Overdentures in the Edentulous Mandible Supported by Implants and Retained by a Dolder Bar: A 5-Year Prospective Study

Alexander Heschl, DDS, DMSc;* Michael Payer, MD, DDS, DMSc, PhD;† Volker Clar, DDS;* Marlene Stopper, DDS;* Walther Wegscheider, MD, DDS, PhD;‡ Martin Lorenzoni, MD, DDS, PhD§

ABSTRACT

Purpose: This prospective study was performed to evaluate the outcomes of XiVE® S plus implants (Dentsply Friadent, Mannheim, Germany) following conventional restoration with bar structures and overdentures in the edentulous mandible.

Materials and Methods: A total of 39 patients were treated with four interforaminal implants ($n = 156$) splinted by a Dolder bar. Overdentures were attached to the bars after 3 months of healing. As primary outcome measures, clinical and radiological parameters were evaluated at the time of implant placement (baseline) and once a year (1, 2, 3, 4, 5 years) after functional loading. Secondary outcome measures included (i) primary stability and surgical complications, as well as (ii) Periotest® (Medizintechnik Gulden, Modautal, Germany) values, implant survival, and prosthetic complications at baseline and follow-up.

Results: A total of 156 implants were placed. The vast majority ($n = 149$) were tightened to >30 Ncm, while torques in the range of 20–30 Ncm were obtained in the remaining cases ($n = 7$). Mean crestal bone levels around the implants were 0.41 mm at baseline and 1.04/1.20/1.34/1.45/1.44 mm after 1/2/3/4/5 years respectively. The mean values of the plaque, calculus, bleeding, and mucosal indices remained low throughout this period. The reported follow-up periods involved one implant loss after 3 months (survival rate: 99.4%) and one implant failure after 4 years (success rate: 98.4%). Prosthetic complications included factures of bars ($n = 3$) and denture teeth ($n = 7$). Prosthetic survival was 100%.

Conclusions: Dolder bars to restore oral implants in the edentulous mandible appear to offer a high rate of implant survival, good stability of the peri-implant tissue, and a low rate of prosthetic complications.

KEY WORDS: crestal bone measurement, Dolder bar, edentulous mandible, overdenture

INTRODUCTION

Various designs of implant-supported fixed and removable superstructures have yielded good clinical results in the edentulous mandible over the past few decades. Bar structures (Dolder, round, and milled bars) and fixed dental prostheses supported by interforaminal implants are the most common treatment modality used in oral implantology to rehabilitate the edentulous mandible[1–7] and to improve the quality of life and psychological well-being of patients.[8] Survival rates are documented to range from 97.1% to 100% based on implants and from 88% to 100% based on superstructures after 1 to 10 years of follow-up.[9]

Multiple factors contribute to implant survival – including bone quantity and quality, primary stability, number/length/diameter/distribution of implants across the arch,[10] implant surface and geometry,[11–13] loading protocol, prosthetic design, occlusal concept, and maintenance of oral hygiene. There is unanimous agreement that primary stability is closely related to

*Research associate, Department of Prosthodontics, School of Dentistry, Medical University Graz, Graz, Austria; †associate professor, Department of Oral Surgery and Radiology, School of Dentistry, Medical University Graz, Austria; ‡professor and head, Department of Prosthodontics, School of Dentistry, Medical University Graz, Austria; §associate professor, Department of Prosthodontics, School of Dentistry, Medical University Graz, Austria

Reprint requests: Univ.-Prof. Dr. Martin Lorenzoni, Department of Prosthodontics, School of Dentistry, Medical University Graz, Auenbruggerplatz 12, 8036 Graz, Austria; e-mail: martin.lorenzoni@medunigraz.at

Source of Funding: The study was self-funded by the authors and their institution.

DOI 10.1111/j.1708-8208.2011.00380.x

bone structure, and that higher rates of implant survival are obtained in the mandible than in the maxilla.[6,14–16] Numerous studies confirm that the interforaminal region should be preferred for implant placement in the edentulous mandible, but opinions differ on how many implants are required to adequately support the rehabilitations.[2,7,17]

Mericske-Stern[18,19] concluded that two implants offered the same quality of retention as three or more implants for hybrid dentures in the edentulous mandible. Visser and colleagues[7] failed to observe any clinical or radiographic differences between two and four implants over 5 years of follow-up. According to Besimo and colleagues,[20] at least three or four implants should be placed for hybrid dentures if no support by natural abutments is present. Very clearly, however, a bar structure attached to four (rigidly splinted) implants will effectively prevent nonaxial rotation, excessive loading, and micromovements.[3] Cantilever extensions have become established to avoid placing implants in sites with advanced resorption and to prevent injury to the alveolar nerve.[21] Placing cantilevers on bars has proven useful to offer adequate occlusal support in posterior segments.[22] Functional overloads can be prevented by limiting distal extensions such that no teeth are present beyond the first molar sites.[23,24] According to Semper,[25] crestal bone loss was not adversely affected by bar-retained prostheses with ≤12 mm distal bar extensions but remained comparable to the degree of bone loss observed in earlier studies.[25] A systematic review by Cehreli and colleagues[26] did not yield any differences in crestal bone loss around implants retaining or supporting mandibular overdentures based on different implant or attachment designs. The ideal type of retention designs to be used for overdentures in view of postinsertion maintenance requirements has been discussed controversially. While den Dunnen and colleagues[27] did not encourage the use of cantilever extensions to avoid extensive postinsertion care, other authors[28,29] reported a low incidence of prosthetic maintenance requirements for mandibular overdentures that were rigidly supported by implants.

Esposito and colleagues[11] conducted a systematic review of the literature to analyze survival and success rates obtained with immediate, early, and conventional loading of implants. They failed to identify any statistically significant differences between the various protocols, but there was a trend toward higher failure rates among implants subjected to immediate and early loading as compared with conventional loading. De Smet and colleagues[30] used a prospective study design to evaluate loading protocols in the edentulous mandible. They reported similar results for early and conventional loading, whereas the risk of failure was found to be increased among distal implants subjected to immediate loading.

Evidence has shown that enossal implants splinted by a Dolder bar constitute an extremely helpful treatment concept with high success rates.[31] The objective of this prospective study was to evaluate mandibular implants loaded with bar-retained overdentures for implant survival, restorative success, surgical complications, restorative complications, and crestal bone loss. The primary hypothesis of this study was that bar-retained overdentures in the edentulous mandible, supported by four screw-type implants and delivered in a conventional loading protocol, would achieve clinically and radiographically predictable long-term outcomes. A secondary hypothesis to be verified was whether the presented treatment modality should be recommended for dental rehabilitation of elderly patients in regard to prosthetic complications, implant success, implant complications, and ability to perform proper oral hygiene.

MATERIALS AND METHODS

Patients

The study was executed at a single center. All patients gave their informed consent prior to treatment. Institutional approval of the study protocol was obtained from the local ethics commission at the Medical University of Graz, Austria.

Patients were included in the study if they met the following criteria: (1) 18 years or older; (2) adequate vertical and horizontal bone volume to place four implants at least 11 mm in length and 3.8 mm in diameter; (3) primary stability ≥20 Ncm; (4) edentulism in the mandible for at least 6 months; and (5) good motivation to comply with periodic recalls.

Patients were excluded from the study if they met the following criteria: (1) heavy smoking (combined with other risk factors such as untreated periodontitis, diabetes, osteoporosis); (2) bruxism; (3) untreated acute/chronic periodontitis and/or peri-implantitis; (4) pregnancy; (5) previous radiotherapy in the head and

TABLE 1 Implant Lengths and Diameters Used in the Present Study

	Implant Length (mm)		
Implant Diameter (mm)	11	13	15
3.8		10	64
4.5	1	10	63
5.5	3	2	3

neck area; and (6) poor motivation to comply with periodic recalls.

Thirty-nine patients (22 men and 17 women) with a mean age of 60.9 (28–79) years were included and treated with implants in the interforaminal area of the mandible from 4/2000 through 1/2004. A total of 156 implants were placed and splinted by a Dolder bar (which included distal extensions) after 3 months of healing. The decision for a conventional treatment protocol was purely patient-driven after extensive consultation. Two surgeons (W.W and M.L.) placed XiVE® S plus implants (Dentsply Friadent, Mannheim, Germany); the implants used were 3.8 mm ($n = 74/47.44\%$), 4.5 mm ($n = 74/47.44\%$), and 5.5 mm ($n = 8/5.13\%$) in diameter; 11 mm ($n = 4/2.56\%$), 13 mm ($n = 22/14.10\%$), and 15 mm ($n = 130/83.33\%$) in length and were placed at sites 32/34/42/44 (Table 1). The opposing maxillary arches had been restored with complete overdentures ($n = 35$) or with removable/fixed partial dentures in the presence of natural teeth ($n = 4$).

Planning Procedure

Following a detailed intraoral and extraoral examination, each patient was provided with a mandibular complete denture (denture base: ProBase Hot or Paladon 65; anterior teeth: SR Vivodent or Magister; molars: SR Orthotyp or Orthognat; Ivoclar Vivadent, Schaan, Liechtenstein; Heraeus Kulzer, Hanau, Germany) adjusted to the anatomical and physiological situation. Once fabricated, each complete denture was duplicated and cast in clear resin (Palapress clear, Heraeus Kulzer). The anterior area between the two mental foramens (where the implant heads were located) in this duplicate denture was countersinked and subsequently utilized as surgical template.

Clinical Procedure

All implants were placed by two experienced implant surgeons (M.L and W.W.) of the same department without adjunctive regenerative measures and not before 6 months after extraction (late placement). Surgical procedures were conducted under local anesthesia (Ultracain DS forte cartridges®, Sanofi-Aventis, Frankfurt, Germany) with the patients covered by antibiosis (initiated 1 day preoperatively) and antiphlogistic treatment. In addition, a 0.2% chlorhexidine digluconate solution (Chlorhexamed® Forte 0.2%, GlaxoSmith-Kline, Munich, Germany) was prescribed. Patients were instructed to rinse 3 days before the procedure and postoperatively for 7 days on a daily basis. Surgery was started by placing a crestal incision and vertical releasing incisions to elevate a mucoperiosteal flap. Then the surgical template was applied and pilot drilling performed for ideal implant angulation. Implant bed preparation was continued by using a sequence of burs covering all diameters available in increasing order to effectively minimize any deviations from the pilot drillings.[32] Subsequently the implants were inserted strictly in accordance with the manufacturer's recommendations to a torque exceeding 20 Ncm (W&H® Implantmed, W&H Dentalwerk Bürmoos, Bürmoos, Austria). The final position of each implant was established with a manual ratchet (Friadent® ratchet, Dentsply Friadent).

The implant mounts/temporary abutments (Temp-Base®, Dentsply Friadent) were removed and replaced with cover screws. This was followed by vertical mattress sutures for impermeable and tension-free wound closure. All implants were left submerged for 3 months of healing and were then surgically exposed in a second-stage procedure. After 2 weeks of healing, an impression was taken with a polyether material in a custom tray, using either the repositioning or the pick-up technique. Healing abutments for soft-tissue conditioning (Friadent®, Dentsply Friadent) were attached to the implants, and the existing complete dentures were subjected to soft relining (Sofreliner Tough, Tokuyama Dental, Altenberge, Germany). U-shaped gold Dolder bars (Stabilor NF IV®, Degudent, Hanau, Germany) soldered to gold copings with distal extensions (maximum length 12 mm from the back of the copings) were fabricated in the laboratory and were subsequently connected to the implants via multipurpose abutments (MP abutment®; Dentsply Friadent). Three retention clips were cured into the existing complete denture, one in the anterior segment between the two mesial implants and two at the positions of the distal extensions. To ensure retention, rigidity and homogeneous load distribution to the

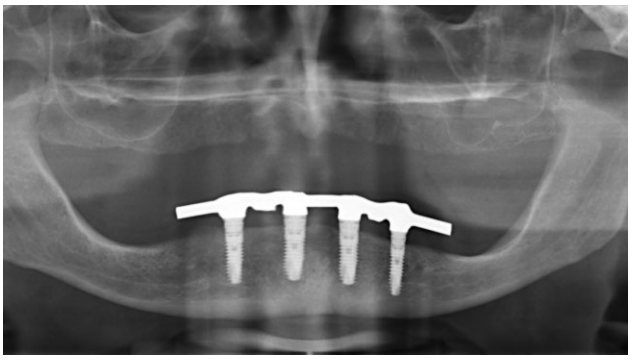

Figure 1 Panoramic radiograph demonstrating the positions of the implants.

implants, no additional spacers were used (Figures 1–3). The peripheral seal areas were relined, if indicated, to prevent impaction of food. All patients were given comprehensive hygiene instructions.

Clinical and Radiographic Examinations

At the time of implant placement (baseline) and then annually for up to 5 years, intraoral digital radiographs (Sidexis Intraoral, Orthophos plus DS, Sirona Dental Systems, Bensheim, Germany) with rectangular collimation were obtained to measure the crestal bone loss on the mesial and distal aspects of each implant. The indicator scale was calibrated using implant length and diameter as references. Crestal bone loss was evaluated by measuring the distance of the implant shoulder to the crestal bone margin on the mesial and distal aspects. Whenever the buccal and lingual bone contours overlapped, a mean value was applied. All radiographs were investigated for evaluability by an experienced investigator. Areas of interest were measured at ×2 magnification and statistically analyzed (Figure 4). Any questionable

Figure 2 Intraoral picture of inserted Dolder bar. 564 × 336 mm (72 × 72 DPI).

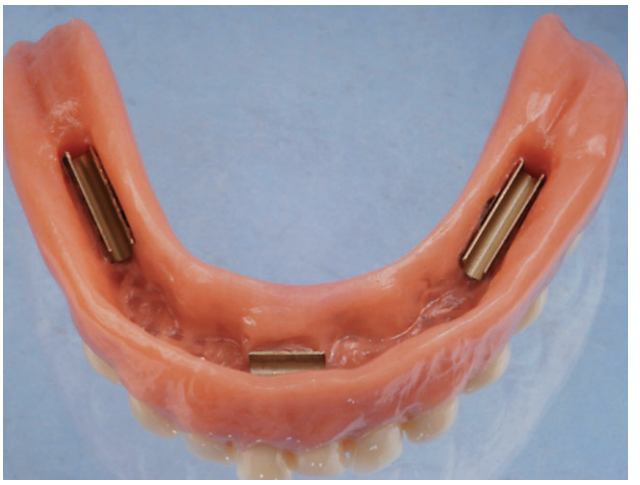

Figure 3 Overdenture with cured retention clips. 412 × 313 mm (96 × 96 DPI).

results of measurement were reevaluated and consensually settled by two more independent investigators.

The peri-implant mucosa was assessed every year based on several parameters. Mombelli and colleagues[33] defined the index used to assess plaque (0 = not detected; 1 = detected by running a probe across the smooth marginal surface of the implant; 2 = apparent to

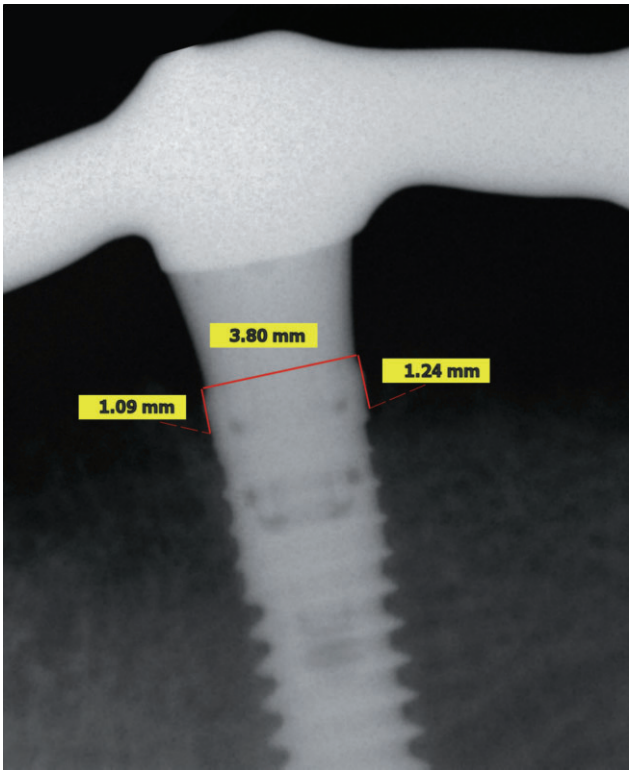

Figure 4 Radiographic crestal bone measurement analysis. 460 × 564 mm (72 × 72 DPI).

the naked eye; 3 = abundantly present). Calculus was documented as being present (score 1) or absent (score 0). Löe & Silness[34] defined the index we used to define the appearance of the peri-implant mucosa (0 = normal; 1 = mild inflammation with slightly altered color; 2 = moderate inflammation with redness, edema, glazing; 3 = severe inflammation with redness, edema, ulceration). Mombelli and colleagues[33] defined the index used to assess bleeding (0 = no bleeding on probing; 1 = isolated bleeding spots; 2 = a confluent red line of blood along the mucosal margin; 3 = heavy or profuse). The bars were removed to evaluate the probing depths (distances between the pocket floor and mucosal margin) around each implant at four locations (mesial, buccal, lingual, distal) using a periodontal probe (Merit B, Hu Friedy, Chicago, IL, USA).

Primary stability (Ncm) and surgical complications were evaluated intraoperatively, Periotest® (Medizintechnik Gulden, Modautal, Germany) values, survival rates, and prosthetic complications were evaluated both at baseline and during the follow-up examination. Clinical inspection was performed to check occlusal relations and the condition of the peri-implant mucosa (e.g., signs of local inflammation).

Statistical Analysis

Mean crestal bone level reductions were determined with the nonparametric Brunner and Langer's test for longitudinal data.[35] The same method was used to compare anterior and posterior implants. The various indices (plaque, calculus, bleeding, mucosa) and probing depths per year were expressed by descriptive means. Linear regression was used to identify a potential correlation between peri-implant tissue health and crestal bone level changes. Data were analyzed both per patient and per implant. Results were considered statistically significant at $p < .05$. All statistical analysis was performed with SPSS® (version 17, SPSS Inc., Chicago, IL, USA) and SAS® (version 9.2, SAS Institute, Cary, NC, USA) software.

RESULTS

A total of 156 implants (XiVE S plus) had been placed within the interforaminal area of the mandible into bone exhibiting type-1 or type-2 quality, as defined by Lekholm and Zarb.[36]

At 4 years, 152 of 156 implants could be evaluated, because one patient did not follow-up. At 5 years, six patients did not follow-up, with three of them having died in the meantime. Radiography showed that none of the implants had been inserted to a subcrestal level, such that the reference point at the implants differed from the bone level by a mean of 0.41 ± 0.24 (0.00–1.60) mm at baseline. Digital radiographic measurements yielded the following bone level reductions: 1.04 ± 0.54 (0.00–2.00) mm at 1 year, 1.20 ± 0.62 (0.00–2.54) mm at 2 years, 1.34 ± 0.71 (0.00–2.89) mm at 3 years, 1.45 ± 0.75 (0.00–3.45) mm at 4 years, and 1.44 ± 0.78 (0.00–4.23 mm) at 5 years. These bone level changes noted from year to year were statistically significant ($p < .05$; LD [longitudinal data]_F1 [treatment factor] as defined by Brunner and Langer;[35] Table 2 and Figure 5).

The F1 (stratification factor)_LD (longitudinal data)_F1 (treatment factor) statistical model defined by Brunner and Langer[35] was used for comparison between the anterior and posterior implants. No significant difference was detected throughout the follow-up period of up to 5 years ($p > .05$) (Table 3). Also, the mean plaque, calculus, bleeding, and mucosal index values remained low throughout this period, and linear regression did

TABLE 2 Bone Level Reductions and Periotest Values

	Crestal Bone Levels					Periotest Values				
Time (years)	Min	Max	Median	Mean	SD	Min	Max	Median	Mean	SD
Baseline	0.00	1.60	0.40	0.41	0.24					
1	0.00	2.00	1.05	1.04	0.54	−7	−2	−5	−5.4	1.3
2	0.00	2.54	1.34	1.20	0.62	−7	−2	−5	−5.1	1.4
3	0.00	2.89	1.50	1.34	0.71	−7	−2	−5	−4.8	1.6
4	0.00	3.45	1.60	1.45	0.75	−7	−1	−5	−4.6	1.8
5	0.00	4.23	1.57	1.44	0.78	−7	−1	−5	−4.6	1.9

SD = standard deviation.

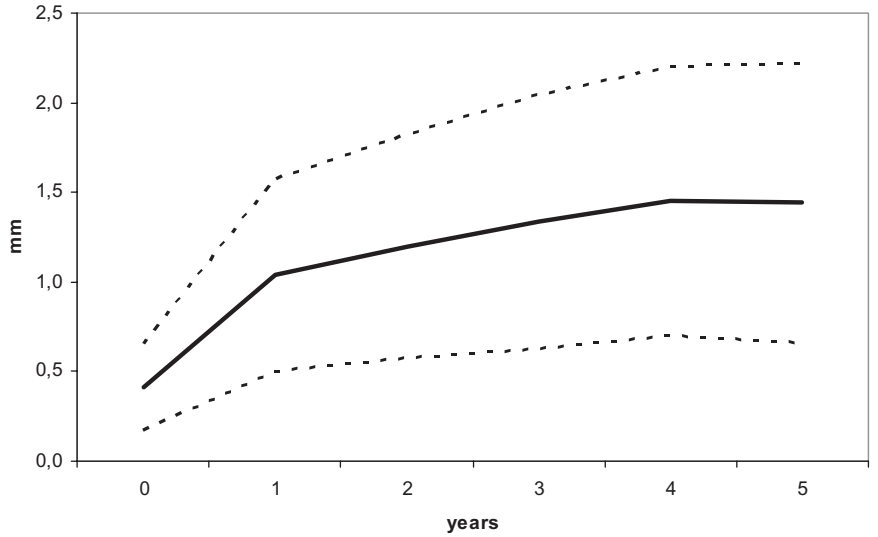

Figure 5 Mean values ± standard deviation of coronal bone levels up to 5 years.

not disclose a correlation between peri-implant tissue health and crestal bone level changes (Table 4). Primary stability was >30 Ncm in 139 implants and ranged from 20 to 30 Ncm in 17 patients. The median of all Periotest values (PTV) was −5 (see Table 2).

Observation periods of up to 6 years involved one implant loss after 3 months (survival rate: 99.4%) and one implant failure after 4 years (success rate: 98.6%). Prosthetic complications included fractures of denture teeth ($n = 7$) and bar fractures ($n = 3$). All complications could be repaired within a single day (prosthetic survival rate: 100%) (Table 5).

To avoid dependencies of implants placed in one region within single patients, statistical analysis was additionally performed at patient level, which reduced the case number from 156 to 39. The same statistical bone level and PTV value developments were observed over time. The Brunner–Langer test (module LD_F1) again revealed a statistically significant time effect ($p < .001$) (Table 6). Wilcoxon's paired test confirmed an increase of bone loss. Based on PTV values, the Brunner–Langer test (module LD_F1) did reveal a time effect (see Table 6). Separating the data into anterior and posterior implants is no longer possible after combining the four implants.

DISCUSSION

Our prospective study included 39 patients with edentulous mandibles, each being treated with four interforaminal implants. Crestal bone loss and prosthetic complications were evaluated as outcome measures over up to 5 years. Albrektsson and colleagues[37] defined bone level reductions of 1.5 mm (first year) and 0.2 mm

TABLE 3 Bone Level Reductions at Anterior (32/42) and Posterior (34/44) Implant Sites

	Bone Levels Around Anterior Implants					Bone Levels Around Posterior Implants				
Time (years)	Min	Max	Median	Mean	SD	Min	Max	Median	Mean	SD
Baseline	0.00	1.60	0.40	0.40	0.26	0.00	1.10	0.42	0.42	0.22
1	0.10	2.00	1.01	0.99	0.54	0.00	1.99	1.18	1.10	0.54
2	0.10	2.42	1.24	1.13	0.62	0.00	2.54	1.42	1.27	0.63
3	0.15	2.69	1.37	1.27	0.72	0.00	2.89	1.55	1.41	0.71
4	0.15	2.80	1.60	1.38	0.75	0.00	3.45	1.60	1.52	0.75
5	0.15	2.55	1.30	1.35	0.77	0.00	4.23	1.60	1.52	0.78

SD = standard deviation.

TABLE 4 Mean Values and Standard Deviations of Plaque Index, Calculus Index, Gingival Index, Bleeding Index, and Probing Depth

	Mean (SD) Plaque Index	Mean (SD) Calculus Index	Mean (SD) Gingival Index	Mean (SD) Bleeding Index	Mean (SD) Probing Depth (mm)
Year 1	0.4 (0.2)	0.4 (0.3)	0.5 (0.4)	0.9 (0.5)	3.0 (0.7)
Year 2	0.4 (0.3)	0.5 (0.3)	0.5 (0.4)	1.1 (0.5)	3.5 (0.7)
Year 3	0.5 (0.4)	0.5 (0.4)	0.5 (0.4)	0.3 (0.5)	3.5 (0.7)
Year 4	0.5 (0.4)	0.5 (0.4)	0.6 (0.4)	1.3 (0.6)	3.7 (0.6)
Year 5	0.5 (0.5)	0.5 (0.3)	0.7 (0.4)	1.3 (0.6)	3.8 (0.6)

(second year) after implant placement as clinically acceptable. Other authors have called these reductions a "natural biological process."[38,39]

While recent studies and consensus statements have established that implant-supported overdentures in the mandible require at least two implants to optimize prosthetic stability, inconsistent reports on success rates have prevented a consensus about the design of the superstructure.[40–42] Naert and colleagues[43] failed to observe any differences in the clinical and radiographic outcomes of hybrid dentures supported by either two or four implants. After 5 years of follow-up, the implant survival rate was 100%. No significant differences in crestal bone loss were observed between the various groups both after 1 year (0.6 mm) and after 5 years (<0.1 mm per year that followed). Nevertheless, the concept of using only two implants to rehabilitate the edentulous mandible should be questioned because of problems like nonaxial overloading,[3] posterior bone resorption, or denture rotation.[44] Rigid anchoring of these superstructures will reduce the need for prosthetic maintenance.[4,45]

Comparable survival rates between 83% and 100% are documented for implant-supported fixed and

TABLE 5 Implant Success and Survival Rates

Time (years)	Implants	Fails	Losses	Cumulative Survival Rate	Cumulative Success Rate
Baseline	156	0	0	100%	100%
1	156	0	1	99.4%	99.4%
2	156	0	0	99.4%	99.4%
3	156	0	0	99.4%	99.4%
4	152	0	0	99.4%	99.4%
5	128	1	0	99.4%	98.6%

TABLE 6 Bone Level and PTV Values Combined per Patient

	Bone Level					PTV				
Time (years)	Min	Max	Median	Mean	SD	Min	Max	Median	Mean	SD
Baseline	0.04	1.11	0.40	0.41	0.21					
1	0.14	1.93	1.07	1.04	0.47	−6.50	−3.25	−5.25	−5.38	0.67
2	0.14	2.38	1.41	1.20	0.57	−6.25	−3.25	−5.00	−5.13	0.69
3	0.15	2.62	1.51	1.34	0.65	−6.00	−3.25	−4.75	−4.82	0.63
4	0.15	2.69	1.63	1.45	0.68	−6.25	−3.25	−4.63	−4.63	0.62
5	0.15	2.48	1.49	1.44	0.69	−6.25	−3.25	−4.75	−4.61	0.70

PTV = Periotest values; SD = standard deviation.

removable dentures in the mandible.[46,47] Brånemark and colleagues[48] reported that implant survival rates were not significantly different in mandibles restored with four or six implants (88.4% versus 93%). After 6 years of follow-up, however, a trend toward higher failure rates was noted in mandibles restored with four implants. Bryant and colleagues[47] followed up rehabilitations of the edentulous mandible supported by four to six implants over up to 5 years. Both for fixed and removable dentures, they reported 1.17 mm of mean bone loss within the first year of implant placement and 0.38 mm within each year that followed. The present study, by contrast, yielded a mean bone loss of 1.1 mm after up to 5 years of follow-up; thus, the degree of bone loss was smaller than documented by Bryant and colleagues.[47]

Krennmair and colleagues[3] performed a retrospective study on cylindrical versus screw-type implants in the edentulous mandible. They used four interforaminal implants splinted by a bar that included extensions. A mean follow-up of 59.2 months resulted in a cumulative survival rate of 99%. Crestal bone loss was significantly more pronounced around the cylindrical (2.2 ± 0.6 mm) than around the screw-type (1.9 ± 0.6 mm) implants. Within the group of cylindrical implants, a significant difference was also noted between mesial (2.3 ± 0.5 mm) and distal (2 ± 0.5 mm) sites. Within the group of screw-type implants, no such difference between mesial (2.2 ± 0.5 mm) and distal (1.9 ± 0.6 mm) sites was observed.

Our own results are consistent with the findings by Krennmaier and colleagues,[3] both in terms of bone loss and regarding the absence of a significant difference between mesial and distal implants. They are also in keeping with a mean bone level reduction of 1.25 mm reported by Visser and colleagues[7] after 5 years of follow-up. Different results are reported by Wismeijer and colleagues.[49] These authors observed a significantly higher degree of bone loss at mesial (2.1 ± 0.31 mm) than distal (1.4 ± 0.25 mm) implant sites along mandibular rehabilitations supported by four splinted implants. They attributed this bone loss around the central implants to dorsal loads transmitting adverse tensile stresses to the superstructure.

Another cause of increased bone loss is stress transmitted to implants by bar structures lacking passivity of fit. Impression taking aims to transfer the situation encountered in a patient's mouth precisely to a master cast in the laboratory, thus allowing a prosthetic restoration to be fabricated that will not transmit any stresses to the implants. According to a systematic review of the literature, the repositioning technique offers the same degree of accuracy as the pick-up technique for impressions encompassing up to three implants, whereas the pick-up technique used with a polyether impression material does offer greater accuracy in the presence of four or more implants.[50,51] Both (the repositioning and pick-up) techniques were used in the present study. Tightening the bar to the implants was followed by obtaining radiographs and conducting a Sheffield test to verify its gap-free seating.[52]

Krennmair and colleagues[3] also showed that the distal extensions included in their bars affected neither the degree of crestal bone loss nor the implant survival rate. Furthermore, they demonstrated a small number of prosthetic follow-up intervals within the observation period. According to Waddell and colleagues,[53] the areas of maximum force transmission to the bar are the gold cylinders and the extensions soldered to them. Both stresses related to the retention screw and flexural stresses related to the distal extension are transmitted to these areas. Critical factors include the bending moment, extension length, and force level (average force of occlusion function = 250 N). We counteracted these forces by tightening the retention screws to 25 Ncm, which was in accordance with the manufacturer's recommendations, and by confining the extensions to a maximum length of 12 mm.[54,55] Semper[25] evaluated the influence of cantilever length on crestal bone loss under implant-supported and bar-retained overdentures. No difference was found between patients in whom cantilevers (up to 12 mm) were used versus patients without cantilevers. Despite these precautions, we observed three bar fractures, possibly as a result of neuromuscular dysfunction such as bruxism. The therapeutic consequence we have drawn from this finding is that we shall use cast Dolder bars for implant-supported rehabilitations of edentulous patients in an effort to reduce the complication rate even further. Our results for mean plaque, calculus, bleeding, and mucosal indices were similar to those reported by Meijer and colleagues[17] and Krennmair and colleagues[44] even though those authors did not evaluate each group for statistical significance. The mean index values and probing depths observed in the present study remained low and stable throughout all follow-up examinations, although a slight decrease of all parameters was noticed over time.[17,56]

CONCLUSION

To summarize, the present prospective clinical study showed that enossal XiVE S plus implants splinted by a Dolder bar in the edentulous mandible resulted in stable peri-implant conditions and were associated with a low complication rate of the related overdentures over follow-up periods of up to 5 years.

REFERENCES

1. Aglietta M, Siciliano VI, Zwahlen M, et al. A systematic review of the survival and complication rates of implant supported fixed dental prostheses with cantilever extensions after an observation period of at least 5 years. Clin Oral Implants Res 2009; 20:441–451.
2. Gallucci GO, Doughtie CB, Hwang JW, Fiorellini JP, Weber HP. Five-year results of fixed implant-supported rehabilitations with distal cantilevers for the edentulous mandible. Clin Oral Implants Res 2009; 20:601–607.
3. Krennmair G, Krainhofner M, Piehslinger E. Implant-supported mandibular overdentures retained with a milled bar: a retrospective study. Int J Oral Maxillofac Implants 2007; 22:987–994.
4. Krennmair G, Krainhofner M, Piehslinger E. The influence of bar design (round versus milled bar) on prosthodontic maintenance of mandibular overdentures supported by 4 implants: a 5-year prospective study. Int J Prosthodont 2008; 21:514–520.
5. Ledermann P. Complete denture support in edentulous problem mandibles with help from 4 titanium plasma-coated pdl screw implants. SSO Schweiz Monatsschr Zahnheilkd 1979; 89:1137–1138.
6. Lorenzoni M, Pertl C, Zhang K, Wegscheider WA. In-patient comparison of immediately loaded and non-loaded implants within 6 months. Clin Oral Implants Res 2003; 14:273–279.
7. Visser A, Raghoebar GM, Meijer HJ, Batenburg RH, Vissink A. Mandibular overdentures supported by two or four endosseous implants. A 5-year prospective study. Clin Oral Implants Res 2005; 16:19–25.
8. Feine JS, Carlsson GE, Awad MA, et al. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24–25, 2002. Int J Oral Maxillofac Implants 2002; 17:601–602.
9. Gallucci GO, Morton D, Weber HP. Loading protocols for dental implants in edentulous patients. Int J Oral Maxillofac Implants 2009; 24(Suppl):132–146.
10. Mericske-Stern RD, Taylor TD, Belser U. Management of the edentulous patient. Clin Oral Implants Res 2000; 11(Suppl 1):108–125.
11. Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. Cochrane Database Syst Rev 2009; 21:CD003878.
12. Lioubavina-Hack N, Lang NP, Karring T. Significance of primary stability for osseointegration of dental implants. Clin Oral Implants Res 2006; 17:244–250.
13. Morris HE, Ochi S, Crum P, Orenstein I, Plezia R. Bone density: its influence on implant stability after uncovering. J Oral Implantol 2003; 29:263–269.
14. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci 1998; 106:527–551.
15. Miyamoto I, Tsuboi Y, Wada E, Suwa H, Iizuka T. Influence of cortical bone thickness and implant length on implant stability at the time of surgery – clinical, prospective, biomechanical, and imaging study. Bone 2005; 37:776–780.
16. Nkenke E, Hahn M, Weinzierl K, Radespiel-Troger M, Neukam FW, Engelke K. Implant stability and histomorphometry: a correlation study in human cadavers using stepped cylinder implants. Clin Oral Implants Res 2003; 14:601–609.
17. Meijer HJ, Raghoebar GM, Batenburg RH, Visser A, Vissink A. Mandibular overdentures supported by two or four endosseous implants: a 10-year clinical trial. Clin Oral Implants Res 2009; 20:722–728.
18. Mericske-Stern R. Clinical evaluation of overdenture restorations supported by osseointegrated titanium implants: a retrospective study. Int J Oral Maxillofac Implants 1990; 5:375–383.
19. Ueda T, Krmer U, Katsoulis J, Mericske-Stern R. Long-term results of mandibular implants supporting an overdenture: implant survival, failures, and crestal bone level changes. Int J Oral Maxillofac Implants 2011; 26:365–372.
20. Besimo C, Graber G, Schaffner T. Hybrid prosthetic implant supported suprastructures in edentulous mandible. Conus crowns and shell-pin-systems on ha-ti-implants. 2. Prosthetic construction principles. ZWR 1991; 100:70–76.
21. Becker CM, Kaiser DA. Implant-retained cantilever fixed prosthesis: where and when. J Prosthet Dent 2000; 84:432–435.
22. Brosky ME, Korioth TW, Hodges J. The anterior cantilever in the implant-supported screw-retained mandibular prosthesis. J Prosthet Dent 2003; 89:244–249.
23. Hebel KS, Galindo D, Gajjar RC. Implant position record and implant position cast: minimizing errors, procedures and patient visits in the fabrication of the milled-bar prosthesis. J Prosthet Dent 2000; 83:107–116.
24. Eitner S, Schlegel A, Emeka N, Holst S, Will J, Hamel J. Comparing bar and double-crown attachments in implant-retained prosthetic reconstruction: a follow-up investigation. Clin Oral Implants Res 2008; 19:530–537.

25. Semper W. Retrospective analysis of bar-retained dentures with cantilever extension: marginal bone level changes around dental implants over time. Int J Oral Maxillofac Implants 2010; 25:385–393.
26. Cehreli MC, Karasoy D, Kökat AM, Akça K, Eckert S. A systematic review of marginal bone loss around implants retaining or supporting overdentures. Int J Oral Maxillofac Implants 2010; 25:266–277.
27. den Dunnen AC, Slagter AP, de Baat C, Kalk W. Adjustments and complications of mandibular overdentures retained by four implants. A comparison between superstructures with and without cantilever extensions. Int J Prosthodont 1998; 11:307–311.
28. Rentsch-Kollar A, Huber S, Mericske-Stern R. Mandibular implant overdentures followed for over 10 years: patient compliance and prosthetic maintenance. Int J Prosthodont 2010; 23:91–98.
29. Krennmair G, Krainhöfner M, Piehslinger E. Implant-supported mandibular overdentures retained with a milled bar: a retrospective study. Int J Oral Maxillofac Implants 2007; 22:987–994.
30. De Smet E, Duyck J, Vander Sloten J, Jacobs R, Naert I. Timing of loading – immediate, early, or delayed – in the outcome of implants in the edentulous mandible: a prospective clinical trial. Int J Oral Maxillofac Implants 2007; 22:580–594.
31. Dolder E, Durrer GT. The bar-joint denture: a practical textbook. Chicago, IL: Quintessence Pub Co, 1978:11–26.
32. Payer M, Kirmeier R, Jakse N, Wimmer G, Wegscheider W, Lorenzoni M. Immediate provisional restoration of xive screw-type implants in the posterior mandible. Clin Oral Implants Res 2008; 19:160–165.
33. Mombelli A, van Oosten MA, Schurch E Jr, Land NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol 1987; 2:145–151.
34. Loe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. Acta Odontol Scand 1963; 21:533–551.
35. Brunner E, Langer F. Nichtparametrische Analyse longitudinaler Daten-1. München: R. Oldenbourg Verlag, 1999:54–91.
36. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark PI, Zarb A, Albrektsson T, eds. Tissue-integrated prostheses: osseointegration in clinical dentistry. Chicago, IL: Quintessence, 1998:199–209.
37. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1986; 1:11–25.
38. Chung DM, Oh TJ, Lee J, Misch CE, Wang HL. Factors affecting late implant bone loss: a retrospective analysis. Int J Oral Maxillofac Implants 2007; 22:117–126.
39. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent 1989; 62:567–572.
40. Thomason JM, Feine J, Exley C, et al. Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients – the York Consensus Statement. Br Dent J 2009; 207:185–186.
41. Thomason JM. The McGill consensus statement on overdentures. Mandibular 2-implant overdentures as first choice standard of care for edentulous patients. Eur J Prosthodont Restor Dent 2002; 10:95–96.
42. Mericske-Stern R, Probst D, Fahrländer F, Schellenberg M. Within-subject comparison of two rigid bar designs connecting two interforaminal implants: patient's satisfaction and prosthetic results. Clin Implant Dent Relat Res 2009; 11:228–237.
43. Naert I, Gizani S, Vuylsteke M, van Steenberghe D. A 5-year randomized clinical trial on the influence of splinted and unsplinted oral implants in the mandibular overdenture therapy. Part i: peri-implant outcome. Clin Oral Implants Res 1998; 9:170–177.
44. Krennmair G, Sütö D, Seemann R, Piehslinger E. Removable four implant-supported mandibular overdentures rigidly retained with telescopic crowns or milled bars: a 3-year prospective study. Clin Oral Implants Res 2011. DOI: 10.1111/j.1600-0501.2011.02169.x.
45. Weinländer M, Piehslinger E, Krennmair G. Removable implant-prosthodontic rehabilitation of the edentulous mandible:five-year results of different anchorage concepts. Int J Oral Maxillofac Implants 2010; 25:589–597.
46. Makkonen TA, Holmberg S, Niemi L, Olsson C, Tammisalo T, Peltola J. A 5-year prospective clinical study of Astra Tech dental implants supporting fixed bridges or overdentures in the edentulous mandible. Clin Oral Implants Res 1997; 8:469–475.
47. Bryant SR, MacDonald-Jankowski D, Kim K. Does the type of implant prosthesis affect outcomes for the completely edentulous arch? Int J Oral Maxillofac Implants 2007; 22(Suppl):117–139.
48. Brånemark PI, Svensson B, van Steenberghe D. Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism. Clin Oral Implants Res 1995; 6:227–231.
49. Wismeijer D, van Waas MA, Mulder J, Vermeeren JI, Kalk W. Clinical and radiological results of patients treated with three treatment modalities for overdentures on implants of the iti dental implant system. A randomized controlled clinical trial. Clin Oral Implants Res 1999; 10:297–306.
50. Lee H, So JS, Hochstedler JL, Ercoli C. The accuracy of implant impressions: a systematic review. J Prosthet Dent 2008; 100:285–291.
51. Rashidan N, Alikhasi M, Samadizadeh S, Beyabanaki E, Kharazifard MJ. Accuracy of implant impressions with different impression coping types and shapes. Clin Implant Dent Relat Res 2009. DOI: 10.1111/j.1708-8208.2009.00241.x.

52. Eisenmann E, Mokabberi A, Walter MH, Freesmeyer WB. Improving the fit of implant-supported superstructures using the spark erosion technique. Int J Oral Maxillofac Implants 2004; 19:810–818.
53. Waddell JN, Payne AG, Swain MV. Physical and metallurgical considerations of failures of soldered bars in bar attachment systems for implant overdentures: a review of the literature. J Prosthet Dent 2006; 96:283–288.
54. Naert I, Quirynen M, van Steenberghe D, Darius P. A study of 589 consecutive implants supporting complete fixed prostheses. Part ii: prosthetic aspects. J Prosthet Dent 1992; 68:949–956.
55. Sertgoz A, Guvener S. Finite element analysis of the effect of cantilever and implant length on stress distribution in an implant-supported fixed prosthesis. J Prosthet Dent 1996; 76:165–169.
56. Meijer HJ, Batenburg RH, Raghoebar GM, Vissink A. Mandibular overdentures supported by two Brånemark, IMZ or ITI implants: a 5-year prospective study. J Clin Periodontol 2004; 31:522–526.