RETENTION IN CAST METAL VERSUS 3D PRINTED METAL COPINGS IN IMPLANT SUPPORTED MANDIBULAR TELESCOPIC OVERDENTURE

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Abstract

Retention in Cast Metal Versus 3D Printed Metal Copings in Implant Supported Mandibular Telescopic Overdenture

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Aim: The aim of this RCT is to compare the effect of using two different techniques in manufacturing copings in telescopic overdenture retained by two dental implants in the interforaminal region on retention

Methods: 20 patients were randomly divided into two equal groups: (10 patients each)

Group I (The Control group) For patients in this group, the secondary crowns of the telescopic overdenture were made of Cast metal copings hand free technique.

Group II (The intervention group) For patients in this group, the secondary crowns of the telescopic overdenture were made of cast metal copings by indirect 3d printing.

Results: There was a significant difference in overall retention forces between observations. There was no significant difference in overall retention forces between groups.

Conclusion: Indirect 3d printing can be an alternative to conventional free hand waxing up of Co-Cr copings to save time taking into consideration increased cost and complex workflow.

Keywords: Telescopic overdenture, Edentulous, Implant overdenture, Retention, 3D printing.

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Introduction

Conventional dentures are the standard of care for edentulous patients but there are well-known issues with such prostheses, particularly the mandibular denture, namely their lack of stability and retention. As alveolar bone continues to deteriorate over time, previously stable dentures may start to fit improperly. More than 50% of people with mandibular full dentures may experience stability and retention issues.**(Hyland et al., 2009)**

Patients complain of pain when eating and chewing, worrying that the denture will move when they are eating, speaking, or laughing, and worry about how wearing dentures would affect their ability to interact socially. Patients frequently claim that they have to modify their meal choices due to difficulty consuming items that are difficult to bite or chew because of movement of the denture, particularly when eating out and in social situations. Some patients entirely avoid social interactions.**(Fueki et al., 2007)**

Implant-supported overdentures offer better stability and retention of the mandibular denture and better chewing function. Patients also report greater satisfaction with aesthetics because the denture is not visibly moving. Implants reduce further bone resorption and possess documented long-term success rates.**(Fueki et al., 2007)** There is now a large body of evidence that supports the proposal that a two-implant supported mandibular overdenture should be the minimum offered to edentulous patients as a first choice of treatment.**(Thomason et al., 2009)**

The telescopic attachments used with implant overdentures are one of the most interesting and distinctive types of overdenture attachments because they allow better aesthetic results with fewer implants and less restricted implant placement, better access for oral hygiene procedures, better horizontal stability because of their parallel wall design and less torque, and better load distribution on the abutment**.(Ramadan et al., 2021)**

The term 3D printing is generally used to describe a manufacturing approach that builds objects one layer at a time, adding multiple layers to form an object. This process is more correctly described as additive manufacturing and is also referred to as rapid prototyping.**(Dawood et al., 2015)**

Many different printing technologies exist, each with their own advantages and disadvantages. 3D printing is used for the fabrication of metal structures either indirectly by printing in resins or waxes for a lost-wax process, or directly in metals or metal alloys.**(Dawood et al., 2015)**

Cobalt-chromium (CoCr) is very well suited for the double crown technique due to its precise fitting, high elastic modulus, mechanical strength, lower weight compared to gold alloys, high biocompatibility and corrosion resistance.**(Stock et al., 2016)**

Retention of overdentures is of high importance clinically as it determines patients' satisfaction. Overall, patients are more satisfied with implant retained prostheses than with conventional complete dentures.**(Bayer et al., 2012)**

Materials and Methods:

The trial was designed as randomized controlled trial which was approved by the ethics committee of scientific research of Cairo University. Twenty Completely edentulous patients were recruited from the outpatient clinic of Prosthodontic Department, Faculty of Dentistry Cairo University.

Medical and dental history were taken followed by both clinical and radiographic examination. Upper and lower complete dentures were constructed according to the standard protocol

Mandibular denture duplication process was done using an orthodontic plastic box to form a mold of the denture. Barium sulfate to polymethylmethacrylate powder with a ratio of 1:4 was mixed in a blender, monomer was added to get a flowy mix of acrylic resin, The mix was inserted into the mold and the plastic box was closed and placed in a piston.

After setting of the acrylic resin mixture, the duplicated denture was removed from the box, finished, and polished, and then holes were made in the center of each tooth to be used as radiographic stent. (Fig.1)

Double CBCT scan protocol was followed. The CBCT image was imported to Blue Sky Plan® software in DICOM format for virtual implant planning and guide designing. Virtual implants were positioned in the lateral canine region. (Fig.2)

Outline of a partially guided surgical guide was drawn and STL file of the finished surgical guide was exported for printing. The surgical stent was 3d printed using LCD 3D printer.

Surgical preparation

The patients were instructed to take an oral antibiotic and an anti- inflammatory 1 hour before the surgery. The Surgical guide was disinfected using Lysoformin for 1hour before surgery. The surgical guide was removed from the disinfectant, rinsed with sterile saline, and was tried and firmly seated into the patient's mouth. Anesthesia was administrated and checked for efficiency

Guide was fixed in the patient's mouth, Three Anchor screws were placed and fully screwed into their prepared sites one by one. The guide stabilization and fixation were checked before drilling for implants.

Drilling was done under copious irrigation. Paralleling pins were inserted in the initial osteotomies and parallelism was checked. Implants were ratchet driven in a subcrestal bone level and then cover screws were threaded into the implants. (Fig. 3)

Prosthetic phase:

After 2 months, covering screws were removed and healing abutments were screwed into the implants. Primary impression was taken and open window special tray was fabricated.

Impression copings screwed into fixtures. Dental floss silk was used to splint the transfer copings together and then covered by duralay. Medium body rubber base impression material was used to take the impression. After complete impression setting, the impression copings' screws were unfastened, and the impression was removed together with the transfer coping as one unit. Implant analogues were screwed to the transfer copings. (Fig.4)

Tissue mimic was applied. Impression was then poured in type IV dental stone.

After preparing the abutments, patients were randomly divided into two equal groups: (10 patients each):

Group I (The Control group) Wax patterns for the secondary copings were made on the previously milled abutment then sprued, invested, cast with Co – Cr, finished and polished using conventional free hand technique.

Group II (The intervention group) The cast with primary milled copings was scanned using extraoral scanner Copings was designed on the Exocad software. The copings were then 3d printed in castable resin using LCD 3D printer. The castable resin patterns were sprued then invested and conventionally cast after resin elimination with cobalt chromium alloy then finished and polished.

The master cast was modified and duplicated into a refractory cast on which the Wax pattern of the metal framework was constructed for both groups, The wax pattern was then sprued, invested and cast. The framework was finished, polished, and fitted to the master cast.

The healing caps were removed and abutments were screwed in the patient's mouth and the secondary copings were placed over. The framework was tried in the patient's mouth for adaptation and seating and then modelling wax was fit on the framework for jaw relation record.

Impression of the maxillary denture was taken and poured in stone. Facebow record was registered, and then maxillary cast was mounted on semi-adjustable articulator. The mandibular cast was mounted in relation to the maxillary cast. Setting up of the lower teeth was done then tried in the patient's mouth. Processing of the mandibular denture was done in the conventional manner. Self-cure acrylic resin was used to make chairside attachment pick up. After pick up, final insertion of the overdenture in the patient's mouth was done.

Patients were recalled after one week of insertion then after 1 month, 3 months, and finally 6 months. At each interval, patients were monitored in terms of patient satisfaction and overdenture retention.

Force gauge was used to measure denture retention. Upward pull was done while patient is in upright position and head supported until denture dislodgement occurs. The measuring unit was Newton. Three readings were taken, and the average was recorded.

Fig.1: Mandibular denture duplication

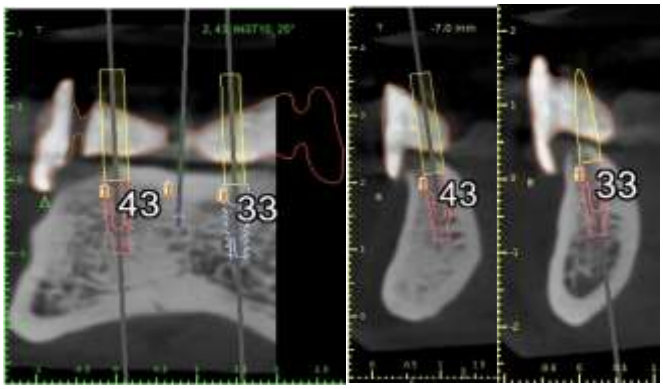

Fig. 2: Virtual implant Placement

Fig.3: Paralleling pins in place

Fig.4: Impression with transfer copings and analouges

Results: (Table 1)

Effect of time

For both groups, there was a significant difference between observation times. Retention forces significantly increased with the advance of time in both groups. For both groups, there was a significant difference between each 2 observation times. (Fig.5)

Effect of group

For all observation times, there was no significant difference between groups. (Fig.6)

	Sum of Squares	df	Mean Square	F	P value
Time	1511.045	3	1239.531	101.974	**<0.001***
Group	61.987	1	61.987	.162	0.692
group * subgroup	50.789	3	16.930	3.428	**0.023***

*p is significant at 5% level of significance

Table 1: Summary of repeated measures ANOVA for retention forces

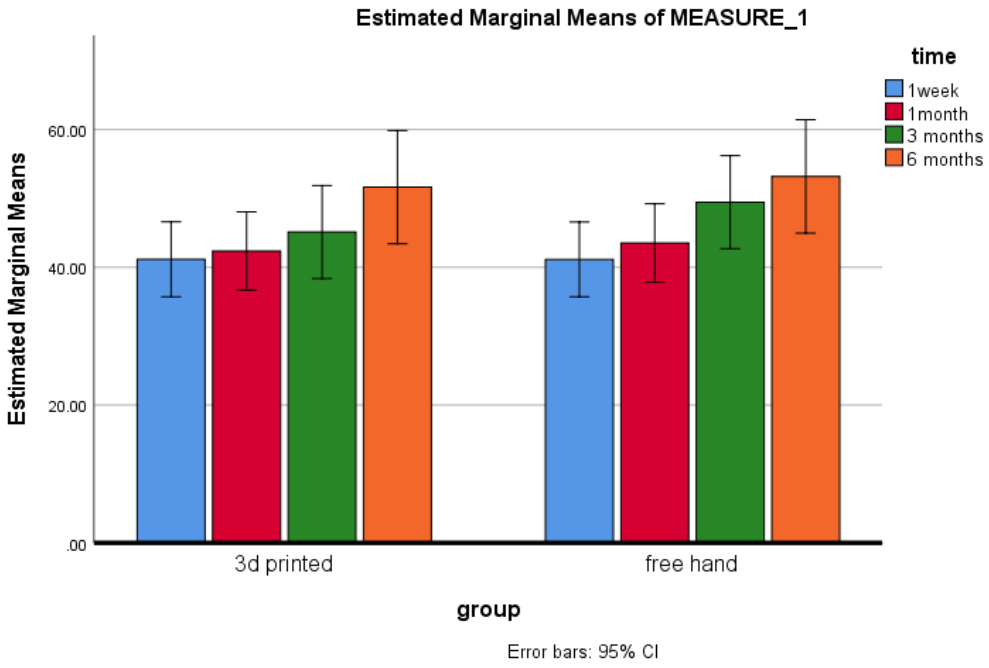

Fig. 5: Comparison of retention forces between observation times for both groups

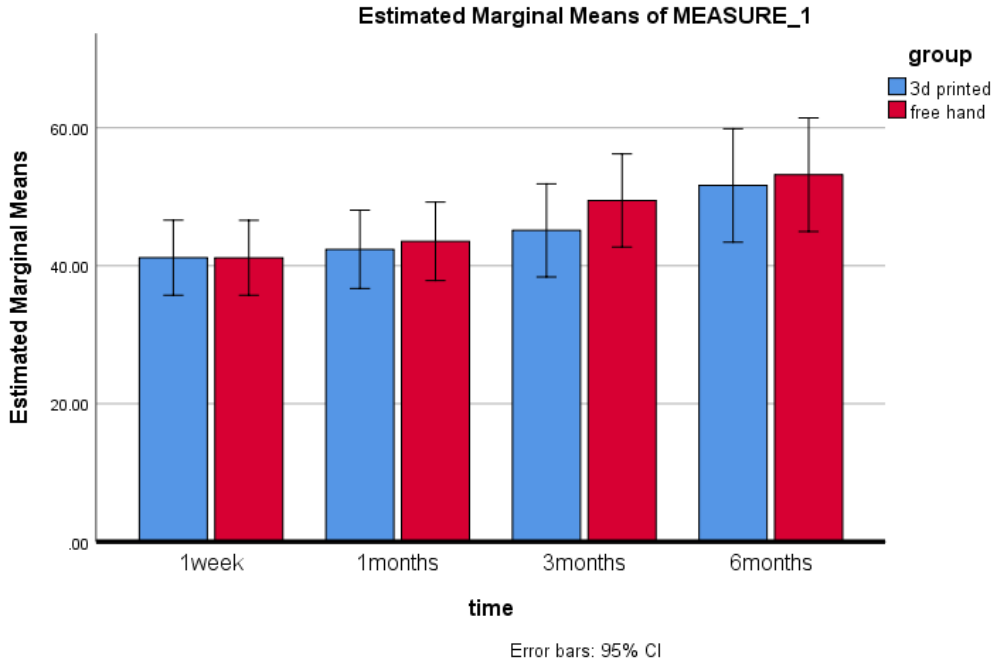

Fig. 6: Comparison of retention forces between groups at all observation times

Discussion:

To prevent any occlusal interferences that might exert unfavorable forces against the implants, the maxillary arches were chosen to be completely edentulous. The same occlusal pattern can be created in both groups, giving the study a reliable variable. Sufficient interarch space not less than 15mm in order to have

sufficient space for the copings, denture base, teeth placement and adequate closest speaking space.

Heavy smokers and patients with history of periodontal disease were excluded from the study. It was found that smoking and a history of periodontitis were significant risk factors for peri-implantitis that was more severe than usual. It was also found that increasing daily cigarette consumption was associated with a higher risk of implant failure. Smoking more than one pack per day can be viewed as a risk factor for implant failure.**(Polymeri et al., 2022)**

Studies demonstrated that poorly managed diabetes negatively affect the osseointegration and primary stability of dental implants. Hemoglobin A1C (HbA1C) test values under 7% indicate proper glycemic levels over the previous 6 to 8 weeks. Thus ,uncontrolled diabetic patients with HbA1c more than 7% were excluded.**(De Angelis et al., 2023)**

In this study, patients received implant supported mandibular telescopic overdenture due to the documented problems related to conventional mandibular complete dentures.

Since it covers a smaller surface area of the foundation tissues, the mandibular denture typically presents more challenges than its maxillary counterpart. The problem of retention and stability is more pronounced with mandibular dentures as compared to maxillary dentures. This is due to the fact that the covered surface area is approximately half to that in the maxillary arch.(Jain and Rathee, 2019) One of the distinctive benefits of the telescopic attachment is that the retention gained by the telescopic system has the potential to increase over time. This may be the case as a result of increased adaptation between the patrix and the matrix.**(Warreth et al., 2015)**

Guided implant placement was the technique of choice to control the positional errors and achieve parallelism of inserted implants avoiding non-axial loading that results from non-parallel implants. The position of the definitive prosthesis, the emergence site, the space available for the attachment components, and the thickness of the mucosa covering the bone can all be verified using a radiographic guide.**(Geng et al., 2015)**

It is thought that two dental implants will be enough to support the mandibular overdenture and give it the necessary stability and retention. Additionally, studies of several populations have shown that patients who receive two implant overdentures (as opposed to complete mandibular conventional dentures) rate their quality of life significantly higher than patients who receive new conventional dentures.**(Burns, 2015)**

Implants were placed in the canine or lateral region as this has the advantage of bone preservation and a decrease in marginal bone loss. On the other hand, when implants are placed in the premolar area, the fulcrum line upon which overdentures usually rotate and is

moved more posteriorly, often increasing the "seesaw effect", and consequently transmitting the load to the implants. This is less evident in the canine and lateral zones.**(ELsyad et al., 2019)**

Prefabricated titanium abutments, which act as primary copings, were prepared using milling machine to make sure accurate and same taper angle and height of both abutments in both groups. A convergence angle of 6 degrees results in a retention force of 5-10 N which is gained by the wedging action. It was mentioned that 4 to 8 degrees angle may be used according to the crown length and the physiologic movement of the abutment. Other authors recommended 2 degrees angle to maintain accepted retention. The smaller the convergence angle the greater the retention force.**(Kamel et al., 2021)**

Clearance of 0.3 mm occlusal and 0.03 mm axial was done between the primary and secondary copings. This space allows a minor lateral movement between the crowns and prevents stress occurrence. This non-rigid design allows some freedom in the vertical and rotational movements between both copings. Studies showed that resilient design was successful when used in implant supported overdentures.**(Hakkoum and Wazir, 2018)**

Investment powder liquid ratio and cycle of resin burn out were done according to the manufacturer's instructions. Incorrect powder liquid ratio may result in improper setting of investment, mould splits or cracks during conventional preheating**.(Rudd and Rudd, 2001)**

Intraoral attachments pick up was done to ensure no changes in occlusion or seating of the denture. It was concluded that chairside processing of housings improves retention and stability of overdentures that use stud style resilient attachment systems.**(Scherer, 2021)**

It was advocated that lower denture retention is most accurately measured by pulling the denture in vertical direction from its geographic center which is the center of gravity of the surface, or that point on which the surface of the area would balance.**(Mustafa, 2015)**

Retention forces significantly increased with the advance of time in both groups. For both groups, there was a significant difference between each two observation times. This may be due to the difference in hardness between titanium which is the primary coping material and cobalt chrome which is the secondary coping material so no wear for the secondary copings by the smooth primary copings.**(Merk et al., 2016)** Also this may be caused by the walls' contact surfaces are enough to make friction points which in time, shifted from friction points into friction surfaces, requiring a greater force to separate copings.**(Fischer et al., 2020)** In addition, this coincides with Beuer(Beuer et al., 2010) et al who proved that the surface roughness of the primary crowns affects the retention force as smooth surfaces

provide better retention because they provide better adaptation of double crowns with minimal gap distance in between. However, a study done in 2019 concluded decrease of retention force with advance of time, This may be attributed to changes in surface topography and wear of opposing surfaces of the inner and outer copings.**(Emera et al., 2019)**

For all observation times, there was no significant difference between the two groups in retention. This may be due to same copings' design and material. Moreover, despite the intervention group utilized the printing technology, yet the rest of work was carried in traditional way. That might result in deficiency of overall accuracy of final prototype. Furthermore, printed resin investment and resin elimination are very sensitive techniques. All this can end up with accumulative errors that affect the overall accuracy.**(Bhargav et al., 2018)** This finding coincides with a study done in 2018 which concluded that Co-Cr metal copings fabricated indirectly from resin patterns using rapid prototyping showed clinically acceptable marginal discrepancies and internal spaces. These spaces did not differ significantly from those obtained with the conventional lost-wax technique.**(Kim et al., 2018)**. On the contrary, a study in 2021 concluded there was a statistically significant difference in the marginal gap of Co-Cr copings fabricated by different techniques. Co-Cr copings fabricated by 3d printing had less marginal gap in relation to lost wax technique resulting in better fit and retention of the superstructure.**(Alqahtani et al., 2021)**

Within the limitations of this research, we can conclude that:

- Indirect 3D printing can be an alternative to conventional free hand waxing up of Co-Cr copings, taking into consideration increased cost and complex workflow.
- The difference in accuracy between the two techniques is insignificant and does not affect the results clinically.

Regardless the technique of copings' fabrication, both overall patient satisfaction and retention increased with time.

References:

ALQAHTANI, A. S., ALFADDA, A. M., ELDESOUKY, M., ALNUWAISER, M. K., AL-SALEH, S., ALRESAYES, S., ALSHAHRANI, A., VOHRA, F. & ABDULJABBAR, T. J. A. S. 2021. Comparison of marginal integrity and surface roughness of selective laser melting, CAD-CAM and digital light processing manufactured Co-Cr alloy copings. 11, 8328.

BAYER, S., KOMOR, N., KRAMER, A., ALBRECHT, D., MERICSKE-STERN, R. & ENKLING, N. J. C. O. I. R. 2012. Retention force of plastic clips on implant bars: a randomized controlled trial. 23, 1377-1384.

BEUER, F., EDELHOFF, D., GERNET, W. & NAUMANN, M. J. C. O. I. 2010. Parameters affecting retentive force of electroformed double-crown systems. 14, 129-135.

BHARGAV, A., SANJAIRAJ, V., ROSA, V., FENG, L. W. & FUH YH, J. J. J. O. B. M. R. P. B. A. B. 2018. Applications of additive manufacturing in dentistry: A review. 106, 2058-2064.

BURNS, D. R. J. J. O. P. O. D. I. 2015. Mandibular implant overdenture treatment: consensus and controversy. 77-86.

DAWOOD, A., MARTI, B. M., SAURET-JACKSON, V. & DARWOOD, A. J. B. D. J. 2015. 3D printing in dentistry. 219, 521-529.

DE ANGELIS, P., RELLA, E., MANICONE, P. F., DE ROSA, G., GALLOTTINI, S., LIGUORI, M. G., PAPI, P., DESANTIS, V., PASSARELLI, P. C. & D'ADDONA, A. The Effect of Diabetes and Hyperglycemia on Horizontal Guided Bone Regeneration: A Clinical Prospective Analysis. Healthcare, 2023. MDPI, 1801.

ELSYAD, M. A., MARYOD, W. H. & MOSTAFA, A. Z. J. J. O. P. 2019. Effect of implant position on clinical and radiographic outcomes of locator-retained mandibular overdentures: a 1-year prospective study. 28, e699-e704.

EMERA, R., ABELKHALEK, S., RASHED, M. J. I. J. O. D. & SCIENCES, M. 2019. Periodic retention evaluation of two implants retained complete mandibular overdenture with zirconia-PEEK telescopic attachments. 18, 15-24.

FISCHER, C. A. I., GHERGIC, D. L., VRANCEANU, D. M., ILAS, S. A., COMANEANU, R. M., BACIU, F. & COTRUT, C. M. J. M. 2020. Assessment of force retention between milled metallic and ceramic telescopic crowns with different taper angles used for oral rehabilitation. 13, 4814.

FUEKI, K., KIMOTO, K., OGAWA, T. & GARRETT, N. R. J. T. J. O. P. D. 2007. Effect of implant-supported or retained dentures on masticatory performance: a systematic review. 98, 470-477.

GENG, W., LIU, C., SU, Y., LI, J., ZHOU, Y. J. I. J. O. C. & MEDICINE, E. 2015. Accuracy of different types of computer-aided design/computer-aided manufacturing surgical guides for dental implant placement. 8, 8442.

HAKKOUM, M. A. & WAZIR, G. J. T. O. D. J. 2018. Telescopic denture. 12, 246.

HYLAND, R., ELLIS, J., THOMASON, M., EL-FEKY, A. & MOYNIHAN, P. J. J. O. D. 2009. A qualitative study on patient perspectives of how conventional and implant-supported dentures affect eating. 37, 718-723.

JAIN, P. & RATHEE, M. 2019. Stability in mandibular denture.

KAMEL, A., BADR, A., FEKRY, G. & TSOI, J. J. J. O. C. M. 2021. Parameters affecting the retention force of CAD/CAM telescopic crowns: a focused review of in vitro studies. 10, 4429.

KIM, S.-B., KIM, N.-H., KIM, J.-H. & MOON, H.-S. J. T. J. O. P. D. 2018. Evaluation of the fit of metal copings fabricated using stereolithography. 120, 693-698.

MERK, S., WAGNER, C., STOCK, V., SCHMIDLIN, P. R., ROOS, M., EICHBERGER, M. & STAWARCZYK, B. J. M. 2016. Retention load values of telescopic crowns made of Y-TZP and CoCr with Y-TZP secondary crowns: Impact of different taper angles. 9, 354.

MUSTAFA, A. J. T. D. J. 2015. Effect of the lingual ledge of neutral zone impression on the retention and stability of mandibular complete denture in elders with atrophied alveolar ridge. 12, 111-118.

POLYMERI, A., LOOS, B. G., ARONOVICH, S., STEIGMANN, L. & INGLEHART, M. R. J. J. O. P. 2022. Risk factors, diagnosis, and treatment of peri-implantitis: A cross-cultural comparison of US and European periodontists' considerations. 93, 481-492.

RAMADAN, R., ELSHERBEENY, Y., THABET, Y., KANDIL, B., GHALI, R. J. D. & PROBLEMS, M. 2021. Retention of a telescopic overdenture on customized abutments after the simulation of 1 year in function. 58, 201-206.

RUDD, R. W. & RUDD, K. D. J. T. J. O. P. D. 2001. A review of 243 errors possible during the fabrication of a removable partial denture: part II. 86, 262-276.

SCHERER, M. D. J. I. D. T. 2021. When to use laboratory vs. chairside processing of overdentures. 12, 16-23.

STOCK, V., SCHMIDLIN, P. R., MERK, S., WAGNER, C., ROOS, M., EICHBERGER, M. & STAWARCZYK, B. J. M. 2016. PEEK primary crowns with cobalt-chromium, zirconia and galvanic secondary crowns with different tapers—A comparison of retention forces. 9, 187.

THOMASON, J. M., FEINE, J., EXLEY, C., MOYNIHAN, P., MÜLLER, F., NAERT, I., ELLIS, J. S., BARCLAY, C., BUTTERWORTH, C. & SCOTT, B. J. B. D. J. 2009. Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients-the York Consensus Statement. 207, 185-186.

WARRETH, A., ALKADHIMI, A. F. & SULTAN, A. 2015. Mandibular implant-supported overdentures: attachment systems, and number and locations of implants–Part I.