Implant-Supported Maxillary Overdentures Retained with Milled Bars: Maxillary Anterior Versus Maxillary Posterior Concept—A Retrospective Study

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Purpose: *The aim of the present retrospective investigation was to evaluate implant-supported maxillary overdentures using either anterior (group 1) or posterior (group 2) maxillary implant placement.* ***Material and Methods:*** *Maxillary overdentures were planned with support by either 4 implants placed in the maxillary anterior region (group 1) or 6 to 8 implants placed in augmented maxillary posterior regions (group 2, bilateral sinus augmentation) and anchored either on an anterior or on 2 bilaterally placed milled bars. Cumulative implant survival rate, peri-implant conditions (marginal bone loss, pocket depth, Plaque Index, Gingival Index, Bleeding Index, and Calculus Index) and the incidence and type of prosthodontic maintenance were assessed and compared for the 2 groups. In addition, the cumulative survival rate for implants placed in grafted regions was compared with that of implants placed in nongrafted regions.* ***Results:*** *Thirty-four patients (16 for group 1 and 18 for group 2) with 179 implants were available for follow-up examination after a mean period of 42.1 ± 20.1 months. Four initially placed implants failed to osseointegrate and were replaced, but no further losses were seen during the loading period, for a 5-year cumulative implant survival rate of 97.8%. No differences in implant survival rates were seen between either the group-1 (98.4%) and group-2 (97.4%) concepts or nongrafted (98.0%) and grafted (97.5%) implants. The peri-implant parameters showed a healthy soft tissue, good oral hygiene, and an acceptable degree of peri-implant marginal bone loss. The rigid fixation of all overdentures was associated with a low incidence of prosthodontic maintenance, without any significant differences between the 2 groups.* ***Conclusions:*** *In well-planned overdenture treatment programs, a high survival rate and excellent peri-implant conditions can be achieved for implants placed in the anterior or posterior maxilla. Rigid anchorage of maxillary overdentures either on an extended anterior milled bar or on 2 bilateral posterior milled bars provides for a low incidence of prosthodontic maintenance. (Comparative Cohort Study)* Int J Oral Maxillofac Implants 2008; 23:343–352.

Key words: *dental implants, edentulous maxilla, maxillary overdentures, milled bars*

Implant-prosthodontic rehabilitation of the edentulous jaw is a predictable and successful treatment modality.[1–3] Although fixed and removable implant-supported prostheses in the mandible have been used with excellent long-term results,[1–7] less favorable success rates have been reported for maxillary implants and especially for maxillary implant-supported overdentures.[8–12] In general, bone quality and bone volume as well as number and position of implants are factors that influence loading conditions and may be associated with maxillary implant success and implant prosthodontic treatment outcome.[2,3,8–11]

Several reports have described higher survival rates in patients originally planned for maxillary implant-supported overdenture treatment compared with unplanned or rescue procedures.[12–16] Thus, Palmqvist et al[12] made a distinction between planned overdenture treatment and emergency situations and found a much better survival rate (more than 90%) for planned cases. These results were confirmed by Widbom et al,[16] who demonstrated a low success rate (46%) in nonplanned treatment procedures and a higher degree of success (77%) in planned cases for maxillary implant-supported overdentures.

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Fig 1a Panoramic radiograph of implants placed in the maxillary anterior region.

Fig 1b Panoramic radiograph of implants placed in augmented bone in the maxillary posterior region.

In most studies reporting on maxillary implant-supported overdentures, the implants were located in the anterior maxillary region.[8–12,15,16] However, implants placed in anterior maxillary regions for overdenture anchorage showed failure rates that often correlated with anterior maxillary bone quality and bone volume and with implant characteristics, especially implant length and diameter.[10–12,15,16] Numerous investigations of the maxillary posterior region after sinus augmentation procedures have shown high success rates for dental implants placed in augmented maxillary posterior regions, even for the support of maxillary overdentures.[13,17–22] Thus, implant placement in the posterior maxilla for overdenture anchorage may be an alternative to treatment with implants placed in the maxillary anterior region.[12,13,17]

The international literature includes only a few detailed reports of maxillary implant-supported overdentures, and there is a lack of reports comparing the anterior maxilla with the posterior maxilla region for implant placement for overdenture stabilization. Maxillary overdentures are predominately anchored on anterior implants by round bars.[11,15,16] For the maxillary posterior region, different prosthodontic treatment modalities such as splinted bars or unsplinted single attachments have been described and used successfully for overdenture anchorage.[17,23] However, the use of milled bars as rigid retention for overdentures either in the anterior maxillary region or bilaterally in the posterior maxillary region has rarely been described in detail.[13,24,25]

The objective of the present study was a retrospective evaluation of the clinical outcome of maxillary implant-supported overdentures rigidly anchored on milled bars. The results with respect to implant survival, peri-implant structures, and prosthodontic maintenance in particular were evaluated, and the results for implants in the anterior maxilla were compared with the results for implants in the posterior maxilla.

MATERIALS AND METHODS

Patient Selection and Implant Treatment

From 1998 through 2004, 34 patients (18 men, 16 women, age: 61.2 ± 11.2 years) with edentulous maxillae were admitted consecutively for implant-supported overdenture treatment. Implant placement surgery was planned in all cases, followed by restoration with a maxillary overdenture. Major inclusion criteria were the need of removable prostheses as a soft tissue support (lip support) and the patients' wish for removable dentures. Preoperative planning included radiographic diagnosis (panoramic radiograph, lateral cephalogram, axial and/or dental computerized tomographic scans) and prosthodontic records (diagnostic setup, determination of sagittal relation between the maxilla and mandible, planning of a bar connection in the maxillary anterior region). For all patients there was also the intention to place implants with an adequate length and diameter (length ≥ 13 mm, diameter ≥ 3.8 mm). No overdenture was fabricated as a rescue procedure.

The preoperative radiographic diagnosis and the prosthodontic records as well as the planned implant characteristics (length, diameter) were the criteria for subdividing the study population into 2 groups:

Group 1 (anterior implants, anterior concept) consisted of patients (n = 16) without sagittal discrepancy between the anterior maxilla and mandible and with presence of an anterior maxillary ridge of adequate width and height. In the anterior group, 4 submerged implants were placed in the nongrafted maxillary anterior region (Fig 1a). A prosthodontic prerequisite for using the anterior concept was that a splinted suprastructure in the maxillary anterior region would not have a negative influence on the palatal prosthodontic situation (phonetic disturbance).

Group 2 (posterior implants, posterior concept) consisted of patients (n = 18) with a sagittal discrepancy and/or a maxillary anterior ridge of inadequate

Table 1a Characteristics of Patients in Each Group

	Group 1	Group 2
Augmentation	None	Bilateral sinus lift
No. of patients	16	18
Mean age ± SD (y)	64.7 ± 8.6	58.1 ± 12.7
Female-male ratio	11/5	13/5
Implants (n)	64	115
Mean no. of implants per patient ± SD	4	6.3 ± 0.8
Healing period (mo.)	6	9 to 12
No. of milled bars	1	2
No. of smokers	5	4
No. of patients with diabetes	1	1

Table 1b Characteristics of Initially Placed Implants

	Diameter							
	3.8 mm		4.3 or 4.5 mm		5.0 or 5.5 mm		Total	
Length	n	%	n	%	n	%	n	%
13 mm	16	8.7	6	3.3	0	0	22	12.0
15 or 16 mm	82	44.8	74	40.4	5	2.7	161	87.9
Total	98	53.5	80	43.7	5	2.7	183	99.9

width and height. These patients underwent internal sinus augmentation (a 1-stage procedure in 12 cases and a 2-stage procedure in 24 cases) and the placement of 6 to 8 implants bilaterally in the posterior maxilla (Fig 1b). The most anterior implant (canine region) was placed in nongrafted bone, while the posterior implants (premolar/molar region) were placed in grafted areas. Bilaterally placed implants were splinted with 2 milled bars for overdenture anchorage.

Sinus augmentation procedures were performed in the traditional manner using the lateral window technique.[18,19,26] The amount of graft material collected varied depending on the amount needed. Autologous bone was harvested from intraoral (retromolar area, n = 6) or extraoral donor sites (the tibia in 8 cases and the iliac crest in 4 cases) and mixed with hydroxyapatite (Bio-Oss; Geistlich, Wollhusen, Switzerland) in a ratio described in previous studies.[21,22] Table 1a illustrates the characteristics of patients of groups 1 and 2.

Implant treatment was designed to follow a standard protocol and was carried out according to a standard procedure. The implants placed were root-form screw-type or step-screw design (Camlog root-line; Alltec, Wurmberg, Germany; Frialit-II, Dentsply Friadent, Mannheim, Germany). Surgery was performed as recommended by the manufacturers, and after a healing period of 6 to 12 months (group 1: 6 months; group 2: 9 to 12 months), the implants were uncovered, healing abutments were inserted, and prosthodontic procedures were started. Table 1b shows the distribution by length and diameter of the 183 implants initially placed.

Prosthodontic Treatment

For all patients the splinting suprastructure for implants consisted of a milled bar (titanium or gold alloy) of a 2- to 4-degree tapered design with a retention device for metal-reinforced overdentures. All overdentures were reinforced by a cast framework and consisted of 12 acrylic resin teeth. In the anterior group (group 1), the bar was cantilevered posteriorly where the maximal length of bar cantilevering was calculated according to the planned prostheses. The extension of the maximal cantilevering length for the overlying prosthesis (most posterior occlusal surface) was no more than 1.5 times the distance between the most anterior implant and the most posterior implant.[25,27] The extension of the milled bar was made in a similar manner, as described in a study evaluating mandibular overdentures with milled anterior bars (ie, the extension was always shorter than the prosthodontic extension and was within the defined dimension).[28] For the anterior bar (anterior concept), additional retention devices (Preci Vertex; Alphadent, Antwerp, Belgium) were used in the posterior bar extensions, and Variosoft (Bredent, Senden, Germany) was used in the splinted anterior bar region (between the 2 anterior implants; Fig 2a). In the posterior concept (group 2), both laterally situated milled bars included mesially and distally located retention devices (Preci Vertex; Fig 2b). All overdentures had a horseshoe design and were reinforced by a cast framework (Figs 3a, 3b, and 4). For all patients rigid anchorage of the maxillary dentures was achieved. In summary, each anterior restoration (n = 48) was retained by 3 retention devices, while each posterior restoration (n = 72) was retained by 4 retention devices.

Implant Follow-up Examination

After completion of the prosthetic treatment all patients were included in a strict maintenance care program, with regular monitoring at intervals of 6 to 12 months. These examinations included investigation of parameters of implant success and peri-implant conditions as well as prosthodontic maintenance.

For the most recent follow-up, implant survival rate and peri-implant conditions were evaluated. Examination of peri-implant conditions included evaluation of

Fig 2a Milled bar with posteriorly cantilevered extensions, including retention devices.

Fig 2b Bilaterally milled bars, including retention devices.

Fig 3a Overdenture base with a metal-reinforced framework for the anterior concept.

Fig 3b Overdenture base with a metal-reinforced framework for both posterior bars (posterior concept).

Fig 4 Horseshoe design of maxillary overdentures for both the anterior and posterior concepts.

peri-implant marginal bone loss (mm) and probing (pocket) depth in millimeters as well as Plaque Index, Bleeding Index, Gingival Index, and presence of calculus. Plaque and Bleeding Index were assessed according to Mombelli et al[29] (score 0 to 3). For assessing potential peri-implant inflammation the Gingival Index according to the modified Silness and Löe Index[30] was used (score 0 to 3). Probing (pocket) depth was defined as the mean of measurements at 4 sites (mesial, distal, lingual, buccal) made using a calibrated periodontal probe (Hu-Friedy, Chicago, IL). The presence (score 1) or absence (score 0) of calculus was noted.

Peri-implant marginal bone loss in millimeters was assessed radiographically on a panoramic radiograph and/or single periapical radiographs made using the paralleling technique. The distance between the crestal bone level and a defined reference point on the implant (lateral border of the implant platform) was measured for each implant on an initial radiograph made immediately after implant placement on on the most recent radiograph.[31]

Postinsertion Maintenance/Subjective Patient Satisfaction

During the follow-up period, prosthodontic complications and repairs for the implant-supported overdentures were registered and evaluated (based on Payne et al[32]). The following events were registered:

1. Implant component maintenance: implant loss or fracture, abutment screw loosening, abutment or bar fracture

2. Prosthesis component maintenance: matrix activation or renewal (acryl Preci matrix, acryl, Variosoft matrix), overdenture teeth fracture or renewal, overdenture fracture, denture margin adaptation (reduction or relining), overdenture rebasing, and opposing prosthesis maintenance (fracture, rebasing, or replacement)

Overall subjective patient satisfaction with implant-supported overdentures was assessed by questionnaires[28] at the most recent follow-up examination. Patients rated general satisfaction, chewing ability, denture stabilization, satisfaction with speech, and esthetics by answering questions with either 1 (not satisfactory), 2 (adequate), 3 (satisfactory), 4 (good), or 5 (excellent).

Statistical Analysis

The parameters were recorded in descriptive statistical manner, tabulated, and evaluated. A life table was constructed to generate the cumulative survival rates for the implants. Categorical variables for nonparametric data were compared using the χ^2 test, and mean values were tested with the Student *t* test. For all statistical analyses, Stat View 5.0 (SAS Institute) was used. $P < .05$ was considered the level of statistical significance.

RESULTS

Implant Survival

One hundred eighty-three implants were initially placed, including 4 implants which were lost during the healing phase, to support maxillary overdentures either on 4 anterior or 6 to 8 posterior implants. One hundred seventy-nine implants were prosthetically loaded and included in the follow-up program. No patient dropped out permanently, but patients missed annual follow-ups (temporary dropouts) for various reasons. At the time of data collection for this retrospective study, the overdentures had been in situ for at least 1 year and up to 7 years (mean ± SD 42.1 ± 20.1 months) with no significant difference between the 2 groups (group 1: 45.8 ± 15.7 months; group 2: 39.1 ± 23.2 months).

Group 1 comprised 16 patients (11 female, 5 male; 64.7 ± 8.6 y) with 64 root-line screw implants (4.0 implants/patient; 64 Camlog root-line implants; length, 13 or 16 mm; diameter, 3.8 to 5.0 mm; Fig 2a). One initially placed screw root line implant was prematurely lost during the osseointegration period. It was replaced by a new implant, which was used for the initially proposed prosthodontic procedure.

Group 2 comprised 18 patients (13 female, 5 male; age: 58.1 ± 12.7 y) with 115 root-form implants (6.3 ± 0.8 implants/patient; 106 Camlog root-line implants; length, 13 or 16 mm; diameter, 3.8 to 5.0 mm; 9 Frialit-II; length, 15 mm, diameter, 4.5 to 5.5 mm) were available for follow-up investigation (Fig 2b). Out of 118 initially placed implants, 37 implants were placed in nongrafted maxillary anterior regions and 81 implants were placed in grafted maxillary posterior regions. Three initially placed implants (1 placed in nongrafted bone, 2 placed in grafted bone) were prematurely lost during the osseointegration period and replaced. It was clearly evident that technical and medical expenses were significantly lower for the patients of group 1 (1 milled bar + 4 implants + overdenture) than for patients of group 2 (2 milled bars + 6 to 8 implants + overdenture).

Table 2a shows the cumulative survival rates of all implants (CSR: 97.8%) and especially those used for the anterior (group I: CSR: 98.4%) and posterior (group II: CSR: 97.4%) prosthodontic concept. Table 2b illustrates the CSR of grafted and nongrafted implants used for overdenture stabilization. There were no differences in the CSR between implants used for the anterior and the posterior concept as well as between grafted and nongrafted implants used for overdenture stabilization.

For the patients (n = 34) included in the follow-up study the opposite jaw presented as follows: dentate patients (n = 11), patients with fixed partial dentures (n = 10), or patients with implant-retained mandibular dentures (rigid fixation on milled bar supported on 4 implants; n = 13).

Peri-implant and Radiographic Parameters

Table 3 shows the mean values for the peri-implant parameters obtained at the last examination. Most patients exhibited good oral hygiene and the implants were often free of plaque and calculus. Some marginal bone resorption was observed at the time of uncovering. It was more pronounced in the anterior group, but the difference between the anterior and posterior groups was not significant.

Prosthodontic Maintenance and Subjective Satisfaction

The prosthodontic complication rate or the extent of maintenance required for purely implant-supported overdentures retained by a milled bar is shown in Table 4. The prevalence of prosthodontic maintenance did not differ between the 2 groups (concepts). Implant component maintenance included abutment screw loosening (6 of 179 implants [5%]) but no implant, abutment, or bar fracture. The most common postinsertion prosthodontic maintenance procedures required were modifications of the prosthesis margin (reduction or addition; n = 11). Mainte-

Table 2a Life Table Analysis Showing Implant Failure and Cumulative Survival Rates

	Total				Group 1				Group 2			
	No. of implants	Failures	CSR (%)	OD	No. of implants	Failures	CSR (%)	OD	No. of implants	Failures	CSR (%)	OD
Placement	183	4	97.8		65	1	98.4		118	3	97.4	
Loading to 1 y	179	0	97.8	34	64	0	98.4	16	115	0	97.4	18
1 to 2 y	165	0	97.8	31	56	0	98.4	14	109	0	97.4	17
2 to 3 y	142	0	97.8	27	52	0	98.4	13	90	0	97.4	14
3 to 4 y	92	0	97.8	18	40	0	98.4	10	52	0	97.4	8
4 to 5 y	74	0	97.8	15	36	0	98.4	9	38	0	97.4	6
> 5 y	54	0	97.8	10	16	0	98.4	4	38	0	97.4	6

OD = maxillary overdentures.

Table 2b Life Table Analysis Showing Implant Failure and Cumulative Survival Rates in Grafted and Nongrafted Regions

	Total			Nongrafted implants			Grafted implants		
	No. of implants	Failures	CSR (%)	No. of implants	Failures	CSR (%)	No. of implants	Failures	CSR (%)
Placement	183	4	97.8	102	2	98.0	81	2	97.5
Loading to 1 y	179	0	97.8	100	0	98.0	79	0	97.5
1 to 2 y	165	0	97.8	90	0	98.0	75	0	97.5
2 to 3 y	142	0	97.8	80	0	98.0	62	0	97.4
3 to 4 y	92	0	97.8	56	0	98.0	36	0	97.4
4 to 5 y	74	0	97.8	48	0	98.0	26	0	97.4
> 5 y	54	0	97.8	28	0	98.0	26	0	97.4

Table 3 Peri-implant Bone Resorption, Pocket Depth, and Soft Tissue Conditions of the Followed Implants (n = 179) in Relation to the Anterior or Posterior Regions at the Follow-up Examination

	Total		Group 1 (anterior)		Group 2 (posterior)	
	Mean	SD	Mean	SD	Mean	SD
Bone loss (mm)	2.1	0.6	2.2	0.6	2.0	0.5
Probing depth (mm)	3.6	1.3	2.8	2.0	3.2	2.1
Plaque Index (0–3)	0.5	0.4	0.5	0.5	0.5	0.7
Gingival Index (0–3)	0.3	0.4	0.3	0.5	0.3	0.5
Bleeding Index (0–3)	0.3	0.4	0.4	0.3	0.3	0.5
Calculus Index (0–1)	0.3	0.5	0.3	0.4	0.2	0.5

Group 1 versus group 2.

Table 4 Type of Prosthodontic Maintenance and Complications for Maxillary Overdentures

	Total	Group 1 (anterior)	Group 2 (posterior)
Implant component maintenance			
Abutment screw loosening/implants	6/179	2/64	4/115
Prosthodontic maintenance			
Matrix activation renewal (acrylic retention)	8/120	2/48	6/72
Prosthetic teeth fracture/renewal	6	4	2
Denture margin adaptation (reduction/addition)	11	6	5
Overdenture rebasing	2	1	1
Occlusal adjustment	3	1	2
Fracture/renewal of opposing denture	5	3	2

nance of the integrated retention elements (acrylic clip activation or renewal) was registered in 8 cases (8/120 retention devices [6.6%]).

The high subjective satisfaction scores were observed for all 5 areas assessed by questionnaire at the last follow-up examination. The mean scores were 5.0 for general satisfaction, 5.0 for chewing ability, 5.0 for denture stabilization, 4.7 ± 0.3 for satisfaction with speech, and 4.6 ± 0.2 for esthetic results. There was no signification difference between groups 1 and 2.

DISCUSSION

In contrast to the excellent implant and prosthodontic success rates for implant-supported mandibular overdentures,[2–7] several studies have described a higher number of implant and prosthodontic complications for implant-supported maxillary overdentures.[8–12] Poor bone quality, low bone quantity, short implant length with machined designs, and poor initial stability are potential problems encountered in the edentulous maxillae and may be responsible for a higher susceptibility for implant loss and loss of maxillary overdentures.[2,3,8–12] However, changes in implant characteristics, greater predictability, and utilization of grafting and surgical technique modifications for use in soft bone have all increased the success rates of maxillary implants in recent years compared to the early results.[13,16,17]

For improving the predictability of maxillary implant-supported overdentures, differentiation between planned and unplanned implant treatment procedures may be beneficial.[12–16] In the present study, implant-supported overdentures were planned in all cases in the anterior or posterior region. Through the use of a sophisticated treatment planning protocol, including the use of predefined criteria for implant characteristics, especially adequate length (≥13 mm) and diameter (≥ 3.8 mm), the present study demonstrated a cumulative 5-year survival rate higher than 98%. This is consistent with results of previous studies showing that planned implant placement for maxillary overdenture treatment has a significantly better outcome than rescue procedures.[15,17] Additionally, according to success criteria, which do not require individual annual measurements of crestal bone as an essential criteria for success, but rather absence of peri-implant radiolucency on radiographs,[33] the present findings suggest that the procedure described could also be associated with a high implant success rate.

In most previous studies investigating maxillary implant-supported overdentures, implants were placed in the anterior maxilla.[8–12,14–16] Although it has been recommended that a minimum of 6 implants be used in cases where a maxillary overdenture is supported solely by implants, the present study demonstrates that 4 anterior implants (with defined characteristics) can support an overdenture with a milled extension bar with high implant and prosthesis survival rates. However, because of the anatomy of the anterior maxillary ridge, placement of the anterior maxillary implants is often limited with respect to length and diameter; thus, this region is associated with the use of short implants. In separate studies, Mericske-Stern et al[15] and Widbom et al[16] found a high prevalence of loosening of short maxillary anterior implants (≤ 10 mm) supporting overdentures.

In contrast to investigations of maxillary overdentures supported by implants placed in anterior region, the findings of the present study demonstrate that implant placement in posterior maxillary region for overdenture anchoring may provide for an excellent survival rate even after sinus augmentation.[18–23] After a mean observation period of 40 months, no overall differences in implant survival rates or marginal bone resorption were seen between implants placed using the anterior or the posterior prosthodontic concept. Moreover, no differences in implant survival rates were seen between implants placed in grafted posterior regions and nongrafted anterior regions, which confirms previous reports of high success rates for implants placed in augmented maxillary regions.[9–23,34–36] The predominant use of implants with a sufficient length and diameter as well as other characteristics of the implants used may provide for a high survival rate after successful osseointegration and may be beneficial for long-term success without complications for both concepts used in this study.[15,17,20,31] Thus, instead of placement of short implants with higher risk for loosening in the anterior maxillary region, the results obtained suggest more detailed planning and preferential implant placement in the augmented maxillary posterior region.[19,34]

Interestingly, no differences were observed between anterior implants with anteriorly extended bars and the more frequently used posteriorly placed implants with bilateral bars with respect to peri-implant conditions (eg, Plaque Index, Bleeding Index, pocket depth).[15,36–38] Although the posterior concept (group 2) comprised a larger number of implants and 2 bars, no significant differences were noted with regard to hygienic and peri-implant parameters.[15,23] The healthy soft tissue and the good oral hygiene status may have been related to the strict recall program and the periodontal hygienic procedures performed for the patients,[15,17] and the peri-

implant marginal bone resorption encountered must be considered an expected development within the biologic band width.[36,37] In addition, a high degree of patient satisfaction was observed.

Choice between the anterior and posterior concepts should be based not only on maxillary anatomy and implant characteristics but also on the expected prosthodontic results. When anterior maxillary implants are connected and a sagittal discrepancy of the maxillomandibular relation is present, a connecting bar (inclusive prosthesis) can engage the palatal space and lead to phonetic problems similar to those described with fixed prostheses.[39,40] For such anatomic situations the bilateral posterior anchoring system should be preferred to the anterior concept, even if augmentation procedures are required.[15,17,23]

For maxillary overdentures, the implant survival rate and the postplacement prosthodontic maintenance have been described as influenced by the superstructures and especially by bending moments occurring in resilient anchoring systems.[16,17] Ferrigno et al[17] found a significantly lower implant survival rate and a higher prosthodontic maintenance rate for Dolder bars with resilient anchoring systems than for milled bars with rigid fixation of full-arch fixed prostheses. Similarly, Widbom et al[16] reported frequent prosthodontic maintenance for overdenture clip replacement and denture relining when using resilient anchoring systems.

A notable result of the present study was that overdentures rigidly anchored on implants with milled bars clearly showed a low incidence rate of prosthodontic maintenance requirements without any significant differences between the 2 prosthodontic concepts.[24,25] Thus, milled bars with either distal extensions from the anterior region or 2 bars placed bilaterally confirmed the hypothetical statement of Payne et al[32] that a distal support may provide for a more stable overdenture. The results obtained are consistent with the findings of Dudic et al,[41] who demonstrated that a rigid overdenture stabilization on implants is associated with fewer prosthodontic complications than a resilient anchorage system. This may be due to the design of the implant-supported prosthesis, which had a frictional overcasting that did not allow prosthesis rotation, thus reducing wear on the clips.[12,41-43] This observation is in accordance with the findings of Smedberg et al[44] and Zitzmann et al,[13] who used a similar bar design for overdenture prostheses in their studies. The use of reinforced frameworks may help reduce the complication rate as well.[13,25,44]

It is a well-known fact, described in previous studies, that in cases with advanced atrophy and with unfavorable maxillomandibular relations, soft tissue support by prosthetic margins and prosthetic posts is necessary to ensure adequate cosmetic results.[45–47] In cases where soft tissue support is lacking, the use of a fixed prosthesis would deteriorate facial appearance and esthetics. Lack of soft tissue support may also be an exclusion criterion for the placement of implants in the anterior maxilla, as in group 1 in the present study. However, the use of the milled bars for rigid anchorage of overdentures combines the favorable features of removable and fixed prostheses.[25,47] Thus, denture stability and retention as well as implant survival rate may be similar to those observed with fixed prostheses, but the flanges of the overdenture may be utilized to compensate for esthetic and vertical disharmony and to facilitate handling and cleaning.[45–47]

Unfortunately, intricate technical work such as that described in the present study is associated with high costs. With regard to the medical and technical expenses, both treatment modalities with maxillary overdentures are certainly associated with higher costs than the conventional bar prosthesis. In addition, the posterior concept of group 2 is also more costly than the posterior concept of group 1. In the present study, the patients were informed of these costs and received financial support; therefore, cost was not a reason for them to refuse this treatment concept. Although the production costs for such implant-prosthetic solutions are high, their long-term stability, low complication rate, and reduced need for maintenance should also be taken into consideration.[48,49] Milled bars for the anchorage of an implant-supported rigid maxillary overdenture provide clinical benefits which justify their consideration as a viable treatment option in edentulous maxillae.

CONCLUSIONS

On the basis of this retrospective clinical review, the following was observed:

- Overall, maxillary implants supported by milled bars for rigid overdenture anchoring were associated with a high survival rate and satisfactory peri-implant conditions.
- Implants placed for the support of a maxillary anterior concept and those placed in support of a posterior concept did not differ with respect to survival rate or peri-implant parameters, regardless of placement in augmented or nonaugmented regions.
- The use of milled bars and metal-reinforced prosthesis frameworks led to a low incidence of prosthodontic complications.

- The use of the milled bars for rigid anchorage of fixed-removable maxillary overdentures combines several favorable prosthodontic features of removable and fixed prostheses.

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