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Effect of Different Abutment Materials on The supporting structures of Implant Retained Telescopic Mandibular Overdenture

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Abstract

Purpose: The aim of the study is to evaluate the effect of using two different abutment materials; BioHPP and cobalt-chromium on the supporting structure of implant retained telescopic mandibular overdenture by radiographic analysis.

Methodology: Fourteen completely edentulous patients were selected from Removable Prosthodontics Department, AinShams University according to the inclusion and exclusion criteria. All patients received implant assisted telescopic mandibular overdenture. After osseointegration, CAD/CAM technology was used for fabrication of primary and secondary copings of the first group by milling wax then they were casted into cobalt chromium alloy while in the other group the primary and secondary copings were made from BioHPP material by CAD/CAM milling. Crestal bone loss was measured using cone beam CT at overdenture insertion, at 6 months and at one year follow-up.

Results: The results of this study showed statistically significant difference between both groups where a lesser bone loss was observed in the BioHPP group at six months and at one year follow-up.

Conclusion: Within the limitations of the follow up period, it could be concluded that the use of BioHPP material as implant abutments in telescopic mandibular implant overdenture can make a lesser bone loss than the conventional cobalt chromium copings over one year follow up.

Keywords: BioHPP, Cobalt chromium, Implant retained telescopic overdenture, Cone Beam CT.

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Introduction:

The first option of treatment for edentulism is the implant overdenture treatment as considered by a lot of authors. It provides a higher retention, stability, patient satisfaction, masticatory function as well as high survival rates of the dental implant itself. So, implant overdentures has been widely used as a rehabilitation of edentulous patients. (1,2)

A form of implant overdenture treatment is the implant retained overdenture which has been used as a successful line of treatment. This treatment modality also achieves satisfactory pleasant results by using fewer numbers of implants and allowing oral hygiene access. (2)

A lot of attachment system can be used with implant overdentures. Some of the attachments are splinted like bars and some are non-splinted like ball and socket, magnets and telescopic attachment. (3)

Telescopic attachment is a treatment modality that has been widely and successfully used for dentures support. It is a system of double crowns in which a cylindrical form anterior crown rests on the tooth or implant to provide support for a removable crown embedded in the fitting surface of the denture. (3)

Due to its superior properties, BioHPP (Bio High Performance Polymer) has been optimized especially for dental applications. It is considered a variant of poly-ether-ether-keton (PEEK) that contains about 20% ceramic filler. Extremely good polishing properties, constant homogeneity, and high mechanical properties were obtained by this addition. (4, 5)

As a prosthetic material, BioHPP has many advantages as; nearly similar elasticity to bone which will make shock-absorbing effect (off-peak property), preparation of bridges that are light in weight with a metal-free restorations, as well as absence of corrosion. It also has no visco-plastic fractures and very low abrasion (within physiological range), low plaque affinity, low material fatigue, and high biocompatibility. (5)

Cone beam computed tomography (CBCT) has been rapidly commercialized and this will increase dental practitioner access to 3D radiographic assessments in dental practice. CBCT provides clinicians with sub-millimeter spatial resolution images of high diagnostic quality with relatively short scanning times (10-70 seconds) and a reported radiation dose equivalent to that needed for (4-15) panoramic radiograph.(6)

Hence, this study was conducted to evaluate the effect of using different abutment materials (BioHPP, cobalt chromium) on the crestal bone loss around dental implants of telescopic implant retained overdenture.

Materials and Methods:

Fourteen completely edentulous patients were selected from the outpatient clinic prosthodontics Department faculty of Dentistry Ain Shams University to participate in this study according to the following criteria:

Inclusion criteria:

- Age range between 60-77 years.
- The residual mandibular alveolar ridge exhibiting minimum 13 mm in height and minimum 5.5 mm in width.
- Patients having angle's class I jaw relation.
- Patients with adequate inter-arch distance (15 mm minimally) as determined by diagnostic jaw relation.
- Patients free from temporo-mandibular joint disorders.

Exclusion Criteria:

- Patients with history of clenching and bruxism.
- Patients with systemic diseases that might affect bone quality, contribute to bone resorption, increase the surgical risk, delay or complicate post-operative

healing (e.g patients with diabetes mellitus).
- ❖ Patients with inadequate inter-arch space (less than 15 mm).
- ❖ Alcoholic patients or smokers.
- ❖ Patients who will undergo radiation therapy or chemotherapy.

All the selected patients were rehabilitated by mucosa supported maxillary complete denture and two implants retained mandibular over denture (implants are 3.5mm in diameter and 10 mm in length). All participants were informed with the details and steps and they signed an informed consent form that they agree for implant placement.

All the patients were motivated to the treatment and were informed that they will be a part in a study that needs their best co-operation.

Any information about the case was kept private.

Laboratory investigations including complete blood picture, blood sugar level (glycocylated hemoglubin, fasting blood glucose and post-prandial blood glucose), erythrocyte sedimentation rate and alkaline phosphatase tests were all done to all patients.

Full extraoral , intraoral examinations and mounted diagnostic cast evaluation were performed for all the patients through to fulfil the pre-mentioned criteria.

Complete dentures were constructed following the conventional technique. After finishing and polishing, the dentures were delivered to the patient. Any necessary adjustments were done and post insertion instructions were given to the patient.

Pre-operative CBCT (Cone Beam CT) was carried out for all patients with gutta percha placed at the canine and lateral incisors positions for evaluation of the available bone height and width from crest of the ridge to the inferior border of the mandible to reveal at least about 5.5 mm width and 13 mm height.

Pre-operative patient preparation

Chlorohexidine (Hexitole mouth wash) mouth wash was prescribed one week before surgery.

Augmentin (Augmentin 1gm, Medical union Pharmaceuticals Co., Egypt) one tablet every 12 hours was prescribed for the patient 24 hours before surgery and for one week after surgery.

Cataflam 50mg (Cataflam 50mg, Novartis pharma, Basle, Switzerland) tablet was prescribed for one week after surgery as analgesic.

Surgical procedures

Patients were instructed to rinse with chlorohexidine mouth wash at the time of operation. Surgical area was swapped with Betadine mouth gargle (mundipharma,Australia).

The patient was given bilateral mandibular nerve block anesthesia Articaine Hydrochloride (Articaine HCI, Ubistesin Forte, 3M ESPE, Germany) followed by ring infiltration anesthesia in the surgical region.

Mid crestal incision was made at the proposed implant sites and a full thickness mucoperiosteal flap was reflected. Sequential drilling was performed with internal and external irrigation until reaching the final drill.

The selected implant was installed in the osteotomy and when noticeable resistance was encountered, the adjustable torque wrench was then attached to the implant to finalize the insertion process to bone level. The implant was advanced with the torque wrench to a minimum of 35 Ncm.Cover screw was secured over the implant with screw driver then six to seven simple interrupted sutures were done.

After surgery cone beam CT was done to confirm the implant position and to check the bone level for future follow ups.

Soft liner was applied to the fitting surface of the denture and the denture was delivered to the patient at the day of surgery. The patients were instructed to take their prescribed medications for one week after surgery and to use cold fomentation on the implant site for twelve hours, warm saline mouth wash four times a day starting 24 hours after surgery.

After 3 months osseointegration period, implants were exposed and healing abutments were threaded to the implants. Two weeks after gingival healing, open tray direct impression procedure was performed. Custom relieved acrylic tray was constructed with perforations on the implant positions.

Long impression posts were threaded to the implants and splinted in patient mouth using flowable composite resin with minimal dimensional changes to prevent movement of the impression posts during impression removal.

Light consistency rubber base impression was loaded around the impression posts and the overall impression was made using putty material (Zhermack®, Badia Polesine, Rovigo, Italy).Implant analogues were attached to the impression posts and the impression was poured using hard stone. On the model, 2 Ti-base abutments were threaded to the implant analogues.

To standardize the dimensions of the abutments (primary copings), and to make accurate results they were (both groups) designed with CAD- CAM system (Dental Designer-Premium 2013, 3Shape, Copenhagen, Denmark)/CAM system (inLab MC X5 Dentsply Sirona Dental Systems GmbH Bensheim, Germany). The cast was scanned with the desktop scanner (InEos X5 scanner Dentsply Sirona Dental Systems GmbH Bensheim, Germany) and on the software; the primary copings were designed with standardized dimension in both groups.

Conical crowns were designed for the abutments following Marburg design system (resilient type) where only the cervical part of the crown is parallel to the outer crown.The length of the abutments was 6 mm with a retention height of 3 mm, while the width of the finish line was 0.8 mm. (figure 1)

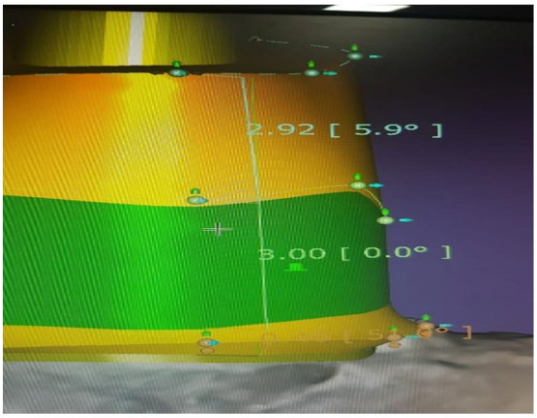


Figure 1: Primary coping planning on software

Subsequently, the designed copings were milled from either milled wax or BioHPP materials.

For group one, The designed wax patterns were milled to make their circumferential walls parallel to each other's in mesiodistal and buccolingual direction regardless implant inclination.

The primary (inner) copings made from wax and then casting was done (without the ti-base) using conventional lost wax technique.

Then the finished coping were cemented on the ti-base using self-adhesive resin cement (Rely X Unicem 2m LOT 509981m 3M ESPE, Seefeld, Germany) and tried in patient mouth. (Figure 2)

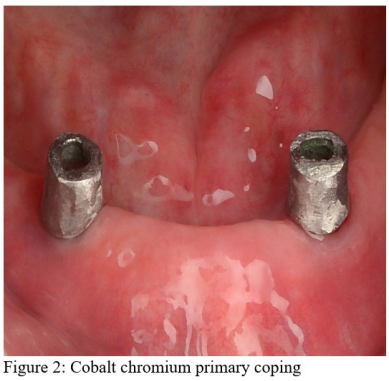


Figure 2: Cobalt chromium primary coping

The cast with primary copings was scanned again using the desktop scanner.Using the 3shape software, two secondary copings were designed with a 1.0 mm-thickness to cover the primary copings.

The secondary copings were made with retentive grooves for better contact with the fitting surface of the denture, then the designed copings were also milled in wax then invested and casting procedure was done with cobalt chromium alloy.

For group two, The designed copings were milled in BioHPP discs (BioHPP, high performance polymer) (Bredent GmbH & Co.KG,Weißenhorner Str. 2, 89250 Senden, Germany).

Then the milled copings were cemented on the Ti-bases using the same self-adhesive resin cement like group one and tried in patient mouth. (Figure 3)

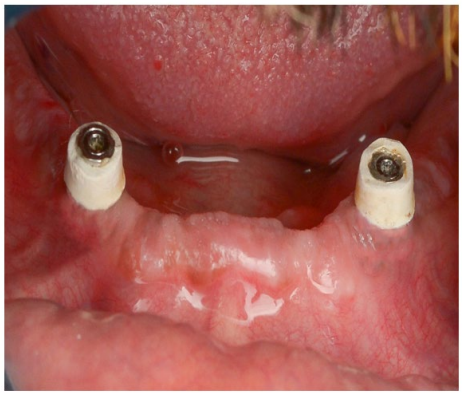
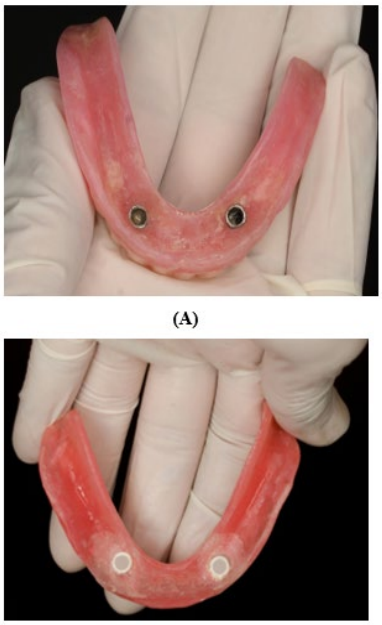


Figure 3: BioHPP primary coping

BioHPP secondary copings were made with grooves also and were painted with Visio.link Adhesive to facilitate bonding of BioHPP to acrylic resin of the denture base (pick up).

For both groups the abutments were placed intraorally and the secondary copings were placed over them and the usual pick-up was done using self-cure acrylic resin. (Figure 4)



(A)

(B)

Figure 4: Pick-up of secondary copings A: cobalt chromium B:

The overdentures were finished and delivered to the patients with emphasis on oral hygiene procedure, the occlusion was refined and follow up visits were scheduled with patients on 3 months regular recalls.

Clinical follow up:

CBCT was used to detect changes in crestal bone height at denture insertion, six months after the insertion and one year after insertion.

On each follow up visit, mesial and distal crestal bone levels were calculated from the reconstructed corrected sagittal views.

Alveolar bone height around implants was measured in relation to the implant apex. A horizontal tangent line was drawn to the apex of implant and then three successive vertical measures were taken for alveolar bone height for each side and the

mean length of three measures for each side was taken.
This was done at the two sides at each interval and the data were calculated and tabulated for statistical analysis.

Results:

To compare between the mean amount of crestal bone loss in the two studied groups during the follow up intervals, independant t test was performed and the results are shown in table (1) and figure (5).

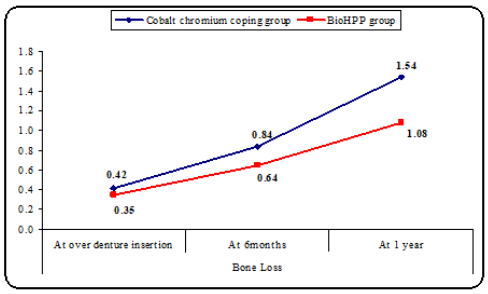


Figure 5: Follow up for bone loss in cobalt chromium coping group and BioHPP group

At the time of overdenture insertion, the mean amount of the detected crestal bone loss was (0.42) mm and (0.35) mm for group one and group two respectively. This difference of bone loss before loading was found to be statistically insignificant as shown in table (1).

Six months after loading, the mean amount of the detected peri-implant bone loss was (0.84) mm and (0.64) mm for group one and group two respectively as shown in table (1). The difference between the two groups was found to be statistically significant p-value < 0.001.

One year after implant loading, the mean amount of the detected peri-implant bone loss was (1.54) mm and (1.08) mm for group one and group two respectively as shown in table (1). The difference between the two groups was found to be statistically significant p-value < 0.001.

Table (1): mean value, standard deviation and independent T test for peri-implant bone loss for the two studied groups during the follow up period

Bone Loss		Cobalt chromium group	BioHPP group	Test value•	P-value	Sig.
		No. = 7	No. = 7			
At over denture insertion	Mean±SD	0.42 ± 0.07	0.35 ± 0.05	1.976	0.072	NS
	Range	0.3 – 0.53	0.26 – 0.4			
At 6months	Mean±SD	0.84 ± 0.06	0.64 ± 0.06	6.143	0.000	HS
	Range	0.75 – 0.94	0.55 – 0.7			
At 1 year	Mean±SD	1.54 ± 0.12	1.08 ± 0.08	8.539	0.000	HS
	Range	1.38 – 1.74	0.98 – 1.15			

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)
•: Independent t-test

Regarding group one (cobalt chromium copings), the mean value of crestal bone loss measured six months, and at the end of the follow up period was found to be 0.84 mm and1.54 mm respectively. Statistical analysis of the data revealed significant bone height change $p < 0.05$.

Regarding group two (BioHPP group), the mean value of crestal bone loss measured six months after implant loading and at the end of the one year follow up period was found to be 0.64 mm and 1.08 mm respectively. Statistical analysis of the data revealed significant bone height change $p < 0.05$.

Discussion:

05.

Discussion

CAD/CAM technology was used as it gives a standardized manufacturing process and reliable and predictable workflow.(7)

For the first group, cobalt–chromium (CoCr) alloy was used for construction of telescopic overdenture framework because it is a cheap alternative and it has a high strength, high modulus of elasticity, as well as high resistance to corrosion. (8)

While for the second group, BioHPP was used which is a recent material considered as a modification of PEEK; the medically known material. The modification was done by adding 20% ceramic fillers which gave in a stronger mechanical properties and it made it a suitable

alternative for cobalt chromium alloy which is usually used. Also the elasticity of human bone resembles the elasticity of BioHPP. Such a property made it a very useful material for the restoration of dental implants.(9)

Construction of cobalt chromium copings were made using CAD/CAM technique for designing and milling of the wax not milling the metal directly as the milled Cr-Co framework showed more distortion than the milled wax. It was suggested that milled Cr-Co framework has a tighter fit which increase the difficulty in placing the framework this is because of the wear on milling burs and the vibration in the milling machine. (10)

BioHPP copings were made by milling not pressing as pressed BioHPP has a low elastic modulus, so they are softer and more deformable compared to milled BioHPP material which will affect the accuracy of the study. (11,12)

Crestal bone loss for both groups was within the normal range that occurs during the first year of implant placement and loading.

All the implants had successful osseointegration with bone and the success criteria for the implants were all fulfilled where in the first year after implant surgery, bone resorption should not exceed 2 mm, whereas in the following years, a 0.2 mm limit should not be exceeded. (13-15)

The result also showed that both groups have slight insignificant bone loss at overdenture insertion before loading. The possible causes of bone loss without loading are surgical trauma and lack of positive stimulation due to absent occlusal forces. (16(

In both the two studied groups, there was statistically significant increase in bone loss at 6 months than at over denture insertion and also at 1 year than at over denture insertion.

Crestal bone loss can be regarded as wound healing process that occurs one month after implant insertion. The stability of the implant and implant abutment junction play an important early role in crestal bone levels. (17) However, late marginal bone resorption has been attributed to biomechanical factors. (18)

First year crestal bone loss in two-stage approach is generally caused by the micro-gap at the connection of the abutment to the fixture that invariably results in a microgap (10–50 μm), which is connected to a larger residual cavity created between the abutment screw and the internal implant wall. (19-21)

It was also found that cyclical loading of the implant-abutment interface can cause the liquid contained in implant cavities to be pumped into the peri-implant compartment. (22)

The lesser bone loss for BioHPP group may be contributed to the reduction of the stresses caused by natural forces and the forces attributed to the prosthetic restoration as this material can reduce peak masticatory forces both for vertical and lateral movement. This property increases the durability of the restoration and produces a positive effect for the patient.The chewing forces reduction is caused by the modulus of elasticity of BioHPP which lies in the range of 4000 MPa which is near the elasticity of human bone (e.g. in the mandible). (11)

Due to close match of elastic moduli of bone and BioHPP, it has been suggested that it can promote the bone remodeling process. This is will reduce the stress shielding effects and encourage bone remodeling. Hence, BioHPP could prove to be a viable alternative to titanium in constructing implant abutments or implant itself. (23)

Cobalt chromium alloys exhibit a very high modulus of elasticity; around 230 GPa and the elastic modulus of titanium and zirconia are 110 GPa and 210 GPa, respectively, which are 5–14 times greater than that of compact bone (15 GPa). (24)

These stiff materials do not adequately strain the bone which can result in disuse atrophy and bone resorption. This phenomenon is referred to as stress shielding and is an important cause of failure of orthopedic implants because it results in bone resorption. (25-27)

This was comparable to a study done by Schwitalla et al. where they reported that the values of stress occurring around the bone were higher with BioHPP abutment than in a group using titanium abutment. (28)

In addition, another study suggested that implants made from BioHPP and implants coated cervically with BioHPP lead to bone apposition of surrounding bone based on the finite element analysis and it may reduce the stiffness of existing dental implants. (29)

Comparable results also were found but when using BioHPP as crown material. They claimed that lower modulus of elasticity of crown material will absorbs more energy from the applied load, and transfers less energy to the underlying implant system. (30)

Damping the occlusal impact forces or decreasing its effect on the bone implant interface are the ways by which crown material like acrylic resin or BioHPP can reduce the forces. (30)

Conclusion

Within the limitations the follow up period, from the results obtained from this study, it could be concluded that the use of BioHPP abutments in telescopic mandibular implant overdenture has lesser bone loss than the cobalt chromium abutments over one year follow up.

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