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Seven-Year Retrospective Study on Conometric Retention for Complete Fixed Prosthesis

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Abstract: The aim of the present work was to evaluate retrospectively, after seven years of function, the efficacy of a conometric retention to stabilize complete prostheses (CPs) on four implants. Data from twenty-three patients with CPs supported by four implants, with at least seven years of follow up were retrieved. All the CPs were immediately fixed to the implants using a conometric retention. Outcome measures were prosthesis and implant success, biological and prosthetic complications, probing pocket depth changes, marginal bleeding, and plaque index changes. A total of 92 implants were evaluated. No fixture or abutment fractures were reported. No abutment unscrewing was reported. Four framework fractures occurred after three, four, six, and seven years of function. The overall success rate of the rehabilitation was 82.6%. Mucositis was observed in eight patients and 13 implants. No peri-implantitis was recorded. A 0.55 mm difference of PPD and 0.74 mm of MBL was recorded after seven years ($p < 0.001$). The present implant-supported conometric retention system proved to be effective in giving fixed retention to a CP supported by four implants. Biological complications were easily detected and treated. An adequate metal framework should be provided to the definitive restoration to avoid fractures in the long term.

Keywords: dental implants; conometric abutment; fixed dentures

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1. Introduction

Mandibular complete conventional dentures are frequently associated with stability and retention problems, soreness, pain, and further loss of function [1]. To overcome these problems and improve function, speech, and comfort of edentulous patients, different implant supported fixed and removable solutions have been introduced. Among these, a two-implant supported removable overdenture has been identified as the elective treatment to restore completely edentulous mandibles [2]. Even if implant supported overdentures reduce the overall treatment time and the overall morbidity in cases of severe atrophic jaws, fixed implant supported restorations present better stability, retention, and aesthetics with a reduced extension on the soft tissue [3].

Recently, a systematic review compared mandibular implant supported overdentures and fixes prostheses in terms of patient reported outcomes [4]. From a patient perspective, implant supported overdentures showed greater satisfaction in terms of ease of cleaning. On the other hand, fixed implant supported prostheses were associated with an overall better quality of life, with higher scores in terms of comfort, ease of chewing, and stability [4]. Therefore, the implant supported restorative option must be widely discussed with the patient, considering anatomical and socioeconomical factors and the patient's expectation.

In the case of implant supported fixed prostheses in the mandible, the use of four implants has been widely investigated and is now a well-established and scientifically validated protocol, with a high patient satisfaction rate [5]. Indeed, recent scientific evidence has shown that implant-supported prosthetic rehabilitations are able to improve chewing

and speech through improved denture stability. Furthermore, in the same systematic review, it was stated that supporting a conventional removable prosthesis through implants is the most cost-effective solution when patients want to improve their oral health quality [6].

Traditionally, to fix prosthetic superstructures to dental implants, two main types of connection were proposed: screw retained or cemented connection. However, both these connection types present biological and technical advantages and disadvantages. Even if screw-retained restorations are easier to remove and retrieve in case of complications or need for intervention, cemented restorations allow an easier compensation of implant angulations through individualized abutments [7]. However, both these connection types have their limitations. Screw-retained restorations have been associated with a high rate of technical complications, such as screw loosening or fracture, and ceramic chipping. On the other hand, cemented retained prostheses have been associated to biological complications, such as peri-implantitis, fistulae, or suppuration due to the possible presence of excessive cement [8].

As an alternative to the traditional retention systems proposed to restore dental implants, conometric retention has been proposed, as a successful method to provide fixed retention to complete mandibular dentures immediately after implant placement (Figure 1).

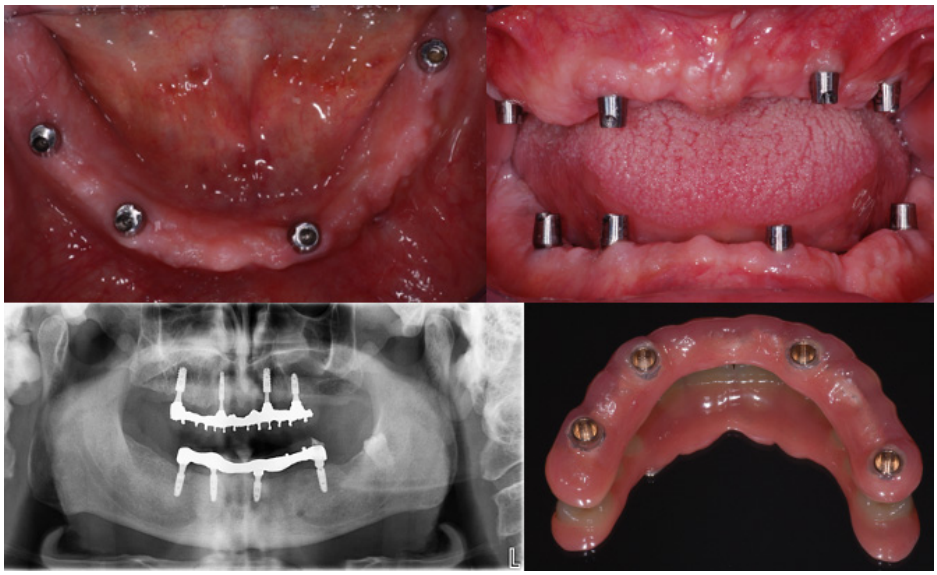

Figure 1. Clinical images showing a complete denture fixed with dental implants and conometric abutments.

Conometric retention consists of the perfect fit of two cones, one on the surface of the abutment and one inside the prosthesis. The prosthesis cone is placed on the abutment with absolute precision, without the use of fixation screws or cement. Retention between the two components is achieved by the friction created due to the perfect fit between the two components. Coupling and activation of retention is achieved by simple vertical pressure of one component on the other, while uncoupling is achieved by application of perpendicular lateral forces [9]. From in vitro evaluations, an insertion force of 20 N led to a constant retentive force comprised of between 5 and 10 N, providing constant fixed retention to complete dentures [10]. Clinically, different studies reported a cumulative implant survival rate ranging between 98.7% and 100%, and a 100% prosthetic survival rate was observed after a follow-up period comprised of between 12 and 60 months [11–13]. Even if clinical data report encouraging implant and prosthetic survival rates, to the best of our knowledge, there is a lack of studies presenting medium to long term follow-up data on conometric retention for mandibular complete dentures.

Therefore, the aim of the present retrospective study was to report the 7-year follow up data of a conometric retention system (ankylos SynCone) used for fixed retention of

four implant supported mandibular complete dentures in terms of marginal bone level (MBL), and implant and prosthetic success rate.

2. Materials and Methods

2.1. Patient Selection

This study reports the retrospective evaluation of radiographic and clinical data of patients treated between 2013 and 2015 with complete dentures supported by four parallel dental implants (Ankylos, Dentsply Friadent GmbH, Mannheim, Germany). Patients were informed about the purpose of the study, the clinical procedures, and the materials to be used, and gave their written consent to the treatment. All the procedures were conducted in accordance with the Helsinki Declaration.

Inclusion criteria were the following:

- Patients with a complete denture fixed by four parallel implants
- Systemically healthy patients
- Patients with complete radiographical and clinical documentation
- Patients with an FU period of at least 7 years.

Exclusion criteria were the following:

- Patients with systemic diseases
- History of intake of drugs that affect bone metabolism
- History of radiation therapy in the head and neck region
- Smoking habit (more than 10 cigarettes per day)
- Drug or alcohol abuse.

2.2. Surgical and Prosthetic Procedures

All the surgical and prosthetic procedures were performed by the same surgeon in a standardized way. A complete mandibular denture (CD) was provided to all patients. After local anesthesia a full thickness mucoperiosteal flap was elevated, and four dental implants (Ankylos, Dentsply, Germany) were placed 2 mm subcrestally, using a free-hand one stage procedure, reaching a minimum insertion torque of 25 Ncm. Standard conical abutments (SynCone Abutments, Dentsply, Germany) were selected and screwed to the implants using a positioning jig to achieve a parallel orientation within them, according to the indications of the manufacturer. The previously delivered mandibular definitive CDs were converted into a fixed conometric retained prosthesis following the reported procedure. Specific secondary copings (SynCone Caps, Dentsply, Germany), providing a conical fit to the abutments, were cured into the CD base directly in the mouth of the patients, using a self-curing cold resin (Probase Cold, Ivoclar, Schaan, Liechtenstein). After the resin polymerization, CDs were removed, reinforced with a metallic framework, and delivered to the patient the same day. Oral hygiene instructions were provided to the patients. One and two weeks after the surgery, the oral hygiene, the occlusion, and the stability of the prosthesis were checked. Five weeks after the surgery, the prostheses were removed to check implant stability and soft tissue healing. If needed, the CDs were relined.

2.3. Clinical Evaluation

Peri-implant tissues and implant health status were evaluated using the following parameters: (i) plaque index (PI), score 0–1 (0 = absence of plaque around the abutment, 1 = presence of plaque around the abutment); (ii) probing pocket depth (PPD) measured from the mucosal margin to the bottom of the pocket in millimeters; (iii) modified bleeding index (MBi), score 0–3. The aforementioned parameters were assessed with a periodontal calibrated plastic probe (TPS probe, Vivadent, Schaan, Liechtenstein).

Any sign of peri-implant inflammation was treated following the most recently available guidelines [14]. A standardized ortopantomography was taken for each subject at the 7-year follow-up visit to compare the peri-implant bone changes (Marginal Bone Level, MBL) over time with the baseline. As previously reported by Bressan and Lops [12], the

distance in the radiographs between the implant margin and the most coronal position of bone-to-implant contact was assessed in millimeters at the mesial and distal aspects of each implant. Measurements were rounded to the nearest 0.01 mm. The ratio between the implant length, measured on the radiograph, and the real length of the implant was calculated and used to evaluate the linear distortion [15]. Technical complications were recorded during the follow-up visits.

2.4. Statistical Analysis

The data were collected in an Excel sheet, and then statistically analyzed (software SPSS 20.0—IBM). Descriptive statistics were used for continuous variables, while frequency analysis was used for dichotomous variables. The normality of continuous variables was previously tested with the Kolmogorov–Smirnov test. The difference between different timeline examinations was tested with paired *t*-test for normally distributed variables, while a Mac Nemar test for related samples was used to test the distribution of dichotomous variables before and after treatment. A diagnosis was performed on the model to confirm the appropriateness of assumptions. The software MlWin 2.24 was used for such analysis. A *p*-value lower than 0.05 was considered as statistically significant.

3. Results

Data from twenty-three patients (14 females and 9 males with an average age of 67 years, with a range of 54–82) were retrieved from medical records. A total of 92 implants and Syncone abutments were evaluated. Implants and abutments features are reported in Table 1. Implants were 3.5 and 4.5 mm in diameter and 8, 9.5, and 11 mm in length. Most of the implants were 3.5 mm in diameter (70 vs. 22) and were comprised of between 8 and 9.5 mm in length (43 and 38). Most of the abutments used were straight or slightly inclined (0° and 7.5°) and with a height between 1.5 mm and 3.0 mm.

Table 1. Characteristics of the implants and of the abutments. (intra = intraforaminal position; extra = extraforaminal position.)

Implants							
Length (mm)	Diameter (mm)						
	3.5		4.5		Total		
	intra	extra	intra	extra	intra	extra	
8	4	28	2	9	6	37	43
9.5	23	5	7	3	30	8	38
11	10	0	0	1	10	1	11
Total	37	33	9	13	46	46	92
SynCone abutments							
Sulcus height of the abutments (mm)							
degree	1.5		3.0		4.5		Total		
	Intra	extra	Intra	extra	intra	extra	intra	extra	Total
0°	9	11	23	15	1	1	33	27	60
7.5°	4	7	6	7	0	1	10	15	25
15°	0	0	2	4	0	0	2	4	6
22.5°	1	0	0	0	0	0	1	0	1
Total	14	18	31	26	1	2	46	46	92

3.1. Prosthetic Evaluation

No fixture or abutment fracture, nor abutment unscrewing, nor retention loss were recorded during the 7-year observation period. Conversely, four framework fractures occurred at three, four, six, and seven years after delivery of the prosthesis. Fractures were at the level of distal cantilever. In case of fracture, the CP was removed and reinforced with a new metal framework, to improve the strength or the prosthesis. CP prostheses were then placed into position. All the prosthetic rehabilitations were still in function at the end of the 7-year follow-up period, with a success rate of 82.6%.

3.2. Biologic and Radiographical Evaluations

During the 7-year observation period, mucositis was observed in 8 patients and 13 implants. No peri-implantitis was recorded. All inflammations were successfully treated with interceptive supportive therapy, consisting of professional cleaning followed by 0.2% chlorhexidine mouth rinses, three times per day for two weeks. Data on PI and MBI parameters at the loading time and after two, five, and seven years of function are presented in Figures 2 and 3. Briefly, PI values remained stable after 2 and 5 years of follow-up, while there was a worsening of values after seven years of follow-up: in fact, most of the implants (59 out of 92) presented plaque, and this value was almost doubled compared to the 5-year follow-up. A similar trend was seen for MBI values. During the follow-up years, the MBI value of 2 increased from 4 implants to 7, 10, and 18 implants, in the follow-ups to 2, 5, and 7, respectively. The MBI value of 1 went from 25 to 28, 29 and 37, while the MBI value of 0 went from 63 to 57, 53 and 37.

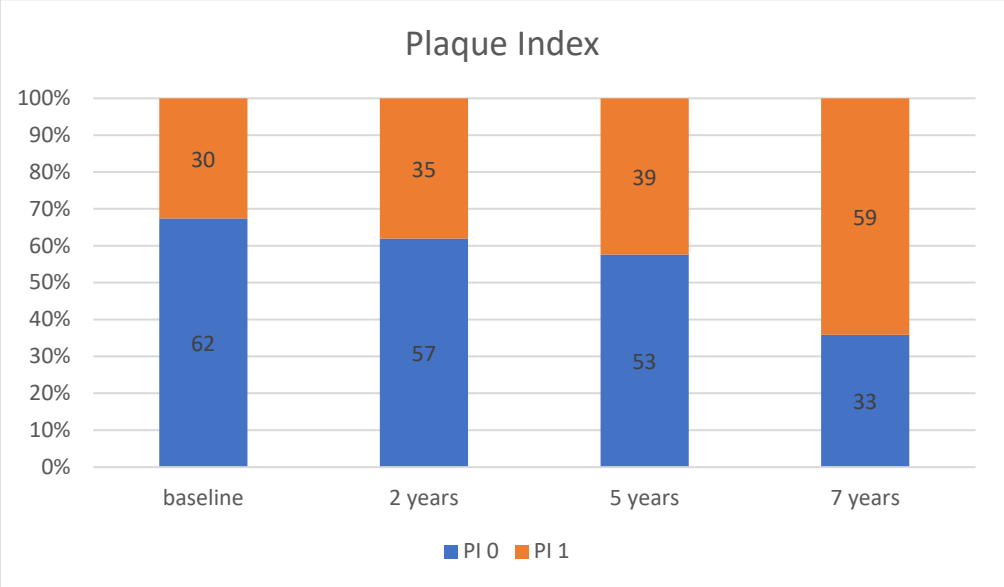

Figure 2. Plaque Index parameters on the different follow-up time points.

Results observed for the PPD and MBL index at different time points (0, 2, 5, and 7 years) are listed in Table 2. A statistically significant difference was found for both the parameters after seven years from prosthesis delivery. The mean difference between 0 and 7 years was 0.55 mm for the PPD index ($p < 0.001$) and 0.74 mm for the MBL index ($p < 0.001$).

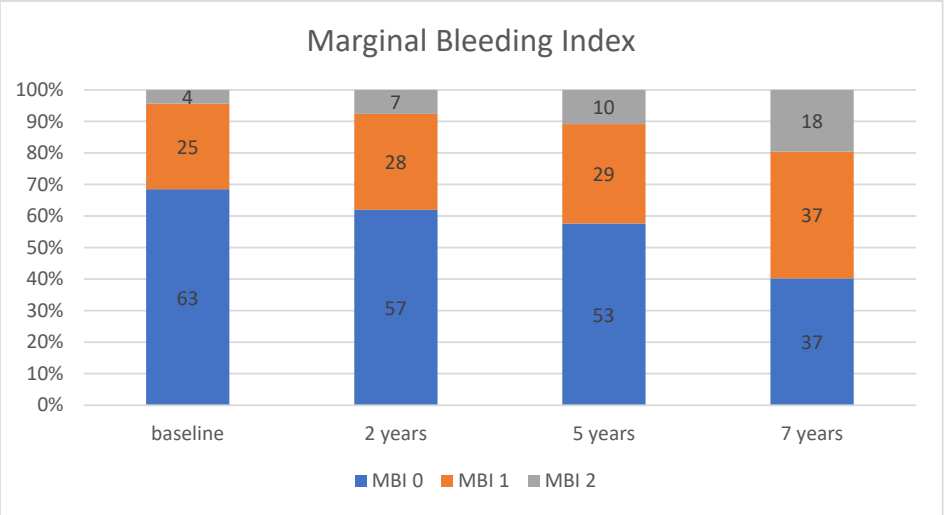

Figure 3. Marginal Bleeding Index parameters on the different follow-up time points.

Table 2. Mean value and standard deviation for PPD and MBL, and results from the ANOVA test.

Parameter	Baseline Mean (±SD)	2 y of Function Mean (±SD)	5 y of Function Mean (±SD)	7 y of Function Mean (±SD)	0–2 y Mean Difference (*p*-Value)	0–5 y Mean Difference (*p*-Value)	0–7 y Mean Difference (*p*-Value)
PPD	1.18 (±0.39)	1.21 (±0.41)	1.36 (±0.48)	1.74 (±0.88)	0.02 ($p = 0.67$)	0.17 ($p = 0.001$)	0.55 ($p < 0.001$)
MBL	1.22 (±0.91)	0.81 (±0.89)	0.71 (±0.89)	0.49 (0.86)	0.41 ($p < 0.001$)	0.51 ($p < 0.001$)	0.74 ($p < 0.001$)

4. Discussion

This retrospective study aimed at investigating MBL, implant, and prosthetic survival rate of four implant supported conometric retained fixed mandibular dentures after a follow-up period of seven years. The present study showed a high implant and prosthetic survival rate and an absence of marginal bone loss, revealing this solution to be stable and reliable in the long term.

Implant supported prostheses, especially in the mandible have been shown to significantly improve patient quality of life, if compared to complete removable dentures [16]. Implant supported overdentures provide various advantages compared to full arch implant supported fixed rehabilitations, such as reduced treatment costs and better cleansability. However, according to a recent RCT [17], systematic review, and meta-analysis [6] patients tend to prefer the latter solution. Conometric retention can therefore be a valuable alternative to provide fixed retention to mandibular complete dentures, merging the advantages of the abovementioned rehabilitative options.

Conometric retention uses the friction between the abutment and the titanium coping to retain the prosthesis without the use of screws or cement [18]. This system has shown outstanding prosthetic results in the short term, both for partial [18,19] and full-arch rehabilitations [12,13], with several advantages both for patients and clinicians. In detail, they can provide fixed support to full arch prostheses, permitting an easy and faster removal of the prosthesis, making professional cleaning and regular check-up easier to perform. Furthermore, the whole procedure can be conducted in the dental office, without the need of dental technicians, reducing the overall time and costs of the treatment. Also, the lack of cement and screws highly reduces the risk of mechanical or biological complications [20].

In the present study, after seven years, clinical and radiographical parameters were within health thresholds. Even if the mean PPD significantly increased during the observed period, with a mean difference of 0.55 mm between the baseline and the 7-year follow-up, at this timepoint the mean PPD value was 1.74 (±0.88) mm. This value results in being lower than those reported both for fixed (2.4 mm to 3.73 mm) [21,22] and removable

(2.3 mm to 3.5 mm) [23,24] implant supported prostheses after a minimum follow-up period of 6.5 years. It can be hypothesized that this lower PPD value might be related to better cleansability of the conometric-retained prosthesis, leading to high stability and health of the peri-implant soft tissue.

This hypothesis could also explain the high stability of MBL along the investigated timepoints. In our study, the mean MBL after a follow-up period of seven years was 0.49 ± 0.86 mm, meaning that the mean MBL was above the implant shoulder. However, a statistically significant mean marginal bone loss (0.74 mm) was found compared to the baseline. Nevertheless, this marginal bone resorption over time can be explained as part of the physiological bone remodeling occurring after implant placement and is compatible with peri-implant tissue health [25,26]. Additionally, subcrestal implant placement has been associated with higher MBL over time [27]. In this study, all the implants were placed 2 mm subcrestally, and this could explain the low mean marginal bone loss after seven years.

The stability of peri-implant tissues over time might also be related to the loading type. Immediate load requires less abutment dis- and re-connections, minimizing the trauma to peri-implant hard and soft tissues, and therefore improving their stability over time [28,29]. Furthermore, when the final prosthesis is immediately delivered, it allows the overall treatment time and costs to be reduced, with great advantage both for patients and clinicians [28,30]. Even if immediate implant load has traditionally been considered a risky procedure for implant osseointegration [31], it has been proven to be a reliable and reproducible option for the rehabilitations of completely edentulous mandible [32]. In the present study, all the implants were immediately loaded, and seven years after, no implant failed. This result is in line with the extremely high implant success rate (94.4–100%) reported in the literature [32].

Implant supported overdentures have been associated with a higher risk of implant failure compared to fixed full-arch rehabilitations [33,34]. This might be related to the better mechanical stability of fixed prosthesis and better stress distribution between the implants. In the present study, no implant failure occurred during the 7-year follow-up period. Conometric retention provide a good force distribution between the four parallel implants, even with a reduced soft tissue support of the prostheses. Therefore, it can be postulated that this solution allows the prostheses to behave more like a fixed than a removable implant supported solution in terms of implant survival rate.

On the other hand, four prostheses frameworks fractures were observed during the follow-up period (17.4%), with a prosthetic success rate of 82.6%. This finding is in line with the 12% framework fracture rate reported by previous studies for implant supported overdentures [20,35]. It must be noted that all the fractures occurred at the distal cantilever portion, and it was always possible to restore the prostheses. Extended cantilever has been reported as a risk factor for prosthetic complications, and therefore should always be avoided [20].

5. Conclusions

Age is a key factor when implant rehabilitation is proposed. In fact, as the population ages, the cleansing capabilities of implant-supported prostheses deteriorate. This is precisely why the tapered-supported prosthesis described in the article represents an optimal solution, in the authors' opinion, because it is easily removable and cleansable, combining the removability characteristics of a traditional prosthesis and the stability of a fixed implant-supported prosthesis. Within the limitations of the present retrospective study, it can be concluded that conometric retention for full-arch mandibular rehabilitation is a reliable solution in the long term. A larger population sample and follow-up will allow even stronger conclusions to be made in the future.

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visualization, R.F.; supervision, E.B. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

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