. et al.** (2021) 'Subtractive versus additive indirect manufacturing techniques of digitally designed partial

dentures', Journal of Advanced Prosthodontics, 13(5), pp. 327–332. doi:10.4047/jap.2021.13.5.327.

23. **Sultana, N., Bartlett, D.W. and Suleiman, M.** (2017) 'Retention of implant-supported overdentures at different implant angulations: comparing Locator and ball attachments', Clinical Oral Implants Research, 28(11), pp. 1406–1410. doi:10.1111/clr.13003.

24. **Sun, W. et al.** (2022) 'The limit of adhesive debris retention: A case study using ultra-low wear Alumina–PTFE', Wear, 496–497, p. 204274. doi:10.1016/j.wear.2022.204274.

25. **Sutariya, P. et al.** (2021) 'Mandibular implant-supported overdenture: A systematic review and meta-analysis for optimum selection of attachment system', Journal of Indian Prosthodontic Society. Medknow Publications and Media Pvt. Ltd., pp. 319–327. doi:10.4103/jips.jips_158_21.

26. **Zafar, M.S.** (2020) 'Prosthodontic applications of polymethyl methacrylate (PMMA): An update', Polymers. Polymers (Basel), pp. 1–35. doi:10.3390/polym12102299.