Crestal Bone Loss and Patient Satisfaction of Screw Retained Restoration Using Multi-Unit Abutments versus Intra-Oral Luting on Titanium Bases in Implant Supported Complete Overdentures: Randomized Clinical Trial

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Abstract

Aim: This study was done to evaluate the crestal bone loss and patient satisfaction of full-arch screw-retained implant prostheses constructed on Multiunit abutments (MUA) versus intraoral cementation on Ti-bases **Materials and methods:** Twenty-two patients with edentulous mandible were recruited, four axial implants were placed then they divided into 2 groups, in group A (control group): a screw-retained full-arch implant prosthesis with PEEK framework was made using Multiunit abutments as the control group, while in group B (intervention group): Ti-bases were used. Crestal bone loss and patient satisfaction was obtained 6 and 12 months (m) after loading. **Results: After a follow up period of 12 m,** Regarding Crestal bone loss there was a significant difference between both anterior and posterior implants in control and intervention group. Regarding patient satisfaction, control was better than intervention in pain during insertion and removal. while intervention was better than control in difficulty to chew hard food. **Conclusion**: after the 12 m follow up period, MUA control group showed less Crestal bone loss with less pain during maintenance insertion and removal of the prostesis. while intervention group was more satisfied regarding difficulty to chew hard food.

Keywords: Bone loss, Patient satisfaction, Screw-retained, Multi-unit, Intra-oral luting cement technique, Titanium bases.

DOI: 10.48047/ecb/2023.12.Si8.623

1 Introduction

Prosthetic rehabilitation of edentulous jaws with a complete denture has been a routine treatment procedure for most patients with acceptable and predictable results. Nonetheless, clinical evidence confirms that a significant proportion of these patients have considerable difficulty adjusting to their prostheses. And patients often express dissatisfaction, a lack of retention, stability, and difficulty chewing their food. [1]

Numerous prosthesis designs have been described for full-mouth rehabilitation using osseointegrated implants. Removable overdenture retained by implants, implant-supported cement-retained bridge, and implant-retained screw-retained prosthesis. [1,2,3] Generally, Cementable prostheses have the advantages of passively fitting frameworks and better esthetics. However, retrievability, repair, and maintenance, choice of cement, and excess cement in the sulcus remain areas of concern. [4]

Usually, an external connection with what is referred to as a multiunit abutment or a transmucosal abutment is required to create a screw-retained prosthesis with practically complete passivity and retrievability. Due to the high expenses and need for advanced dental laboratory capabilities, multiunit restoration is not typically the clinician's first option when repairing a complete arch dental prosthesis.

Extra-oral cemented prosthesis to implant level Ti-bases is a faster prosthetic solution with lower prosthetic complexity, but passivity problem could be encountered due to extra oral cementation errors. While in case of intraoral cementation there is a risk of residual cement biological complications. [5]

So, there was a need for a new prosthetic technique that combines the advantages of the screw-retained and cement-retained implant-supported prosthesis such as retrievability, with reduced prosthetic complexity, passivity, reduced biological complications, and lower cost to the patient with less recall patient visits.

Therefore, this trial aims to determine whether a difference exists between full-arch screw-retained implant-supported prosthesis constructed on multiunit abutments versus prosthesis constructed on ti-bases using intraoral luting cement technique in terms of crestal bone loss and patient satisfaction?

2 Materials and Methods

This trial protocol was approved by the Evidence Based dentistry committee (EBD) of the Prosthodontics department of cairo university. All procedures performed in this study involving human participants were in accordance with the ethical standards of the Research Ethics Committee of Faculty of Dentistry Cairo University (CREC) Ref (18/10/44). The trial was registered at: ClinicalTrials.gov ID: NCT03671668

This trial aims to compare completely edentulous patients receiving a full-arch screw-retained implant prosthesis (p), using intraoral luting cement techique. Multi-unit abutments were used in the (control group), while Titanium bases were used in the (intervention group).

Study Design and patients selection

The trial was a randomized clinical controlled trial- parallel groups. Patients with completely edentulous mandible who had bone bucco-lingual width ≥ 6mm, proper available bone height, and proper amount of attached gingiva (≥2 mm) were recruited. All patients had an opposing natural dentition or full arch implant retained prosthesis with no history of bruxism.

Patients were medically free or controlled diabetic assessed by measuring glycosylated haemoglobin (HbA1c) to be less than or equal to 6.4 percent.

Total of twenty-two patients was recruited in the trial according to the sample size; they were as follows, eight male and fourteen female patients. The age range of the selected participants were between 40 and 55 years old, randomization was done and the total sample was allocated into 2 groups, Total of 44 implants in each group were used to construct the full arch prosthesis for the recruited patients. Block randomization was done with allocation ratio 1:1,every participant grasped an opaque sealed opaque envelop from a box at the prosthetic phase. Being opaque and sealed ensured allocation concealment.

Sample size calculation

Based on a previous study Crespi [6] the difference in crestal bone loss in Group 1 was -1.01±0.33 mm while in Group 2 the difference was -1.23±0.45 mm. using power 80% and 5% significance level , 41implants in each group need to study. This number is to be increased to a sample size of 49 in each group to compensate for losses during follow up. Sample size calculation was achieved using PS: Power and Sample Size Calculation software Version 3.1.2 (Vanderbilt University, Nashville, Tennessee, USA

Clinical Procedures

For eligible patients, four implants (Dentis company (OneQ, SL implant system) with internal conical hex connection and diameter of average 4.1mm, and length of 10 mm) were placed in completely edentulous mandible parallel to each other and were submerged 1mm under bone level according to the normal sequental drillig protocol in the pre-planned implant position using surgical stent.

The steps for final prosthesis fabrication were initiated 3 months after implant placement for both groups; the patient's surgical stent was used to locate the implant position, a small mid-crestal incision was made. Flap was raised and implants were uncovered. Cover screws were unscrewed, and healing caps were fastened for the Ti-base group while for the MUA group ,multiunit abutments from Dentis company were fastened according to manufacturer recommends (30 Newtons) using a torque wrench. In order to minimize the settling effect, the multiunit were retightened at least twice at the recommended manufacturer torque at a 10-min interval. Multiunit healing cap were fastened and interrupted sutures were made (if it was needed). For both groups, a primary impression was made to fabricate a custom tray. The custom tray was characterized with a relief space to accommodate the acrylic splinting between impression copings and a wide perforation to allow accessibility to the impression coping screws. For the MUA group, an open tray pick-up abutment level impression coping with cone connection were fastened over the multi-unit abutments by hand torqueing, while for the Ti-base group ,healing collars were unscrewed, and regular open tray pick-up (implant level) impression copings were fastened over the implants by hand torqueing. For both groups, to ensure impression accuracy, splinting the impression copings were made by self-cure acrylic resin (Duralay. Prestige dentl products UK Ltd, England, UK). One stage impression technique (putty and light body) was made with silicon impression material (Kettenbach GmbH & Co. KG, Im Heerfeld 7, 35713 Eschenburg) using the premade custom tray. **(Figure 1)**

An acrylic verification jig was constructed over the impression copings for both groups using

self-cure acrylic resin to verify the accuracy of the final impression. One screw test was applied to check passivity. If the one screw test revealed a non-passive structure, jig separation and intraoral assembling were performed. For both groups, an occlusion block was constructed over the final cast to make bite registration, after which the case was ready for scanning , a PEEK framework was designed using dental wings software as teeth and a gum part (FP3 screw-retained restoration), the designed restoration was then imported to millbox software for nesting and milling simulation. **(Figure 2)**

A PEEK framework was milled, which was checked by trial insertion intraorally to verify passivity. Permanent cement was used to attach only one metal cylinder on the cast; while temporary cement was used to attach the rest three metal cylinders to the PEEK framework. The permanent cementation of a one metal cylinder allows for proper seating for the framework and prevent movement of the framework due to tissue rebound in deeply placed implants. Later on it was sent to the lab for vennering with Acrylic teeth and Visio.lign (bredent GmbH & Co.KG, Weissenhorner Str. 2, 89250 Senden - Germany) according to the manufacturing instructions. **(Figure 3)**

For both groups , intraoral cementation of the prosthesis at the delivery stage was done.The Ti-base abutments or multiunits sleeves were fastened intraorally and a proper moisture control was applied using cotton roll and suction unite. Cementation was done according to Bredent® instructions for bonding on PEEK framework. The prosthesis was then removed from patient mouth for finishing of excess cement and polishing. In the control group, the prosthetic screw was tightened at 20 Newtons. On the other hand, the the abutment screws of the Ti-bases were tightened at 30 Newtons. Screw holes were closed using Teflon and composite material and final occlusal check was done in centric and eccentric positions. **(Figure 4), (Figure 5)**

Examination and Data Collection

1-Rdaiographic evaluation: Peri-implant marginal bone loss was evaluated at the time of prosthesis placement (T0), 6 months (T6m), and 12 months (T12m) after placement by one of the research team other than the clinician who was responsible for the clinical intervention. For standardization of exposure conditions, intraoral optical scan was taken for each patient at the prosthesis delivery day with an intraoral scanner (opera system, 4/6 Avenue Albert II - Bloc B, 98000 MONACO) over which, a custom-made 3D printed resin jig was designed in reference to each implant site in solidworks software, the function of this jig was to be connected to a special holder arm and a ring, and this jig has a special design which is designed with two wings to hold the x-ray sensor plate and with a square shaped recess to receive the metallic arm of the holder which is connected to the holder ring. The jig STL file was imported again to CAD software (exocad GmbH, Julius-Reiber- Straße 37, 64293 Darmstadt, Germany) to link the jig to a custom designed wafer over the implants at the area of interest. The merged jig in combination with the wafer was exported as STL file to be 3D printed in resin. **(Figure 6), (Figure 7)**

Bone resorption was measured as the distance between the implant-abutment junction and first bone-to-implant contact. To compensate for magnification errors, the known implant length and width were used to correct readings on the images to their actual values. Bone resorption was averaged from mesial and distal aspects of each implant. **(Figure 8)**

2- Patient Satisfaction: Patient satisfaction with Screw-retained prosthesis was investigated through a custom-made questionnaire used in a previous study[7, 8]. The questionnaire was based on a visual analog scale (VAS), in which patients gave their answers as a crossed mark on a scale from 0 to 100 for each question. (Low/ worst to high/best) 0= no satisfaction and 100= complete satisfaction; the questionnaire was given to the patients in Arabic; the questions were translated into Arabic using a forward-backward approach. The translation was done by two independent dentists and bilingual translators who produced one common translation. Evaluation of patient satisfaction was performed 6 months (T6 m), and 1 years (T1) after the prosthesis insertion. **(Figure 9)**

Statistical Analysis

Data was analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 20 (SPSS Inc., Chicago, IL). Numerical data was described as mean and standard deviation. Data was explored for normality using Shapiro-Wilk test. Comparison between more than 3 different groups (quantitative data) was performed using One-Way ANOVA test followed by Tukey`s Post Hoc test for multiple comparisons. Comparison between 2 answers (qualitative data) was performed using Chi square test, while in (quantitative data) was performed by Independent t-test. A p-value less than or equal to 0.05 was considered statistically significant. All tests were two tailed.

3 Results

Normality test revealed the normal distribution of the data. Regarding crestal bone loss around anterior implants , a comparison between both groups at each interval revealed significant difference between them in baseline-6 months & baseline – 12 months as $P < 0.05$ (intervention group was significantly higher than control group), while there was insignificant difference between them in 6 months – 12 months interval as $P > 0.05$, as presented in **(table1).**

A comparison between both groups regarding posterior implant at each interval revealed significant difference between them in baseline-6 months & 6 months – 12 months as $P < 0.05$ (intervention group was significantly higher than control group).

While there was insignificant difference between them in baseline – 12 months interval as $P > 0.05$, as presented in **(table2)**

For patient satisfaction , after 6 months, there was a significant difference between the two groups in Q2, Q4, Q5 & Q6 (intervention was significantly higher than control) and in Q7, Q8 & Q9 (intervention was significantly lower than control) as $P < 0.05$, as presented in **(table3)**

While After 12 months , there was significant difference between them in Q4 (intervention was significantly higher than control) and in Q3, Q7, Q8 (intervention was significantly lower than control) as $P < 0.05$, as presented in **(table 4)**

4 Discussion

According to the literature, the margin of implant-supported restorations should not be located further than 1.5 mm subgingivally as this lead to increasing the risk of peri-implant inflammation.[9, 10]

These studies support our study findings, as it was found that the amount of crestal bone resorption in the ti-base intervention group was increased than the MUA control group, as it was 1.17± 0.331 mm for anterior implants and 1.2 ± 0.277 mm in the Ti-base intervention group versus 1.015 ± 0.386 mm for anterior implants

and 1.1± 0.334mm for posterior implants in the Multiunit control group during the first year after prosthetic loading. This happens as the finish line level of the ti-base, known as the cementation line level, is usually closer to the peri-implant bone, complicating residual cement removal than in the MUA group. [10]

Avish J. Jagathpal demonstrated that extra oral removal of excess residual cement in conventional cement-retained abutments might considerably reduce the presence of non-detected excesses in a clinical trial. [11] Although some authors have suggested no statistical association between periodontal disease history and remodeling of peri-implant tissues. [11], [12] 145 Although different extra oral cementing techniques reported a lower risk of peri-implant disease associated with dental cement, none of these protocols will eliminate the risk. [10]

In our study, we used the intraoral luting technique to maximize the PEEK frame passivity. The rubber dam was used intraorally to control the cement remnants that were further removed extra orally followed by polishing; all of this was utilized to reduce residual cement's biological effect on the peri-implant bone.

According to Cochran, peri-implant bone remodeling after implant placement is more accentuated in the first 6 months after surgery. These authors found 86% of the bone loss in the first 6 months between the initial implant insertion and final placement of the prosthesis. They recorded a mean bone loss of 2.44±1.20 mm after 6 months. The bone loss slowly increased until stable levels were reached in 596 implants assessed after 5 years. [13]

In our study, all the implants were placed in a single step and exposed in the mouth in the same way, where the bone loss involving Dentis OneQ implants was seen to be comparatively smaller 1.015 ± 0.386 mm for anterior implants versus 1.1± 0.334 for posterior implants in the Multiunit control group and 1.17± 0.331 mm for anterior implants versus 1.2 ± 0.277 in the Ti-base intervention group during the first year after prosthetic loading.

Other investigators such as Lee [14], with 70 patients subjected to three years of follow-up, and Hartman [15], with 42 patients and 5 years of follow-up, likewise consider the most bone loss to occur in the first 6 months, followed by gradual stabilization as evidenced by the posterior annual controls.

Although the difference between anterior and posterior implants was not statistically significant; In this study in the two groups, bone resorption was substantially more significant at 12m than at 6m. The increasing occlusal pressure might explain this over time and the development of bone after implant placement. [16] When anterior and posterior implants were compared, it was shown that posterior implants were associated with much more marginal bone resorption than anterior implants.

Tokuhisa observed that occlusal forces are the highest at the molar area. This might be attributable to a variety of factors. Such as, the higher occlusal force exerted on implants in the first molar area compared to canine implants may result in increased stresses around posterior implants and bone resorption. [17] Secondly, in edentulous individuals, mandibular deformation and flexion posterior to the mental foramen produced by jaw motions may impair the prognosis of implants inserted posterior to the foramina after loading. [18] Finally, bone quantity and quality are often lower in the posterior mandibular area than in the anterior mandibular region.

Multiple supra structure unscrewing results in a permanent loss of hemi-desmosomal soft tissue connection surrounding an implant; this results in creating a newer, weaker, and narrower hemi-desmosomal attachment. These factors may contribute to bone resorption, particularly in individuals with a thin mucosa biotype. Multiple abutment screwing-unscrewing sequences have been shown to alter the oral mucosa barrier and result in bone loss. [19,20,21]

Koutouzis T's meta-analysis shows that repeated screwing unscrewing does indeed result in minimal bone loss, despite the disagreement surrounding previous research findings. [22]

Intraoperative installation of multiunit abutments enables the sealing of an implant neck and forming a new, stronger, and broader hemi-desmosomal connection at the neck level of the multiunit abutment. Additional prosthetic manipulations were performed at the level of the multiunit abutment, which is higher than the peri-implant bone. This allowed for the avoidance of repeated screwing/unscrewing at the implant neck level and preserving the hemi-desmosomal link. All of these contributed to the peri-implant bone tissues' stability. [23]

There was a significant improvement in patient satisfaction in this study when patients were rehabilitated with either prosthesis. A change showed this in at least seven of the ten VAS items for each intervention. De Kok reported very similar observations. [24]

There was no statistically significant difference in overall satisfaction between MUA implant-supported prostheses and Ti-base implant-supported prostheses, even though MUA implant-supported prostheses had higher mean overall ratings.

Regarding the MUA control group, the findings of this study indicated an improvement in patient satisfaction almost in all domains insignificantly with the advancement of time. However, with a significant difference, particularly concerning difficulty to chew hard food in six months that get improved after twelve months, this was logic that can be attributed to the patient adaptation to the new fixed option and improved neuromuscular control of the patient that enabled such patients to improve their biting force making them rise the capability to grind and chew hard food easily by time.

This finding was supported by Brennan and Martin-Ares findings, who found that satisfaction with chewing ability, mastication, and eating comfort were considerably greater with implant fixed prostheses than with removable prosthesis. [25,26]

It is well known that creating a fixed screw-retained full-arch prosthesis over multi-unit abutments need more different prosthetic parts than that used directly on the implant level that is not always available in all sizes in all implant systems, with more clinical sessions, this can add to the number of sessions needed for the prosthesis delivery. [23]

On the other hand, the Ti-base intervention group demonstrated a significant increase in patient satisfaction with the advance of time, especially regarding speaking with the prosthesis, the treatment time required for the prosthetic procedures, pain during insertion or removal of the prosthesis at maintenance visits, and discomfort or bleeding during brushing.

The Ti-base intervention group patients experience pain during insertion and removal of the prosthesis, and this was since Ti-bases are implant level going through the whole mucosal thickness every time we insert or remove the prosthesis causing some pain sensation for the patients, and this was evident especially in

patients with non-parallel implants, and this was logic.

This result was in line with Tim Joda, who was comparing the patient-centered outcomes during digital and conventional implant level impressions; he found that traditional implant level impression patients experienced more pain during impression making than digital impression patients as each scan body were captured for each implant separately excluding the insertion and removal event. [27]

As a result, the same Ti-base group patients experience some discomfort or even bleeding each time we insert or remove the prosthesis because we cut the hemi-desmosomal connection created each time at the implant collar area.

This also was in line with multiple studies that observed that repeated supra-structure unscrewing results in a permanent loss of the hemi-desmosomal soft tissue connection surrounding implants resulting in some discomfort or even bleeding each time. [19,20,21]

This was not evident in the MUA control group as trans-mucosal abutments were attached to the implants at the day of the secondary surgical exposure, making no disruption to the hemi-desmosomal mucosal connections, transferring the impression connection and the prosthetic connection to abutment level reducing inconvenience during impression taking especially the splinted type, and reducing pain during insertion and removal of the prosthesis.

5. Conclusion

According to the limitation of our study, it can be concluded that:

- When constructing a screw-retained implant prosthesis, using both multiunit and titanium bases are considering a viable option regards overall patient satisfaction.
- **Regarding bone loss**, Tibase group experienced higher bone loss than MUA group for anterior and posterior implants between different time intervals.
- **For patient satisfaction,** after 6m Ti-bases were better than MUAs regarding difficulty in speaking ,difficulty in chewing hard food & time required for prosthetics. While Ti-base group was lower in pain during insertion and removal & discomfort during brushing, inconvenience in impression after 6 and 12 m.

6. Acknowledgements: Nil

7. Conflicting Interest: The author declares that there is no conflict of interest.

8. Source(s) of Funding: This study was self-funded by the authors.

9. Ethical policy and Institutional Review board statement: The Research Ethics Committee (CREC) of Faculty of Dentistry, Cairo University, Ref (18/10/44).

10. Patient declaration of consent statement:

We have obtained all appropriate patient consent forms.

11 References

1. Balshi TJ. Preventing and resolving complications with osseointegrated implants. *Dent Clin North Am*. 1989;33(4):821-868.
2. Lekholm U. Surgical considerations and possible shortcomings of host sites. *J Prosthet Dent*. 1998;79(1):43-48. doi:10.1016/S0022-3913(98)70192-1

3. Salenbauch NM, Langner J. New ways of designing suprastructures for fixed implant-supported prostheses. *Int J Periodontics Restorative Dent*. 1998.
4. Jivraj S, Chee W, Corrado P. Treatment planning of the edentulous maxilla. *Br Dent J*. 2006;201(5):261-279. doi:10.1038/sj.bdj.4813952
5. Derksen W, Tahmaseb A, Wismeijer D. Randomized Clinical Trial comparing clinical adjustment times of CAD/CAM screw-retained posterior crowns on ti-base abutments created with digital or conventional impressions. One-year follow-up. *Clin Oral Implants Res*. 2021;32(November 2020):1-9. doi:10.1111/clr.13790
6. Bruschi GB, Crespi R, Capparè P, Grande N, Bruschi E, Gherlone E. Radiographic Evaluation of Crestal Bone Levels of Delayed Implants at Medium-Term Follow-up. *Int J Oral Maxillofac Implants*. 2014. doi:10.11607/jomi.3254
7. Sherif S, Susarla SM, Hwang JW, Weber HP, Wright RF. Clinician- and patient-reported long-term evaluation of screw- and cement-retained implant restorations: A 5-year prospective study. *Clin Oral Investig*. 2011;15(6):993-999. doi:10.1007/s00784-010-0460-4
8. Elsyad MA. Patient satisfaction and prosthetic aspects with mini-implants retained mandibular overdentures. A 5-year prospective study. *Clin Oral Implants Res*. 2016;27(7):926-933. doi:10.1111/clr.12660
9. Nóvoa L, Batalla P, Caneiro L, Pico A, Liñares A, Blanco J. Influence of Abutment Height on Maintenance of Peri-implant Crestal Bone at Bone-Level Implants: A 3-Year Follow-up Study. *Int J Periodontics Restorative Dent*. 2017;37(5):721-727. doi:10.11607/prd.2762
10. Pamato S, Honório HM, da Costa JA, Traebert JL, Bonfante EA, Pereira JR. The influence of titanium base abutments on peri-implant soft tissue inflammatory parameters and marginal bone loss: A randomized clinical trial. *Clin Implant Dent Relat Res*. 2020;22(4):542-548. doi:10.1111/cid.12900
11. Jagathpal AJ, Vally ZI, Sykes LM, du Toit J. Comparison of excess cement around implant crown margins by using 3 extraoral cementation techniques. *J Prosthet Dent*. 2021;126(1):1-95-101. doi:10.1016/j.prosdent.2020.04.016
12. Ravidà A, Rodriguez MV, Saleh MHA, et al. The correlation between history of periodontitis according to staging and grading and the prevalence/severity of peri-implantitis in patients enrolled in maintenance therapy. *J Periodontol*. 2021;92(11):1522-1535. doi:10.1002/JPER.21-0012
13. Cochran DL, Nummikoski P V., Schoolfield JD, Jones AA, Oates TW. A Prospective Multicenter 5-Year Radiographic Evaluation of Crestal Bone Levels Over Time in 596 Dental Implants Placed in 192 Patients. *J Periodontol*. 2009;80(5):725-733. doi:10.1902/jop.2009.080401
14. Lee DW, Choi YS, Park KH, Kim CS, Moon IS. Effect of microthread on the maintenance of marginal bone level: A 3-year prospective study. *Clin Oral Implants Res*. 2007;18(4):465-470. doi:10.1111/j.1600-0501.2007.01302.x

15. Hartman GA, Cochran DL. Initial Implant Position Determines the Magnitude of Crestal Bone Remodeling. *J Periodontol*. 2004;75(4):572-577. doi:10.1902/jop.2004.75.4.572
16. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants*. 1986;1(1):11-25. http://www.ncbi.nlm.nih.gov/pubmed/3527955.
17. Tokuhisa M, Matsushita Y, Koyano K. In vitro study of a mandibular implant overdenture retained with ball, magnet, or bar attachments: comparison of load transfer and denture stability. *Int J Prosthodont*. 2003;16(2):128-134. doi:10.1016/S0022-3913(03)00339-1
18. Miyamoto Y, Fujisawa K, Takechi M, et al. Effect of the additional installation of implants in the posterior region on the prognosis of treatment in the edentulous mandibular jaw. *Clin Oral Implants Res*. 2003;14(6):727-733. doi:10.1046/j.0905-7161.2003.00958.x
19. Abrahamsson I. The mucosal barrier following abutment dis/reconnection An experimental study in dogs. *J Clin Periodontol*. 1997;24(8):568-572. doi:10.1111/j.1600-051X.1997.tb00230.x
20. Abrahamsson I, Berglundh T, Sekino S, Lindhe J. Tissue reactions to abutment shift: An experimental study in dogs. *Clin Implant Dent Relat Res*. 2003;5(2):82-88. doi:10.1111/j.1708-8208.2003.tb00188.x
21. Becker K, Mihatovic I, Golubovic V, Schwarz F. Impact of abutment material and dis-/re-connection on soft and hard tissue changes at implants with platform-switching. *J Clin Periodontol*. 2012;39(8):774-780. doi:10.1111/j.1600-051X.2012.01911.x
22. Koutouzis T, Gholami F, Reynolds J, Lundgren T, Kotsakis G. Abutment Disconnection/Reconnection Affects Peri-implant Marginal Bone Levels: A Meta-Analysis. *Int J Oral Maxillofac Implants*. 2017;32(3):575-581. doi:10.11607/jomi.5367
23. Ashurko I, Trofimov A, Tarasenko S, Mekhtieva S. Full-Mouth Screw-Retained Implant-Supported Rehabilitation with Multiunit Abutments Using Virtual Guided Surgery and Digital Prosthetics Protocol. *Case Rep Dent*. 2020;2020(1):1-9. doi:10.1155/2020/3585169
24. De Kok IJ, Chang KH, Lu TS CL. Comparison of threeimplant- supported fixed dentures and two-implant-retained overdentures in the edentulous mandible: A pilot study of treatment efficacy and patient satisfaction. *Int J Oral Maxillofac Implant*. 2011;26(2):415–426.
25. Brennan M, Houston F, O'Sullivan M OB. Patient satisfaction and oral health-related quality of life outcomes of implant overdentures and fixed complete dentures. *Int J Oral Maxillofac Implant*. 25(4):791-800.
26. Martín-Ares M, Barona-Dorado C, Guisado-Moya B, Martínez-Rodríguez N, Cortés-Bretón-Brinkmann J, Martínez-González JM[a]. Prosthetic hygiene and functional efficacy in completely edentulous patients: satisfaction and quality of life during a 5-year follow-up. *Clin Oral Implants Res*. 2016;27(12):1500-1505. doi:10.1111/clr.12604

27. Joda T, Brägger U. Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial. *Clin Oral Implants Res*. 2016;27(12):e185-e189. doi:10.1111/clr.12600

Figure 1: open tray pick-up impression pouring

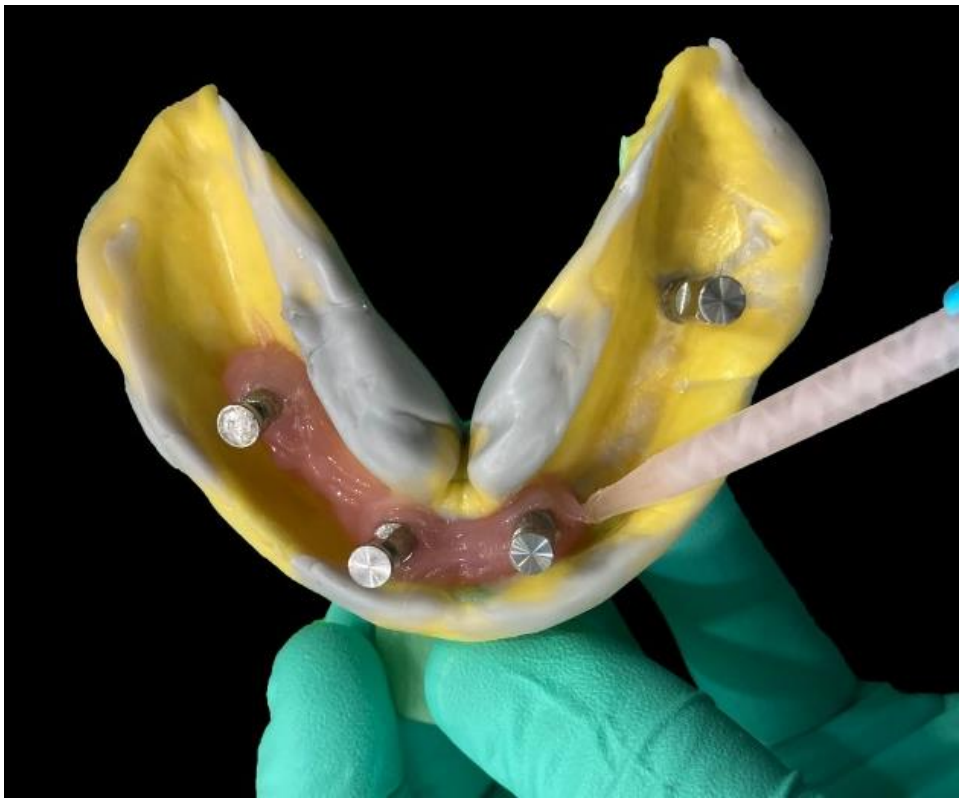


Figure 2: Cast scanning , and PEEK Framework designin

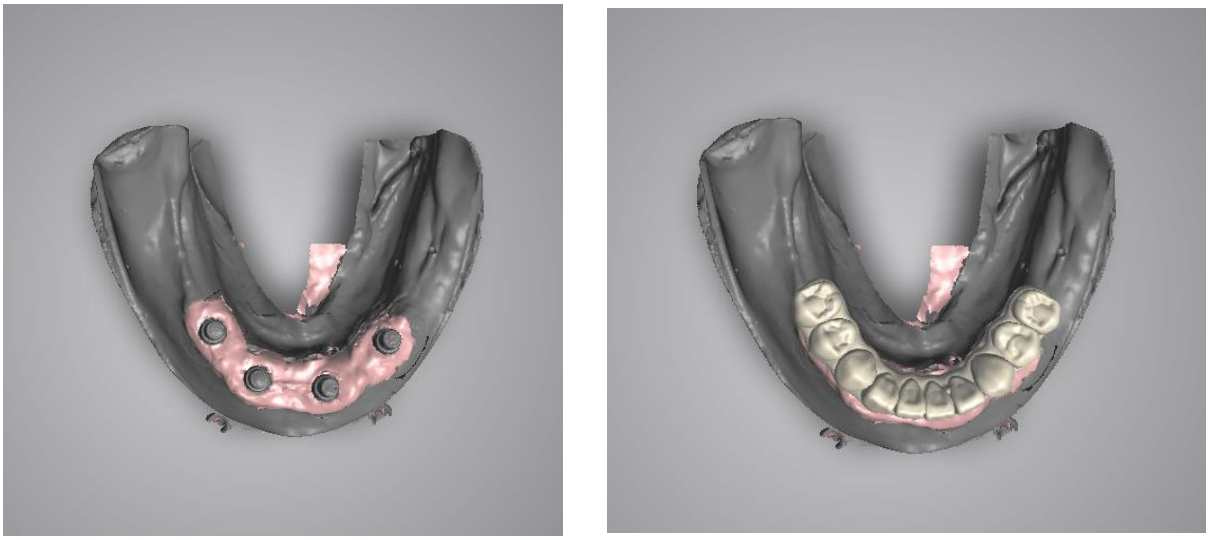


Figure 3: Milled PEEK framework after Finishing and visioline caracterization

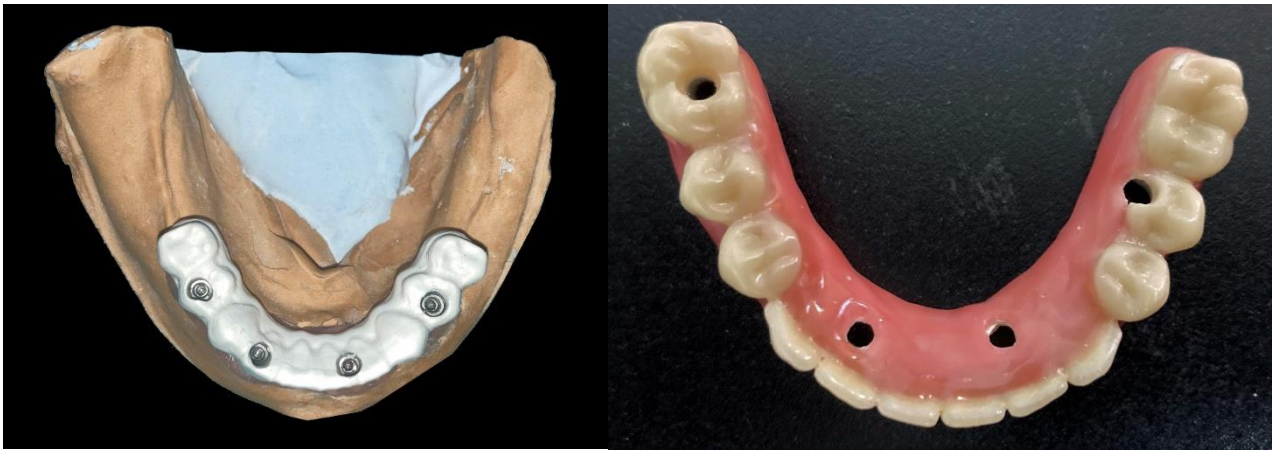


Figure 4: Framework after ti-bases and multi-unit sleeves cementation and excess cement removal

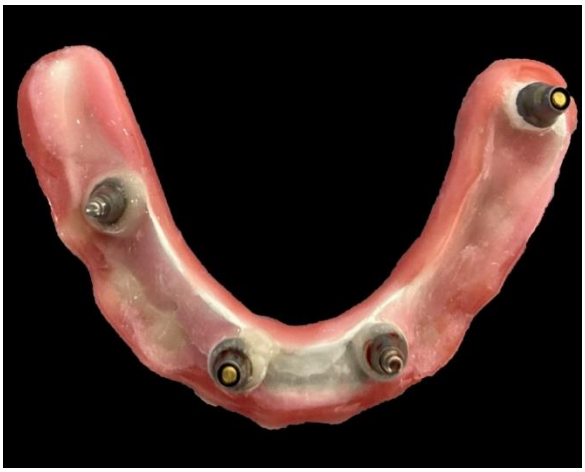


Figure 5: Framework after Intraoral lute cementation for tibases and MUA sleeves.

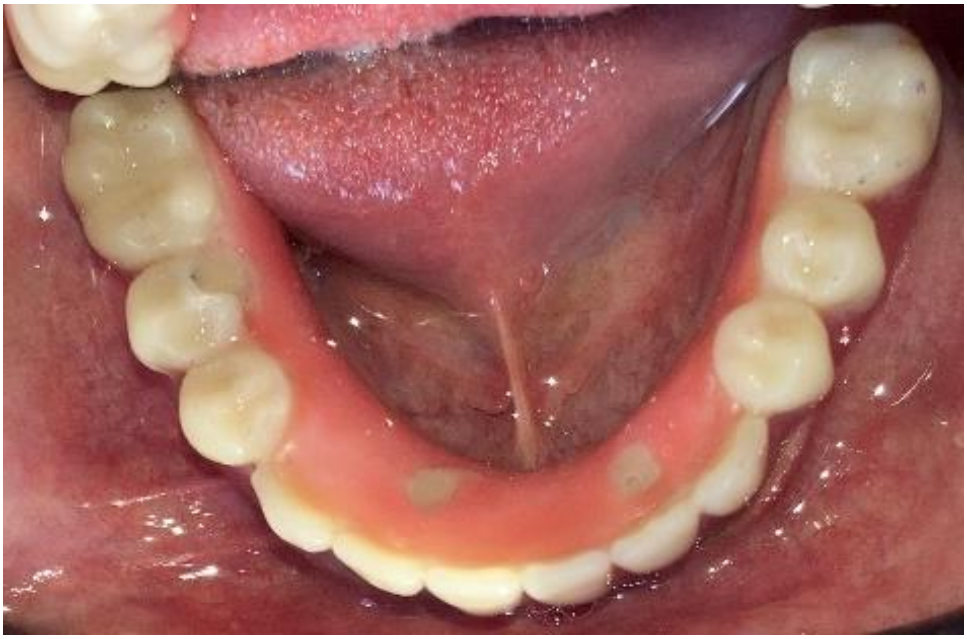


Figure 6: Scanning Jig after import to exocad

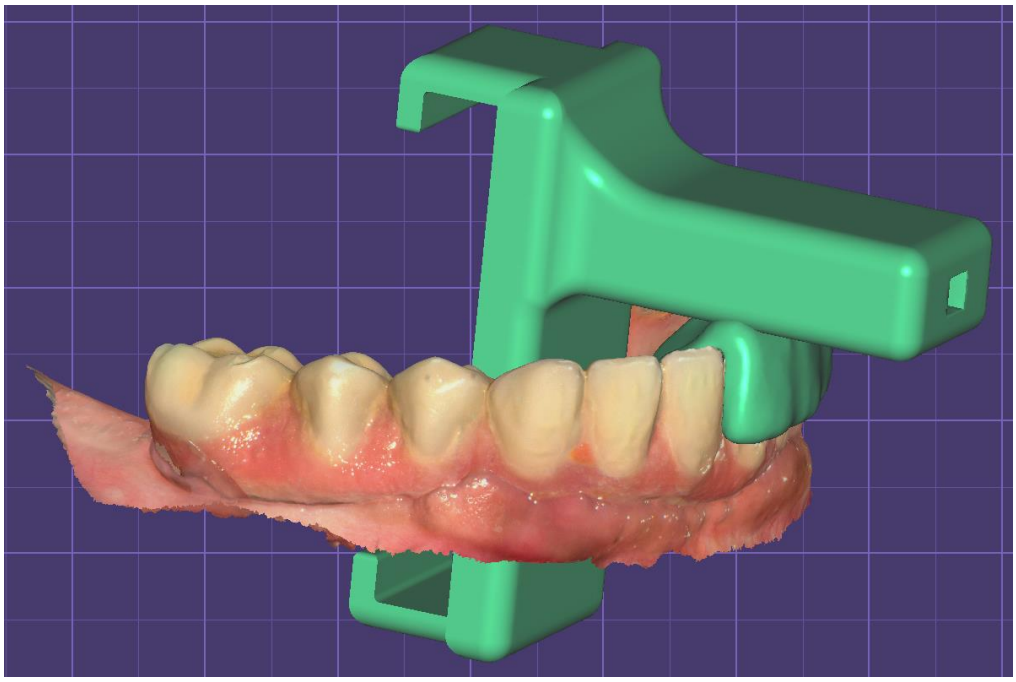


Figure 7: Scanning Jig after assembly and patient exposure

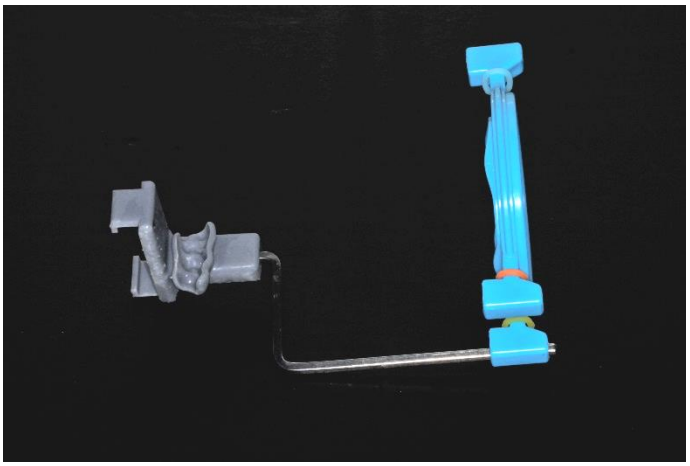


Figure 8: crestal bone loss measurements in control and intervention group

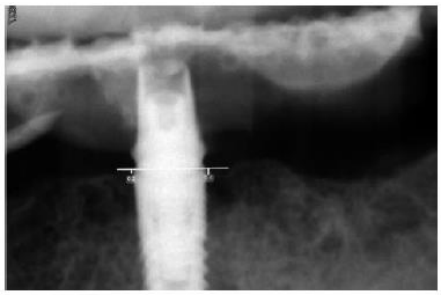
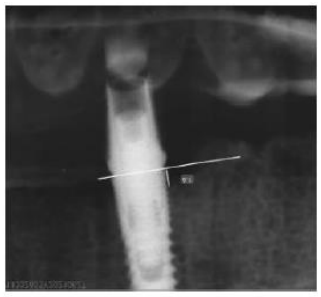
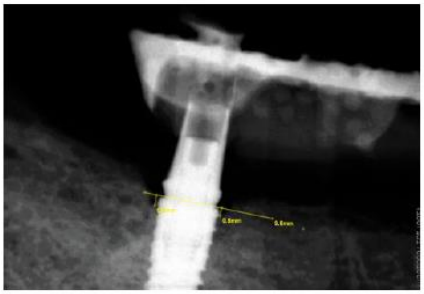
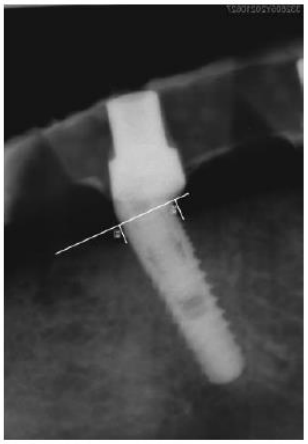
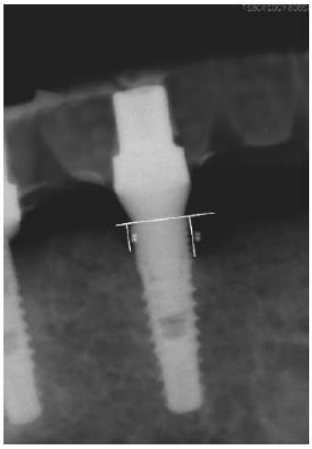
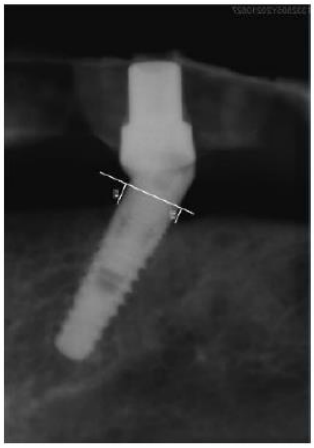







Figure 9: Satisfaction quietionnaire

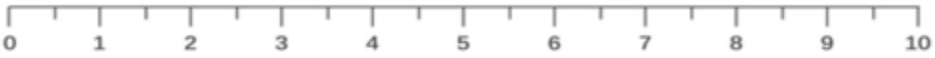
Appendix 6: Patient satisfaction questionnaire

a. English version:

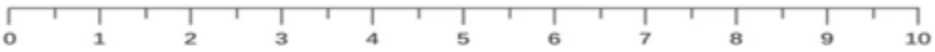
Please answer the following questions by placing a cross mark on the line at the point at which you feel that it represents your answer.

Note the start of the line on the left side represents the worst possible result or experience that you could imagine whereas the end of the line of the right side represents the absolute best possible result or experience that you could imagine.

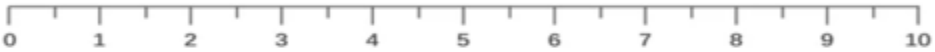
1. **Describe the extent of comfort with your screw-retained prosthesis.**



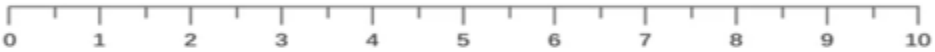
2. **Do you have difficulties speaking with your prosthesis?**



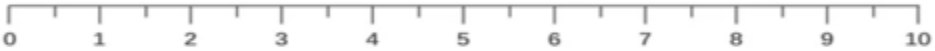
3. **How difficult is it for you to chew soft foods?**



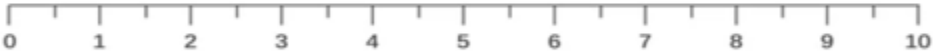
4. **How difficult is it for you to chew hard foods?**



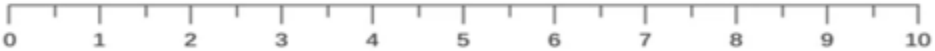
5. **How would you rate the ease of hygiene procedures**



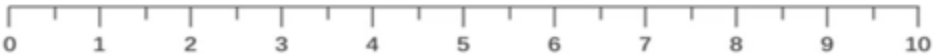
6. **What is your opinion on the treatment time required for the prosthetic procedures?**



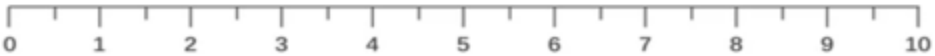
7. **How convenient was the impression procedure for you?**



8. **Did you experience pain during insertion or removal of prosthesis at maintainance visits?**



9. **Did you experienced any discomfort or bleeding during brushing?**



10. **How did you rate the overall satisfaction?**

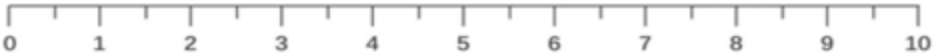


Table 1: Comparison between control & intervention group regarding crestal bone loss in anterior implants

	Follow up	Control group		Intervention group		P value
		M	SD	M	SD	
Anterior	baseline- 6 months	0.24	0.179	0.35	0.138	0.001*
	6 months - 12 months	0.77	0.21	0.82	0.192	0.24
	baseline - 12 months	1.015	0.386	1.17	0.331	0.04*

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

Table 2: Comparison between control & intervention group regarding crestal bone loss in posterior implants

	Follow up	Control group		Intervention group		P value
		M	SD	M	SD	
Posterior	baseline- 6 months	0.25	0.092	0.456	0.121	0.001*
	6 months - 12 months	0.85	0.189	0.75	0.162	0.009*
	baseline - 12 months	1.1	0.334	1.2	0.277	0.13

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

Table 3: comparison between control & intervention group after 6 months

After 6 months		Control group		Intervention group		P value
		M	SD	M	SD	
1	Describe the extent of comfort with your screw-retained prosthesis.	89.00	5.68	82.78	9.72	0.09
2	Do you have difficulties speaking with your prosthesis	83.00	6.75	92.22	3.63	0.001*
3	How difficult is it for you to chew soft foods	84.50	6.85	84.44	5.27	0.98
4	How difficult is it for you to chew hard foods	76.00	5.68	86.11	5.46	0.0007*
5	How would you rate the ease of hygiene procedures	67.00	5.87	71.11	6.51	0.15
6	What is your opinion on the treatment time required for the prosthetic procedures	78.00	5.87	83.89	4.17	0.01*
7	How convenient was the impression procedure for you	87.50	5.40	78.33	7.07	0.004*
8	Did you experience pain during insertion or removal of prosthesis at maintenance visits?	92.50	2.64	80.00	5.00	0.001*
9	Did you experience any discomfort or bleeding during brushing	86.00	5.68	73.89	7.82	0.009*
10	How did you rate the overall satisfaction	88.50	4.12	86.67	5.00	0.38

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

Table 4: comparison between control & intervention group after 12 months

		Control group		Intervention group		P value
		M	SD	M	SD	
1	Describe the extent of comfort with your screw-retained prosthesis.	88.50	3.37	86.11	6.01	0.28
2	Do you have difficulties speaking with your prosthesis	86.00	3.94	83.89	8.58	0.48
3	How difficult is it for you to chew soft foods	89.50	4.38	82.78	5.07	0.005*
4	How difficult is it for you to chew hard foods	82.50	2.64	90.00	4.33	0.002*
5	How would you rate the ease of hygiene procedures	72.50	5.40	77.78	10.93	0.18
6	What is your opinion on the treatment time required for the prosthetic procedures	86.00	3.94	89.44	3.91	0.06
7	How convenient was the impression procedure for you	89.50	3.69	81.11	4.17	0.002*
8	Did you experience pain during insertion or removal of prosthesis at maintenance visits?	93.50	3.37	87.78	3.63	0.001*
9	Did you experience any discomfort or bleeding during brushing	89.00	3.94	87.22	5.65	0.42
10	How did you rate the overall satisfaction	87.50	2.64	85.00	6.12	0.25

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