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CLINICAL RESEARCH

Retrospective cohort analysis of maxillary overdentures retained by unsplinted implants

Evanthia Anadioti, MS,[a] W. Day Gates III, MS,[b] Julie Elpers, MS,[c] Ingeborg J. De Kok, MS,[d] and Lyndon F. Cooper, PhD[e]

ABSTRACT

Statement of problem. Implant therapy involving an unsplinted 2-implant–retained overdenture is well defined as a successful treatment for a patient with an edentulous mandible. However, a similar unsplinted implant therapy supporting a maxillary overdenture is not well characterized.

Purpose. The purpose of this retrospective study was to evaluate maxillary overdentures retained by 4 unsplinted implants measuring implant survival, overdenture survival, and patient-reported outcomes.

Material and methods. Participants who had received an unsplinted implant-retained maxillary overdenture were included in the study. Participants presented for one denture recall appointment, during which comprehensive examination, including radiographs, was performed and clinical findings were recorded. Participants also completed the Oral Health Impact Profile-49 (OHIP-49) and a 20-item visual analog scale (VAS) satisfaction questionnaire. Nonparametric statistical tests were used to compare OHIP-49 and VAS scores across age, sex, time since overdenture insertion, mandibular dental status, smoking status, maxillary mucosal health, and overdenture hygiene.

Results. For the 44 participants, 3 of 4 implants failed in 1 individual. The cumulative implant survival rate was 98% (97.7% patient level). No prosthetic failures (that is, overdenture replacement) occurred, indicating a 100% prosthesis survival rate. The mean ±standard deviation OHIP-49 severity score was 23.6 ±26.0, and the mean ±standard deviation total VAS score was 179.2 ±29.4. Increased age was associated with lower OHIP-49 severity score (P=.036), and participants with unhealthy oral mucosa or denture stomatitis demonstrated significantly higher OHIP-49 severity scores (P=.003).

Conclusions. In this retrospective evaluation, unsplinted implant-retained maxillary overdenture therapy was associated with high implant and prosthetic survival, as well as high patient satisfaction and quality of life. Age, sex, maxillary mucosal health, and mandibular dental status resulted in significant differences with respect to oral health–related quality of life and patient satisfaction, indicating that this treatment option may be ideal for certain patients. (J Prosthet Dent 2019;122:301-8)

Edentulism is prevalent in many parts of the world. Its prevalence may remain stable for several decades in the United States,[1] despite the reductions in the incidence of edentulism in this generation cohort.[2] The management of edentulism using dentures is a minimal intervention that provides social and physiological functions with well-defined limitations and acceptance.[3] The replacement of teeth with fixed or removable implant-supported or retained prostheses, despite the higher initial costs, leads to improvement in oral health–related quality of life (OHRQoL) compared with treatment alternatives.[4,5] These observations have been based largely on experience related to treatment of mandibular edentulism, often involving mandibular overdenture therapy. Although there is abundant evidence that a 2–unsplinted implant–retained overdenture is a successful therapy for the treatment of the edentulous mandible,[6] the use of unsplinted implants retaining maxillary overdentures has not been fully characterized.[7-10] A recent effort to establish guidelines for treatment of the

[a]Assistant Professor, Clinical Restorative Dentistry, Department of Preventive and Restorative Sciences, University of Pennsylvania School of Dental Medicine, Philadelphia, Penn.
[b]Private practice, Mobile, Ala; and Adjunct Assistant Professor, Department of Prosthodontics, University of North Carolina School of Dentistry, Chapel Hill, NC.
[c]Private practice, Boston, Mass; and Adjunct Assistant Professor, Department of Prosthodontics, University of North Carolina School of Dentistry, Chapel Hill, NC.
[d]Associate Professor, Department of Prosthodontics, University of North Carolina School of Dentistry, Chapel Hill, NC.
[e]Associate Dean for Research; Head, Department of Oral Biology, University of Illinois at Chicago, College of Dentistry, Chicago, Ill.

Clinical Implications

The relatively high implant and prosthesis survival rates of maxillary overdentures retained by 4 unsplinted implants suggest that the use of this treatment option is appropriate to treat edentulous patients.

edentulous maxilla includes the use of maxillary overdenture therapy.[11]

Historically, maxillary implant overdenture therapy was viewed with concern for implant failures.[8,12] More recently, maxillary implant survival associated with overdenture therapy has improved.[13] The factors influencing improved implant outcomes for maxillary overdentures include the use of microtextured implant surfaces, improved diagnostics such as cone beam computerized tomography (CBCT) scans, and improved restorative technology such as computer-aided design and computer-aided manufacturing (CAD-CAM).[14-16] Awareness of the important anatomic (morphological intrinsic and extrinsic) and biomechanical aspects on the maxilla has increased to prevent or avoid failures of the past,[8] as well as to meet patients' expectations based on sound evidence.[17]

The survival of implants supporting maxillary overdentures had been attributed to splinting of the implants with a bar.[18-23] However, splinting the implants imposes disadvantages including the need for increased interocclusal space, difficulty in maintenance, soft tissue hyperplasia, stomatitis, and increased cost.[7,8,12,24] Preliminary investigations suggested the potential to use unsplinted maxillary implants overdenture therapy.[25,26] Pilot studies demonstrated that 4 unsplinted implants provided high short-term implant survival.[27-29] This is consistent with the 10-year report demonstrating high maxillary overdenture implant survival for both splinted and unsplinted approaches using only 3 maxillary implants.[30] In a review, the respective implant survival rate of maxillary overdentures supported by 6 or more implants was 97% versus 88.9% for those supported by 4 or fewer unsplinted implants.[10] The authors concluded that an implant-supported maxillary overdenture using at least 4 splinted implants was accompanied by high implant and overdenture survival and that there was an increased risk of implant loss while using 4 or fewer unsplinted implants. Similarly, a more recent systematic review indicated that implant loss for maxillary overdentures supported by less than 4 implants was significantly higher than that for those supported by 4 implants ($P<.001$).[31] Regarding the denture design, a recent systematic review concluded that a palateless design supported by 4 to 6 implants could be a successful treatment for maxillary edentulism.[32]

Another success criterion that influences the choice of therapy is patient-reported outcome measures (PROMs) including its effect on their quality of life and satisfaction.[33] The OHRQoL describes different aspects of life being affected by the oral health, including ability to function, psychological status, social factors, and pain or discomfort.[34] The OHRQoL is assessed by means of patient questionnaires capturing the Oral Health Impact Profile (OHIP-49).[35,36] Implant-related overdenture therapies increase patients' quality of life and satisfaction when compared with conventional dentures and can provide equivalent outcomes to implant-supported fixed prostheses.[37-40] A systematic review of PROMs illustrated that there are conflicting data from relatively small–scale studies of maxillary implant overdentures.[33] To date, the information regarding implant, prosthesis, and patient-reported outcomes for unsplinted implant-retained maxillary overdenture therapy is sparce.[9,32,41]

The purpose of the present investigation was to retrospectively evaluate the clinical, radiographic, and patient-reported outcomes using clinical and radiographic examination, as well as survey instruments, for the maxillary overdenture retained by unsplinted implants as a treatment option. The research hypothesis was that an unsplinted implant-retained maxillary overdenture will show an acceptable level of implant and prosthesis success, as well as acceptably high patient-perceived quality of life and satisfaction.

MATERIAL AND METHODS

This study was an open, retrospective clinical trial to document the implant and prosthesis outcomes, as well as the oral health quality of life (OHQoL) and satisfaction of patients who had received an unsplinted maxillary overdenture (MIOD). The research protocol was approved by the University of North Carolina Institutional Review Board (IRB #13-2828).

The required inclusion criteria for participant enrollment included those patients who received prosthodontic treatment of unsplinted implant-retained maxillary overdenture at the University of North Carolina School of Dentistry before August 2013. Excluded were patients who had any conditions that contraindicate elective dental therapy or denture recall.

Participants were identified through the electronic patient-management software used within the University of North Carolina School of Dentistry by searching records of treatment rendered and procedure billing codes relevant to implants and overdentures. Fifty-five patients met the criteria. They were all contacted by phone, and 44 were enrolled.

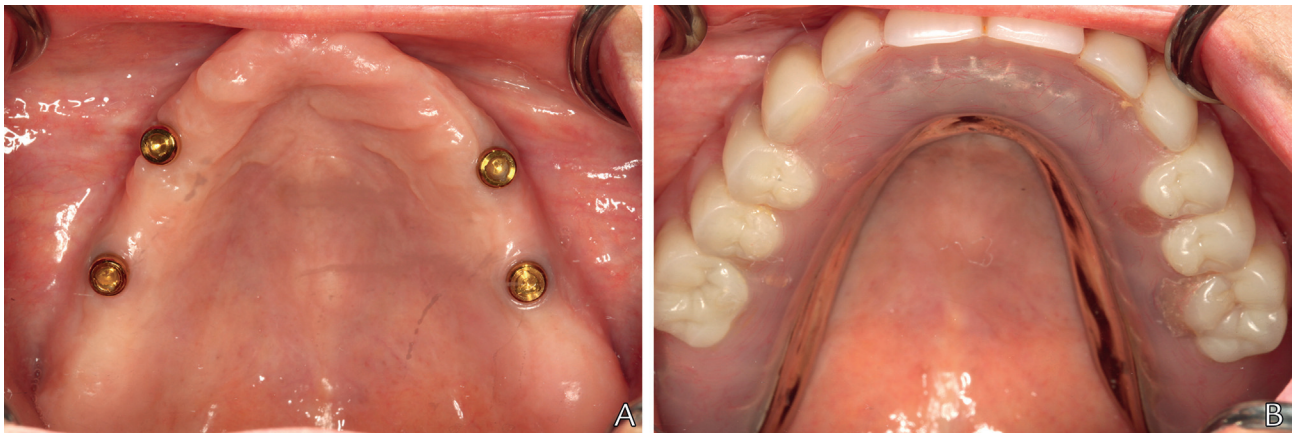

Figure 1. A, Participant with 4 implants and LOCATOR abutments. B, Same participant with implant-retained overdenture with exposed framework in place.

Table 1. Clinical data evaluated per implant and prosthesis

Clinical implant recall						
Plaque Score	**Calculus**	**Pain**	**Probing Depth**	**Sulcus Bleeding Index**	**Exudate**	**Radiographic-Bone Loss**
None	None	Present		Healthy	Present	Mesial
Thin	Absent	Absent		Bleeding	Absent	Distal
Visible				Swelling		
Abundant						

Clinical prosthesis recall				
Arch Shape	**Oral Mucosa**	**Dentition of Mandible**	**Attachment Type**	**Prosthesis Design**
Square	Reactive hyperplasia	Natural	LOCATOR	Palateless
Taper	Stomatitis	PRDP	Ball	Complete coverage
Ovoid	Ulcers	ISFDP	Other	
	Hyperplasia	Overdenture		
	Flabby ridge			
	Angular cheilitis			

ISFDP, implant-supported fixed dental prosthesis; PRDP, partial removable dental prosthesis.

During the single recall appointment, participants were evaluated for enrollment. The evaluation process consisted of a review of medical history and clinical assessment to ensure that the participant currently had an MIOD (Fig. 1). Directly thereafter, informed consent was obtained. All recall appointments and evaluations were conducted by the primary invesigator (E.A.) who had not treated or been involved in previous treatments of any of the participants. The recall appointment consisted of a comprehensive clinical examination, which included oral cancer screening, updated radiographs of the implants (if none were available from within the previous 12 months), oral hygiene assessment, and evaluation of the implant and prosthesis (Table 1). Clinical and radiographic measures were performed and recorded for each of the individual implant positions (right-posterior, right-anterior, left-anterior, and left-posterior). Minor denture adjustments were made, if necessary, the nylon inserts were changed for all participants, and the overdentures were cleaned and polished.

At the end of the appointment, the participants were given time to complete two PROM questionnaires. OHQoL was measured with the 49-item OHIP-49, and patient satisfaction was measured with a 20-item visual analog scale (VAS) questionnaire with regard to their dental treatment. The OHIP-49 severity score was computed as the sum of ordinal response codes across the 49 items, yielding a continuous variable with a potential range of 0 (excellent OHQoL) to 196 (extremely poor OHQoL).[35] A second established summary score for the OHIP-49, the extent score, reported the prevalence defined as the percentage of participant with scores coded 3 or 4 to any 1 or more OHIP-49 items. Participants' opinions about maxillary overdentures, in terms of general satisfaction, retention and stability of dentures, mastication, oral hygiene, comfort, speech, and esthetics, were evaluated by a modified 20-item VAS questionnaire[42,43] (Supplemental Table 1).

Descriptive statistics were compiled and evaluated in a spreadsheet (Excel; Microsoft Corp) and statistical

Table 2. Demographic variables

Demographic Variable (n=44)	N	Percent
Age (mean=70.9, SD=9.1)		
Under 65	11	25.0
65-75	20	45.5
Over 75	13	29.5
Sex		
Male	25	56.8
Female	19	43.2
Time since overdenture delivery (mean=4.69 years, SD=2.36 years)		
Within last 2 years	6	13.6
2-5 years ago	20	45.5
Over 5 years ago	17	38.6
Mandibular dental status		
Overdenture	18	40.9
Natural dentition	13	29.5
ISFDP	5	11.4
PRDP	8	18.2
Smoking status		
Nonsmoker	17	38.6
Ex-smoker	22	50.0
Current smoker	5	11.4
Maxillary mucosal health		
Healthy maxillary mucosa	26	59.1
Stomatitis/cheilitis/ulceration present	18	40.9
Overdenture hygiene		
Good	19	43.2
Some staining only	17	38.6
Poor hygiene	8	18.2

ISFDP, implant-supported fixed dental prosthesis; PRDP, partial removable dental prosthesis; SD, standard deviation.

software (IBM SPSS Statistics, v21; IBM Corp). Summary statistics were generated for OHIP-49 severity and extent scores, as well as the 7 individual OHIP-49 subscales. The Kolomogorov-Smirnov test was used to evaluate normality. Median OHIP-49 severity scores and subscale scores were compared using nonparametric tests (Spearman rho, Mann-Whitney U, Kruskal-Wallis) for 7 demographic variables, namely age, sex, time since overdenture delivery, mandibular dental status, smoking status, maxillary mucosal health, and overdenture hygiene. For the 20-item satisfaction questionnaire, descriptive statistics revealed the count and range of satisfaction scores among the participants, and participants were split into categories such as "highly satisfied" (>50% of questionnaire items rated 10/10) and "less satisfied" (<50% of items rated 10/10) for chi-square analysis across the previously described demographic groups.

RESULTS

Forty-four participants (25 men and 19 women) were recalled, with a total of 171 implants supporting the 44 maxillary overdentures (Table 2). The mean time since delivery was 4.7 ±2.36 years. Fifty percent (n=22) had stopped smoking before the implant therapy, 39% were nonsmokers, and 11% were current smokers. Four participants had 2 implants, 1 participant had 5 implants, and 1 participant had 6 implants placed to support an earlier fixed prosthesis, but with the overdenture, only 4 of the implants had been loaded. The remaining 38 (86%) participants had 4 implants. Regarding the implant systems evaluated, 34 participants had Astra Tech (Dentsply Sirona), 7 had Straumann (Straumann AG), 2 had Zimmer (Zimmer Biomet), and 1 participant had Biomet 3i (Zimmer Biomet). Only 1 implant system was represented per patient. Of the 44 overdentures evaluated, 8 of them provided complete palatal coverage, whereas 77% of them were palateless overdentures, of which 22 incorporated exposed metal frameworks, 12 incorporated embedded metal frameworks, and 2 possessed no framework. Five participants (11%) had ball attachments, and the remaining 39 (89%) had LOCATOR attachments (Zest Anchors).

Table 3. Radiographic marginal bone change measurements

Bone change	Frequency	Valid Percent
Valid		
Bone gain or no loss	59	26.0
≤2 mm bone loss	118	52.0
>2 mm bone loss	50	22.0
Total	227	100
Missing	125	–
Total	352	–

Out of the 44 participants, only 1 had 3 out of 4 implants failed for a cumulative survival rate of 98% at both the patient and implant levels. No prosthetic failures (no overdenture had to be remade) were recorded at examination, and all prostheses were serviceable and in place, yielding 100% prosthesis survival rate.

Out of the total implants evaluated, 62% had bleeding during probing, whereas 51% had thin and/or visible plaque accumulation. In the 44 participants, probing pocket depths of 5 mm or greater were recorded for 10 right-posterior, 7 right-anterior, 8 left-anterior, and 10 left-posterior implants. No exudate or pain was recorded associated with any implant.

Radiographic marginal bone-level data were available for 33 of the participants. The radiographic evaluation indicated that 26% of the sites measured had no marginal bone loss since time of placement, 52% had marginal bone loss of less than 2 mm, and 22% had more than 2 mm bone loss (Table 3). Eighteen participants (41%) demonstrated mucosal complications (Table 4). Two individuals presented with angular cheilitis (4.5%), and 5 individuals presented with mucosal ulcers or sore spots. Eleven participants

Table 4. Oral mucosal findings

Maxillary oral mucosa	Frequency	Percent
Angular cheilitis	1	2.3
Flabby ridge	2	4.5
Healthy	26	59.1
Sore spot	2	4.5
Stomatitis	8	18.2
Stomatitis/angular cheilitis	1	2.3
Stomatitis/burning sensation	1	2.3
Stomatitis/ulcer	1	2.3
Ulcer	2	4.5
Total	44	100

displayed stomatitis, and of these, 3 wore overdentures with embedded frameworks (3/12; 25%), 7 wore overdentures with exposed frameworks (7/22; 32%), and 1 wore an overdenture with complete coverage framework (1/10; 10%). Only 1 out of the 5 smokers included in the study had stomatitis.

Five prosthetic complications were observed in 5 participants at the recall evaluation. Included were 3 abutment issues (2 abutments without nylon attachments and 1 worn LOCATOR) and 2 denture tooth complications (excessive wear and chipping) opposing monolithic zirconia implant-supported prostheses.

The OHIP-49 scores ranged from 0 (excellent OHQoL) to 114 (poor OHQoL) with a mean total score of 23.6 (standard deviation=26) (Fig. 2). The median values of the OHIP-49 severity and extent scores by demographic variables are reported in Table 5. A significant negative correlation between OHIP-49 severity score and patient age was identified (Spearman rho, P=.044). Significant differences in OHIP-49 subscale scores were found across sex (social disability P=.048) and "healthy" versus "unhealthy" maxillary mucosa (functional limitation P=.029 and physical pain P=.003).

The VAS questionnaire scores ranged from 50 (dissatisfied) to 200 (completely satisfied), with a mean total score of 179.2 ±29.4 (Fig. 3). Women were significantly less likely to indicate that "prosthesis does not cause embarrassment" (P=.014) (Table 6). Participants who had their overdentures placed more than 5 years earlier rated the fit significantly lower than those who had them placed less than 2 years earlier (P=.037). Participants with denture stomatitis or visible tissue ulceration scored lower for "treatment expectations realized" (P=.031). Those with mandibular partial removable dental prosthesis (PRDP) rated their ability to talk with their prosthesis and ease of speaking with prosthesis significantly lower than participants with mandibular implant-supported fixed dental prostheses (P=.005) or overdentures (P=.006). No participants with a mandibular PRDP were "highly satisfied" with their maxillary overdentures (P=.004).

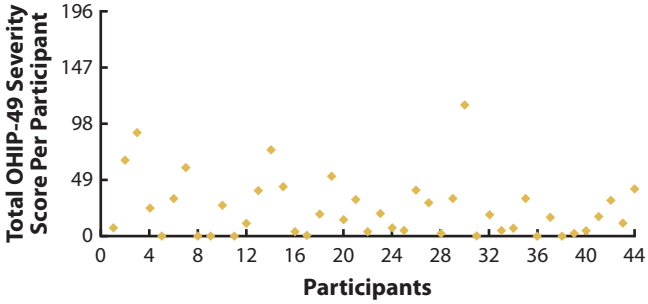

Figure 2. Total OHIP-49 severity score per participant. Lower numbers indicate better oral health–related quality of life (OHRQoL). OHIP-49, Oral Health Impact Profile-49.

DISCUSSION

The results of the study supported the research hypothesis. This open, retrospective clinical study demonstrated that unsplinted implants retaining maxillary overdentures do not fail at higher rates when compared with results published for splinted implants supporting maxillary overdentures.[18] Implant and prosthesis survival upon recall at an average period of 4.7 years was recorded with minimal complications. Participants at the recall period reported high satisfaction and OHRQoL. This retrospective study included only patients with unsplinted implants and did not compare outcomes with splinted implant-supported prostheses. Nevertheless, these findings are consistent with earlier studies suggesting that unsplinted implants can support maxillary overdentures.[26-30]

The present retrospective investigation suggests that unsplinted implants supporting a maxillary overdenture are associated with high implant survival rate after several years of function. A systematic review reported that after 3 years, there was no difference in implant survival of splinted and unsplinted implants.[9] The current findings contribute to a growing data set reporting the successful use of unsplinted implants for maxillary overdentures.

Implant success in the edentulous maxilla is challenged by marginal bone changes[14,15,30] contrary to the relative absence of marginal bone loss measured for unsplinted mandibular implants.[44] The present study, where only 75% of the participants had radiographs, revealed median bone changes of approximately 1 mm over an average 4.7 years, with only 14% of the recorded sites having more than 2 mm of bone loss. Splinting of implants has traditionally been aligned with concepts of greater control of loading and related loading, particularly overloading, of the bone.[19] However, a recent finite element analysis study suggests that splinting may not benefit implants greater than 10 mm in length.[45]

Table 5. OHIP-49 severity and extent scores by demographic variable

Demographic Variable (n=44)	N	Median OHIP-49 Severity Score	P[a]	Median OHIP-49 Extent Score	P[a]
Age (mean=70.9, SD = 9.1)					
Under 65	11	19.0	.195[b]	0.0	.258[b]
65-75	20	22.5	–	1.0	–
Over 75	13	5.0	–	0.0	–
Sex					
Male	25	19.0	.981[c]	1.0	.286[c]
Female	19	11.0		0.0	
Time since overdenture delivery (mean=4.69 years, SD=2.36 years)					
Within last 2 years	6	9.5	.708[b]	0.0	.998[b]
2-5 years ago	20	17.5	–	0.0	–
Over 5 years ago	17	11	–	0.0	–
Mandibular dental status					
Overdenture	18	7.0	.231[b]	0.0	.207[b]
Natural dentition	13	20.0	–	0.0	–
ISFDP	5	5.0	–	0.0	–
PRDP	8	28.0	–	1.0	–
Smoking status					
Nonsmoker	17	14.0	.624[b]	0.0	.146[b]
Ex-smoker	22	19.5	–	1.0	–
Current smoker	5	7.0	–	0.0	–
Maxillary mucosal health					
Healthy maxillary mucosa	26	7.0	.027[c]	0.0	.270[c]
Stomatitis/chelitis/ulceration present	18	29.0		1.0	
Overdenture hygiene					
Good	19	7.0	.157[b]	0.0	.149[b]
Some staining only	17	29.0	–	1.0	–
Poor hygiene	8	19.0	–	1.0	–

ISFDP, implant-supported fixed dental prosthesis; OHIP-49, Oral Health Impact Profile-49; PRDP, partial removable dental prosthesis; SD, standard deviation. [a]Exact significance (2-sided test). [b]Independent-samples Kruskal-Wallis Test. [c]Independent-samples Mann-Whitney U Test.

In this study, all overdenture designs appeared to be equally successful. The few abutment complications recorded included missing/worn nylon inserts, and abutment wear are consistent with required maintenance over time.[46-48] There were no fractured abutments. A prospective clinical study on overdentures retained with telescopic crowns, LOCATOR, and bar attachments reported that the LOCATOR group resulted in superior clinical performance with the least number of complications.[28] The frequent use of LOCATORS may have impacted the low complication rate in the present study.

High implant survival and the relative absence of complications may have contributed to the overall positive patient satisfaction and OHRQoL reported by the participants. A cross-over design comparison with dentures did not show increased satisfaction for the overdenture prostheses.[37] The unsplinted palateless approach to maxillary overdenture therapy may promote high satisfaction.[39,49] There remain few studies that include large numbers of participants to drive the determination of covariables that impact satisfaction.[32] Both the OHIP-49 and the satisfaction survey revealed that the participants who presented with stomatitis were less satisfied with the maxillary overdenture than those participants who had healthy mucosa. Denture stomatitis is reported to be predominately associated with the maxilla and the patients who demonstrate noncompliance to denture hygiene instructions, bruxism, or systemic disease-related stomatitis.[3,50,51] Although this study has not compared unsplinted MIOD therapy with bar-splinted MIOD therapy, *Candida* species colonization and denture-related stomatitis has been shown to be greater in

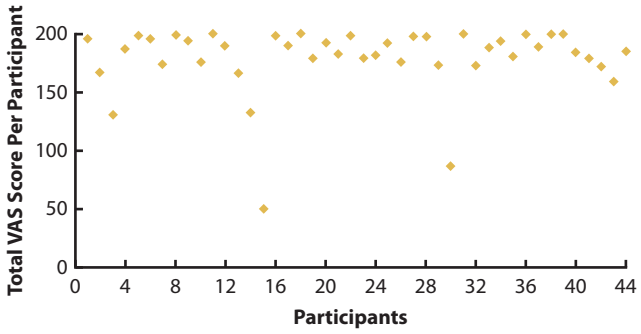

Figure 3. Total VAS score per participant. Higher numbers indicate greater satisfaction with the treatment as perceived by the participant. VAS, visual analog score.

Table 6. Demographic variables for which statistical significant differences were observed with regard to patient satisfaction

		P Value				
Descriptive Variable (n=44)	**N**	**"Prosthesis Does Not Cause Embarrassment"**	**"Rate the Fit of Your Prosthesis"**	**"Treatment Expectations Realized"**	**"Ability to Talk With Prosthesis"**	**"Ease of Speaking With Prosthesis"**
Sex						
Male	25	.014[a]	–	–	–	–
Female	19	–	–	–	–	–
Time since overdenture delivery						
Within last 2 years	6	–	.037[b]	–	–	–
2-5 years ago	20	–	–	–	–	–
Over 5 years ago**	17	–	*	–	–	–
Maxillary mucosal health						
Healthy maxillary mucosal	–	–	–	.031[a]	–	–
Stomatitis/ulceration	–	–	–	–	–	–
Mandibular dental status						
Overdenture	18	–	–	–	–	.006[b]
Natural dentition	13	–	–	–	–	
ISFDP	5	–	–	–	.015[b]	.005[b]
PRDP**	8	–	–	–	*	*

ISFDP, implant-supported fixed dental prosthesis; PRDP, partial removable dental prosthesis. *Exact significance (2-sided test). [a]Independent-Samples Mann-Whitney U Test. [b]Independent-Samples Kruskal-Wallis Test with pairwise comparison to variables indicated with **.

bar- (81.3%) rather than LOCATOR-retained (38.1%) overdentures.[52] Given that more than one-third of participants (18/44) were identified with denture stomatitis upon this recall examination, it is essential that recall visits and denture hygiene be reinforced as part of the MIOD patient management.

The present PROM analysis from 44 participants treated using unsplinted implant-retained maxillary overdentures demonstrated self-reported high rehabilitation (mean total OHIP-49 score of 23.6 ±26). Although it is feasible to attribute improved OHIP scores to the overdenture aspect of therapy, other factors also influence PROMs and may include the age of the treated participants, adaptation period to their edentulous status, difficulties in prosthodontic management, and the expectations of the cohort investigated.[53] Here, the age of the prosthesis negatively impacted satisfaction. This relationship of aging prostheses with reduced PROMs requires further longitudinal assessment.

The nature of the opposing dentition affected the satisfaction of the participants. Specifically, no patients with a mandibular PRDP were "highly satisfied" with their maxillary overdentures, whereas patients with natural dentition, implant-supported fixed dental prosthesis, or overdenture were significantly more likely to report high satisfaction with their maxillary overdenture. Mandibular PRDPs have generally low satisfaction scores because of the anatomic limitations, tongue and muscle movements, and abutment teeth condition.[54] Comprehensive success in the rehabilitation of partial edentulism involving a maxillary overdenture must account for the status of the mandibular prosthesis.

One of the limitations of this clinical study is the use of the retrospective design and the inherent bias that is related with this design. The data of only 33 of the participants were permitted for radiographic evaluation and analysis. Furthermore, there was no information on denture recalls after insertion and patient compliance with maintenance. Finally, the lack of data before insertion of the unsplinted implant-retained maxillary overdenture did not allow for comparison and change assessment on the quality of life and satisfaction of the participants. More studies are needed to assess the economic factors, maintenance, and patients' satisfaction of unsplinted implant–retained overdentures as compared with implant-supported fixed prosthesis as a treatment option for the edentulous maxilla.

CONCLUSIONS

Within the limitations of this retrospective study, the following conclusions were drawn:

1. Unsplinted implant-retained maxillary overdentures have high implant and prosthetic survival rates.
2. Patients have indicated relatively high OHRQoL and treatment satisfaction.
3. Although treatment of maxillary edentulism can be successful using 4 unsplinted implants to retain a palateless overdenture with requisite maintenance, longer term, prospective evaluation is required.

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Corresponding author:
Dr Evanthia Anadioti
University of Pennsylvania School of Dental Medicine
240 South 40th Street
Philadelphia, PA 19104-6030
Email: evanad@upenn.edu

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Supplemental Table 1. Visual analog scale 20-item questionnaire

1. How do you find your prosthesis in general?
2. Did your expectations become real with your prosthesis?
3. How well can you talk with your prosthesis?
4. How do you find appearance of your prosthesis?
5. How well does your prosthesis remain in place?
6. Do you avoid contact with other people because of fear to lose your prosthesis?
7. Does your prosthesis bother you?
8. Describe the extent of discomfort of your upper denture?
9. How would you rate the fit of your denture?
10. Do you have difficulties eating with your prosthesis?
11. Does food impaction regularly occur under your prosthesis?
12. Do you have difficulties speaking with your prosthesis?
13. How often does your prosthesis affect your socializing?
14. Are there activities that you avoid because of the possibility of being embarrassed by your prosthesis?
15. How often does your prosthesis affect your work?
16. How difficult is it for you to bite off hard foods?
17. How difficult is it for you to chew hard foods?
18. How difficult is it for you to chew soft foods?
19. Do you think your implant-supported prosthesis is actually part of your own?
20. Would you repeat the same treatment?