Maxillary Three-Implant Overdentures Opposing Mandibular Two-Implant Overdentures: 10-Year Prosthodontic Outcomes

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Purpose: This study aimed to evaluate the 10-year prosthodontic outcomes with splinted and unsplinted designs for maxillary overdentures on three implants opposing mandibular two-implant overdentures. Materials and Methods: Using two similar implant systems, 40 edentulous participants with existing mandibular two-implant overdentures were randomly allocated to two prosthodontic treatment groups (splinted design with bar units; unsplinted design with ball attachments). Participants had three narrow-diameter implants placed in their edentulous maxillae using a one-stage surgical procedure, and they were conventionally loaded with overdentures. Prosthodontic maintenance events were documented at 1-, 2-, 5-, 7-, and 10-year recalls. Results: Progressive attrition of the cohort resulted in 36 participants being seen for the 1-year recall, 31 participants for the 2-year recall, 26 participants for the 3-year recall, 28 participants for the 5-year recall, 26 participants for the 7-year recall, and 23 participants (nearly 60%) for the 10-year recall. Data showed no significant differences in prosthodontic maintenance or success associated with patrices, matrices, or other aspects of the overdentures using the different attachment systems and designs. Conclusion: Maxillary three-implant overdentures are a viable treatment option for edentulous patients wearing opposing mandibular two-implant overdentures. There were no differences in prosthodontic maintenance and success between the splinted (bar) and unsplinted (ball) designs. Int J Prosthodont 2016;29:327–336. doi: 10.11607/ijp.4631

Resolution of edentulism using fewer implants for overdentures could conform to an acceptable minimal treatment protocol.1-3 Consensus statements considering a minimal standard of care4,5 for mandibular implant overdentures fail to recognize evolving therapeutic methods and multiple clinical approaches6,7 There are concerns about the potential for damaging longitudinal changes in the maxillae of edentulous patients with complete dentures opposing mandibular two-implant overdentures.8-10 These changes could be prevented by placing implants in the maxilla to support an overdenture. Historically, placement of four to eight splinted implants in the maxilla was recommended for overdentures. These recommendations were based on studies in which the opposing mandibles had intact dentitions, extensive crowns/bridgework, fixed partial dentures, or removable overdentures on more than two implants.11-18 However, there is no compelling evidence from long-term randomized trials, prospective studies, or retrospective studies suggesting that patients with mandibular two-implant overdentures should have four or more implants for opposing maxillary overdentures. Considering an alternative approach using fewer maxillary implants could be more appealing for elderly patients with mandibular two-implant overdentures.

Long-term randomized controlled trials (RCTs) or observational studies on prosthodontic maintenance of maxillary implant overdentures of 10 years or longer are rare.19-23 In short-term trials and studies, there are recurring problems of heterogeneity in participant selection, inclusion criteria, and overdenture design, and quantification of prosthodontic maintenance.24 The substantial burden of prosthodontic maintenance is influenced by the specific attachment system, the prosthodontic design of the overdenture, and the number and distribution of the implants.19-21,25
Higher incidences of prosthetic maintenance are anticipated with maxillary overdentures without palatal coverage (open palate).\textsuperscript{19,20,22,23} The literature on maxillary overdentures often focuses on surgical outcomes, neglects detailed prosthetic maintenance, and sometimes even combines the results with those of mandibular overdentures.\textsuperscript{26–34} The prosthetic community has not yet reached consensus on any minimum approach for maxillary overdentures opposed by mandibular two-implant overdentures.

Splinted prosthetic designs have been described in short-term RCTs on four- and six-implant maxillary overdentures in different patient cohorts with opposing mandibular four-implant overdentures.\textsuperscript{35,36} These studies report 100% overdenture survival rate without detailing prosthetic maintenance. Prospective and retrospective studies with 2 to 20 years of follow-up have also been reported.\textsuperscript{27,32,37–41} Unsplinted prosthetic designs, on the other hand, are described in short-term prospective\textsuperscript{32,43} and retrospective\textsuperscript{44} studies of maxillary four-implant overdentures not detailing primary outcomes related to prosthetic maintenance. Case series reports on two or four unsplinted implants for maxillary overdentures also lack prosthetic maintenance details.\textsuperscript{55,46}

In 2001, the present authors reevaluated prosthetic treatment planning for edentulous patients expressing an interest in maxillary overdentures to oppose existing mandibular two-implant overdentures. The published surgical and patient outcomes showed that rehabilitation using three implants for maxillary overdentures is possible.\textsuperscript{37–49} The purpose of this aspect of the RCT was to report on 10 years of prosthetic maintenance (primary outcome) and success (secondary outcome) of splinted and unsplinted prosthetic designs of maxillary three-implant overdentures opposing mandibular two-implant overdentures.

Materials and Methods

Participant Sample

A total of 96 patients were approached regarding a RCT at the Oral Implantology Research Group, Sir John Walsh Research Institute, Faculty of Dentistry, University of Otago, Dunedin, New Zealand. Ethical approval was obtained from the Lower South Ethics Committee, New Zealand (LRS/06/05/020), and the Australian New Zealand Clinical Trials Registry was notified (ACTRN12605006536662). Of these, 40 participants (21 women, 19 men; mean age 64 years, range 55–76 years) were selected. Participants were allocated to one of two implant systems, both with narrow diameters and moderately roughened surfaces (Brånemark System, Nobel Biocare; Southern Implants), using a table of random numbers, sequentially numbered opaque sealed envelopes, and maximum concealment by a senior dental assistant. Supplementary random allocation was to further equal groups of splinted or unsplinted prosthetic designs. Blinding of participants and researchers was not possible due to the physical nature of the intervention. Specific details of inclusion/exclusion criteria, bone quantity/quality according to known classifications,\textsuperscript{50,51} and surgical procedures have been previously published.\textsuperscript{47–49} On completion of the one-stage surgical procedure with connection of healing abutments, the maxillary complete dentures of the participants were generously relieved and tissue conditioners placed (Viscogel, Dentsply) to allow wearing of the prostheses postoperatively.

Prosthetic Procedures

Following a conventional loading protocol, the healing abutments were removed and replaced with permanent abutments (Fig 1). The respective matrices were included in the intaglio surfaces of participants’ existing maxillary complete dentures using closed-mouth reline impression techniques (Fig 2). For the splinted design groups, either multiunit (Brånemark) or standard abutments (Southern) were used with corresponding gold cylinders. For both of these groups, micro-U-shaped bar units with corresponding matrices were used (DCA-512, Nobel Biocare). For each of the unsplinted design groups, each system’s ball abutments were used with their Dalla Bona–type gold alloy matrices (Brånemark: DCA-532, Nobel Biocare; Southern: ZZA1201A Preci-Ball Orax Alloy, Ceka Preci-Line, Alphadent NV).

Laboratory procedures were standardized and were carried out by one dental technician (N.W.). For the splinted designs (bar attachments), the micro-U-shaped bars were sectioned to size, positioned, and joined to the gold cylinders (Pattern Resin, GC). Bar segments were then invested, the pattern resin was burned out, and Oxynon Flux (Degussa) was applied to joint areas and soldered using a gas/oxygen flame with gold solder (Degunorm Lot 700, Degussa). After recovery, cleaning, and polishing, soldered frameworks were checked for passive fit. For the unsplinted designs (ball attachments), the matrices were positioned on the analogs with a vertical path of insertion using a surveyor, and subsequently undercut were blocked out. For all participants, two postdams were scribed: a conventional postdam followed by a second horseshoe-shaped postdam starting and finishing at the hamular notches. Overdentures were processed with high-impact acrylic (Lucitone 199, Dentsply).
Insertion procedures were performed using pressure-indicating paste and occlusal adjustment with clinical remount if necessary. Participants had full palatal coverage of their maxillary primary and secondary stress-bearing areas for the first year, which was thereafter reduced to the secondary stress-bearing areas with an open palate design. ⁵²

**Prosthodontic Maintenance**

Events per participant were documented using categories and standardized criteria ⁵³ by one researcher (A.P.) for the first 7 years and another calibrated researcher (S.M.) to year 10. Patrices and matrix maintenance events were separated from general overdenture maintenance, which included fractures, puncture fractures, and relines or remakes. The need to reline the maxillary overdentures was assessed according to specific criteria: repeated activation or replacement of the matrices, lack of stability causing rocking of the overdenture, repeated adjustments to the contour of the intaglio surface, and subjective complaints of increasing food accumulation under the overdenture. The criteria for remaking overdentures were subject to clinical judgment but corresponded to the criteria for replacing conventional complete dentures.

**Prosthodontic Success**

Prosthodontic success was evaluated at the 1-, 5-, and 10-year recalls using a six-field table. ⁵³ The fields were successful, surviving, unknown (lost to follow-up), dead, retreatment (repair), and retreatment (replace). Overdentures were defined as successful in participants who had no evidence of retreatment.
beyond accepted prosthodontic maintenance, which was defined as no more than either two replacements of the patrices or matrices in year 1, five replacements in 5 years, or a reline of the overdenture in 5 years. Participants who could not be examined by annual recall were defined as surviving and allocated to that field. If the accepted number of maintenance events associated with the original maxillary implant overdenture was exceeded, it was allocated to the retreatment (repair) field. If the maxillary overdenture was no longer serviceable and a replacement prosthesis was indicated, it was allocated to the retreatment (replace) field. When one of the three implants was lost in any participant, the overdenture was allocated to the retreatment (replace) field.

Data Analysis

Descriptive statistics (mean and standard deviation [SD]) and frequencies were computed for all prosthodontic maintenance events (primary outcome) using statistical software (SPSS 17.0, IBM). Chi-square test was applied to assess the differences between attachment systems at 1, 2, 5, 7, and 10 years. Independent t test was used to determine the difference between implant and attachment systems in terms of number of prosthodontic maintenance events recorded during the follow-up period. In all statistical analyses, \( P < .05 \) indicated a statistically significant difference. Prosthodontic success (secondary outcome) by participant, implant system, and attachment system was then determined and tabulated with six-field tables.53

Results

One participant was excluded at implant surgery. In the remaining 39 participants, progressive attrition ensued with nine deaths and seven dropouts over the 10 years of follow-up. Reasons for dropouts were relocation, loss of contact, failure to attend recalls, or medical conditions making attendance impossible. There were 36 participants at the 1-year recall; 31 at the 2-year recall; 30 at the 3-year recall; 28 at the 5-year recall; and 26 at the 7-year recall. Finally, 23 participants (nearly 60%) attended the 10-year recall (14 women, 9 men; mean age 71 years; range 62–84 years). At the 1-year recall, there were equal numbers of participants with ball and bar attachments (n = 18). However, this changed in years 2 to 10. By the 10-year recall, 8 of the 23 remaining participants had bar attachments and 15 had ball attachments. Twenty of the participants (87%) had maxillary three-implant overdentures and the other 3 had maxillary overdentures assisted by only two implants. The number of participants with prosthodontic maintenance events recorded at annual recalls was different from the surgical outcomes reported previously.49 This was because some participants declined radiographs and stability measurements to determine implant success but still attended annual recalls for prosthodontic maintenance.

Combined Prosthodontic Maintenance Events

Overall, there were 223 maintenance events (mean 7.82, SD 2.77, range 1–12) over 10 years (Table 1). The
The mean number of events per participant was 0.97 (SD 1.13) in year 1; 1.55 (SD 1.59) in year 2; 1.23 (SD 1.69) in year 3; 3.30 (SD 2.35) between years 3 and 5; and finally, 2.04 (SD 1.49) between years 7 and 10. The proportion of participants that had one or more maintenance events was 47.5% in year 1; 52.2% in year 2; 42.5% in year 3; 52.5% in year 5; 37.5% in year 7; and 17.5% in year 10. There was no statistically significant difference in the overall combined number of maintenance events over 10 years between the implant systems or between the splinted and unsplinted designs.

**Patrix-Specific Maintenance**

There were 27 patrix maintenance events (Table 1; Figs 3a and 3b). Principal among these was loosening of ball abutments (8/27 events = 30%). The majority of events (20/27 = 74%) occurred in years 3, 5, and 7. These were related to loose patrices or the need to be replaced due to wear, principally in the ball abutment (unsplinted design) groups (19/27 events = 70%). Five ball abutments needed to be replaced during the 10-year period. The bar attachments (splinted designs) required significantly less maintenance (8/27 events = 30%), and it was limited to solder joint fractures. No multiunit or standard abutments or corresponding gold cylinders needed replacing. One multiunit abutment screw fractured in one of the Brånemark bar participants at year 5. Analyses by P values showed no significant differences in patrix maintenance between the two prosthodontic designs over the 10 years.

**Matrix-Specific Maintenance**

There were 136 matrix maintenance events (Table 1; Figs 3c to 3f): 27 in year 1; 35 in year 2; 23 in year 3; 28 in year 5; 17 in year 7; and 6 in year 10. Of the matrix maintenance events, 59% (80/136) occurred with the ball abutment (unsplinted designs), with no significant differences between implant systems or prosthodontic design. Matrix activation was the principal burden in both groups (bar: 24/56 events = 43%; ball: 31/80 events = 39%), followed by matrix replacement/fractures. Matrix replacements (bar: 16/56 events = 29%; ball: 22/80 events = 28%) were similar and occurred in years 2 and 5. The increase in ball and bar matrix replacements in year 2 after removal of the palate of the overdentures was not statistically significant (dislodged/worn matrix housing: P = .53; fractured matrix: P = .31; replaced matrix: P = .71). After year 2, the statistical analyses showed a P value of .01 indicating statistically significant differences in the matrix replacement at years 7 and 10 between the two prosthodontic designs. The time to ball matrix replacement was around 7 years (41.2%), whereas for bar matrix it was closer to 10 years (37.5%).

**Overdenture-Specific Maintenance**

There were 60 events involving overdenture fractures, puncture fractures, or relines or remakes of the original overdenture (Table 1). There were no significant differences by implant system, but an overall
higher incidence was documented for the ball designs (splinted, 39/60 events = 65%; unsplinted, 21/60 events = 35%). The principal overdenture-specific maintenance events were 27 relines over the 10 years (splinted 18/27 = 67%; unsplinted 9/27 = 33%), peaking in years 2, 5, and 7. The increased reline incidence in year 2 was attributed to the necessity for reline procedures to accommodate matrix fractures and replacement. Eleven maxillary overdentures were remade at years 5, 7, and 10, along with an odd remake in year 2 at the patient’s request. Analyses by \( P \) values showed the only significant difference in overdenture-specific maintenance between the two prosthodontic designs over the 10 years was with new overdentures (\( P = .01 \)).

**Prosthodontic Success**

The six-field table analysis was performed for the participants (Table 2) by implant system (Table 3) and by attachment system (Table 4) over the 10-year period. One participant confounded the data by attending the

### Table 2  Prosthodontic Success for All Participants: Six-Field Table Analysis

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<tr>
<th>Year</th>
<th>At start of year</th>
<th>Attended year end</th>
<th>Success</th>
<th>Survival</th>
<th>Retreatment: repair</th>
<th>Retreatment: replace</th>
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### Table 3  Prosthodontic Success By Implant System: Six-Field Table Analysis

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### Table 4  Prosthodontic Success by Attachment System: Six-Field Table Analysis

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year 1 recall and being categorized as a success; being absent at the years 2 and 3 recalls (surviving); but attending the 5-, 7-, and 10-year recalls to be reallocated to the success category. Prosthodontic success rates decreased from 78% at 1 year, to 75% at 2 years, to 57% at 5 years, to 39% at 7 years, and ended at 35% after 10 years.

Discussion

This RCT reports 10-year prosthodontic outcomes of maxillary three-implant overdentures in a unique patient cohort. The prosthodontic maintenance burden or incidence of technical/hardware complications\(^4\) as the primary outcome was high. The secondary outcome of a diminishing rate of prosthodontic success over the 10 years was as a result of the stringent criteria applied.\(^5\) The dropout rate of participants reduced the power of results but did not necessarily introduce biased treatment effects.

The strength of this research is the protracted time over which prosthodontic maintenance was meticulously collated, in comparison with other RCTs\(^6\) prospective or retrospective studies, and case reports.\(^7\) The findings were interpreted not in an improvised manner, but rather with exact \(P\) values over the 10 years as recommended by Cehreli et al.\(^8\) This study also presents times to retreatment, which is reported in less than 1% (3/49) of the studies evaluated by Cehreli et al.\(^6\) All prosthodontic maintenance was grouped together, in contrast to other approaches in which authors separate mechanical (manufacturer components) and technical complications (laboratory-fabricated components).\(^9\) The majority of the prosthodontic maintenance events in the present study were related to mechanical complications of manufacturer components. The limitations of this trial are the participant sample size in a single research center and the truncated number of participants after 10 years.

The etiology of the fatigue failures of the bar solder joints as part of patrix maintenance is known.\(^10\) This trial was initiated prior to the development of computer-aided design/computer-assisted manufacture (CAD/CAM) technology, which could have avoided this aspect of maintenance.\(^11\) It is hardly surprising that there was less patrix maintenance of the splinted designs, even with these solder joint fractures, as compared with numerous ball abutments needing to be retightened or replaced in the unsplinted designs.

Matrix maintenance events peaked after year 2, rather than year 1. The authors acknowledge that this was dictated by the trial design, where the reduction of palatal coverage after 1 year changed the mucosal support for the overdentures and increased maintenance.\(^12\) The high maintenance could also be attributed to the divergence of the implants,\(^13\) the limited interalveolar space in some bar participants,\(^14\) and the principal issue of wear and tear of the attachment systems.\(^15\) Past and current recommendations for maxillary overdentures with open palates are decision making at treatment-planning stages, and a preference for a cast metal framework where vertical space is restricted and high midline strain values are overcome.\(^16\) This is supported by biomaterials research indicating that reinforcement of maxillary complete dentures may reduce the risk of fracture and deformation.\(^17\) Bearing in mind that a high-impact acrylic resin without any cast metal framework reinforcement was used in the present study, the number of overdenture fractures was remarkably low. The frequent puncture fractures were attributed to restricted interalveolar space with strict participant selection criteria for minimal to moderate maxillary residual ridge resorption.

The extent of matrix activation was similar for splinted and unsplinted designs and for both implant systems. Following the maintenance events of years 1 and 2, the 7-year longevity of the ball matrices compared with 10 years for the bar matrices contrasts with that of long-term outcomes from the present authors’ mandibular overdenture RCT and the Toronto group’s prospective study.\(^18\) By virtue of the criteria for participant selection, including limited residual ridge resorption, the lack of interalveolar space also resulted in numerous matrices being dislodged. The systematic review by Cehreli et al found that significantly more matrix replacements occurred at year 5 than during the first year when the combined maxillary and mandibular overdenture data were analyzed. In the present study, in contrast, the matrix replacement events were similar in years 1 and 5, with reductions by years 7 and 10. The maintenance events of both ball and bar matrices spiked at year 2 in both prosthodontic design groups. Thereafter, the time to replacement of ball matrices was around 7 years (41.2%), whereas for bar matrices it was closer to 10 years (37.5%). Relines of the maxillary overdentures peaked in years 2, 5, and 7. In year 2, the higher incidence can be coupled with the increased matrix replacement events also requiring relines. By years 5 and 7, the relines would be expected. New maxillary overdentures were needed equally in years 5, 7, and 10. Again, this is to be compared with other long-term mandibular overdenture research.\(^19\) The present authors struggled to find similar substantial maxillary overdenture studies where the prosthodontic maintenance of both splinted and unsplinted designs have been so comprehensively evaluated, other than the retrospective study of up to
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72 months by Närhi et al.29 Their small number of 11 participants treated with maxillary bar overdentures retained by three to six clips and 5 participants with overdentures assisted by two to six ball attachments did not allow them to make recommendations on the attachment systems. Details on prosthodontic maintenance were still scarce, with only 7 participants requiring ongoing prosthodontic maintenance. Only 3 of the 16 participants had an opposing mandibular implant overdenture. A 20-year retrospective study on maxillary overdentures by Sanna et al40 failed to describe the prosthodontic maintenance required by the overdentures. By contrast, Visser et al,41 in a robust 10-year report on 39 consecutive participants, comprehensively revealed prosthodontic maintenance of maxillary six-implant overdentures with milled mesostructures (also incorporating Ceka attachments). However, there were various types of opposing mandibular prostheses/dentitions. Only 4 out of 39 (10%) patients had opposing mandibular two-implant overdentures, and 17 out of 39 (44%) had mandibular four-implant overdentures. The predominant maintenance events were repairs to the acrylic denture teeth, the overdenture bases or the milled bars; activation (50%)/replacement (25%) of Ceka attachments; and replacement of abutments/abutment screws. Relines were not required except in cases of implant failures. Hence, 23% of participants needed new maxillary six-implant overdentures, with 50% of these being due to implant loss and subsequent replacements. A historical 5-year multicenter study by Watson et al37 of maxillary overdentures reported prosthodontic maintenance from nine centers with an original cohort of 30 participants and 117 implants rehabilitated using different bars for splinted designs opposing various mandibular prostheses and dentitions. Findings on the 53% of participants remaining drew weak evidence on significant matrix and patrix maintenance, a 60% incidence of relines, and a high incidence of fractures. A short-term report by Kiener et al48 of up to 3.2 years on 41 consecutive participants involved 4 to 6 maxillary implants with splinted bars (34/41; 83%) or unsplinted ball attachments (7/41; 17%) with overdentures reinforced with a cast metal framework. The authors stated that only a few patients had fewer than four implants. There were 85 maintenance events, with the most frequent issue being retightening of the bar screw (patrix) and adjustments of the bar retainers (matrices). Repairs were mostly related to broken overdenture teeth, with no prosthesis fractures observed. Two new prostheses were needed, and overdenture stability (survival) was reported at 95%.

The present authors believe a knowledge gap exists in prosthodontic recommendations for the minimum number of implants for maxillary overdentures opposing mandibular two-implant overdentures. This research has shown no difference in the prosthodontic maintenance between splinted and unsplinted designs when using three maxillary implants; therefore, using bars for a splinted design is unnecessary. The authors link this recommendation to their surgical47,49 and prosthodontic data and to their qualitative research,48 conforming to recommendations proposing more robust patient-based and clinical outcomes for implant overdentures.61 Sadowsky et al24 recently proposed that, applying the hierarchy of evidence by Sackett et al,62 the evidence supporting the attachment system decision making is mainly at level 1A (systematic reviews of RCTs) to 3A (systematic review of case-controlled studies). This RCT could contribute at level 1B (RCTs with narrow confidence interval).

The historical foundation of clinical approaches to maxillary implant overdentures with large numbers of implants supported by high-tech prosthodontics is limited to patients within the United States, some parts of Europe, and certain Asian countries.3 As the concept of a minimum acceptable protocol offers a selection of treatment options complying with principles and appropriate treatment protocol to suit the resources available and the preferences of the patient,63 a maxillary three-implant overdenture using an unsplinted design may conform.

The current literature is faced with a relative lack of focused RCTs in removable prosthodontics.64 In addition, a wider dissemination of evidence-based findings using a public access database registry system is seen by some as imperative.65 On the other hand, the use of RCTs as a complete proxy for patient management has been recently questioned,66,67 and recommendations have emerged to create evidence in a more representative context of practice-based research.68 Therefore, combining evidence from clinical trials such as the present study with additional RCTs on maxillary three-implant overdentures in clinical practice-based research, together with larger patient cohorts, is encouraged.

Conclusions

Maxillary three-implant overdentures are a viable treatment option for edentulous patients wearing opposing mandibular two-implant overdentures. No differences were observed in the prosthodontic maintenance and success between the splinted (bar) and unsplinted (ball) designs.

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References

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