A 3-Year Prospective Clinical Study of Telescopic Crown, Bar, and Locator Attachments for Removable Four Implant–Supported Maxillary Overdentures

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Purpose: To evaluate telescopic crown (TC), bar, and locator attachments used in removable four implant–supported overdentures for patients with edentulous maxillae. ***Materials and Methods:*** A total of 30 maxillary edentulous patients were enrolled in a 3-year prospective study. Ten patients (group A) were treated with overdentures supported by TCs, 10 patients (group B) with overdentures supported by bar attachments, and 10 patients (group C) with overdentures supported by locator attachments. A total of 120 implants were used to restore oral function. During the 3-year follow-up period, implant survival and success rates, biologic and mechanical complications, prosthodontic maintenance efforts, and patient satisfaction were evaluated. ***Results:*** All 30 patients were available for the 3-year follow-up and exhibited 100% implant survival and success rates. Peri-implant marginal bone resorption was not statistically significant for the three groups. There were lower plaque, bleeding, gingiva, and calculus indices in group C compared with groups A and B. The number of prosthodontic maintenance visits revealed eight complications in the TC group, seven complications in the bar group, and four complications in the locator group. However, there were no differences in the clinical effects of the overdentures in the three groups. ***Conclusion:*** Within the limits of this prospective study, it was concluded that the locator system produced superior clinical results compared with the TC and bar attachments in terms of peri-implant hygiene parameters, the frequency of prosthodontic maintenance measures, cost, and ease of denture preparation. However, longer-term prospective studies are required to confirm these results. *Int J Prosthodont 2013;26:566–573. doi: 10.11607/ijp.3485*

Compared with conventional dentures, implant-supported overdentures represent an attractive clinical alternative due to the elimination of many of the problems reported by wearers of conventional complete dentures, such as insufficient stability and pain during mastication.[1–3] Previous research has confirmed that an implant overdenture can provide a stable centric occlusion for edentulous patients and improve objective chewing ability by 25% compared with a complete denture.[4] Moreover, an implant-supported prosthesis may lead to a 300% increase in the maximum occlusal force of a denture patient.[5]

Various attachment systems have been successfully used with implant-supported overdentures in recent years. These systems can be classified as telescopic crowns (TCs), bars, locators, balls, and magnets. Dental practitioners and technicians select attachment systems based on their experience and training.[6] Since their introduction in the 1970s, TCs have been widely used to support dentures, with the natural teeth supporting the TCs themselves.[7–10] After the advent of implants, implant-supported TC overdentures have also been successfully used to restore oral function in edentulous patients.[11–13] TCs offer many advantages, including easy access for oral hygiene, easy handling of the overdentures,

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and comparatively high retention, which enables good mastication and phonetics.[14,15]

The implant-supported bar overdenture is a therapeutic option that offers many advantages for patients with a severely reabsorbed edentulous ridge. Bars offer retention capacity, are inexpensive, have low maintenance cost, provide correct dimensions, are easy to replace, and allow simple insertion and removal of the prostheses.[16]

The locator attachment is a new system that does not involve the splinting of implants. Since it was introduced in 2001, the locator has been widely and successfully used to support dentures. This attachment is self-aligning, has dual retention, and is available in different colors with different retention values.[17–19] Although there have been few clinical studies on the locator system, locator attachments have many clinical advantages, such as their availability in different vertical heights; their resilience, retentiveness, and durability; and the presence of some degree of built-in angulation compensation. In addition, repair and replacement are quick and straightforward.[20–22]

Clinical follow-up studies have reported that removable implant-supported prostheses have been used in the mandible with excellent long-term results.[1,23–26] However, less favorable mid-term and long-term survival and success rates were originally reported for maxillary implants supporting overdentures. Compared with the mandible, the maxilla contains softer bone and a different distribution of occlusal forces.[27] Therefore, a greater number of implants are required in the maxilla compared with the mandible. However, there are no specific guidelines for the number of implants necessary to support a maxillary overdenture.[28,29] A minimum of four well-spaced implants is often recommended for an implant-supported and -retained overdenture. Many studies have demonstrated that the use of only four maxillary implants can successfully restore oral function for completely maxillary edentulous patients using different abutments such as TCs, bars, and locators.[30–34]

However, there is scant literature containing direct comparisons of TCs, bars, and locators for implant-retained overdentures in completely maxillary edentulous patients.

Therefore, the aim of this 3-year, prospective, clinical study was to evaluate the treatment outcomes of completely maxillary edentulous patients with removable four implant–supported overdentures supported by TC, bar, and locator attachments. The implant survival, peri-implant tissue health, marginal bone resorption, and prosthetic complications were investigated at regular intervals during the follow-up period.

Materials and Methods

Patient Selection

From July 2006 to August 2010, 30 patients were selected to participate in this prospective clinical study at the Department of Oral and Maxillofacial Surgery and the Department of Oral and Craniomaxillofacial Implantology, Ninth People's Hospital Affiliated with Shanghai Jiao Tong University, School of Medicine, Shanghai, China. The inclusion criteria were as follows: *(1)* an edentulous jaw; *(2)* the selection of removable four implant–supported maxillary overdentures by the patient; *(3)* sufficient maxillary bone volume for the placement of implants with a minimum 4.1-mm diameter and 10-mm length; and *(4)* the patient's availability for the entire duration of the study. The exclusion criteria included bone grafted or irradiated arches, any uncontrolled systemic or neurologic diseases, and a heavy (more than 15 cigarettes per day) smoking habit. Thirty patients (18 women and 12 men aged 57 to 79 years, mean: 60.4 years) fulfilled these criteria and were enrolled in the study. Ten patients (group A) were treated with overdentures supported by TCs, 10 patients (group B) were treated with overdentures supported by bar attachments, and 10 patients (group C) were treated with overdentures supported by locator attachments. All patients provided informed consent for participation in this study.

Implant Placement and Prosthodontic Treatment

After a complete examination of the hard and soft tissues, four implants (ITI, Institute Straumann) were placed in each edentulous maxilla. Panoramic radiographs formed the basis of the primary investigation, and computed tomography (CT) scans were used to further investigate and assess the bone height and width at each implant site, the thickness of the cortical plates and cancellous bone, and the ridge angulation. An artificial bone material (Bio-Oss, Geistlich) was used to assist the placement of the implants in patients with insufficient maxillary bone volume. Three to 6 months after the completion of bone augmentation, a radiographic examination was performed to confirm that the implant placement had been successful.

The maxilla was then restored with TC-, bar-, or locator-retained removable dentures. Ten patients (40 implants) received a rigid anchoring system with TCs connected to four interforaminal implants. The inner TCs were cast in gold alloy directly on the abutments and were screwed onto the implants. As previously described,[35] the outer crowns were fabricated

Table 1 Patient Characteristics

	Group A (n = 10)	Group B (n = 10)	Group C (n = 10)
Mean age (y) (SD)	58.5 (5.3)	62.4 (6.2)	60.2 (6.3)
Sex (M/F)	4/6	3/7	5/5
Implants (n) Length (mm) Diameter (mm)	40 10, 12 4.1	40 10, 12 4.1	40 10, 12 4.1
Mean edentulous period (y) (SD)	1.4 (1.2)	1.3 (1.1)	1.6 (0.9)
Mean maxillary bone height (mm) (SD)	12.3 (3.1)	12.1 (2.8)	12.5 (3.2)

using electroformed, pure gold copings. Ten patients (40 implants) received a rigid anchoring system splinted with the four implants. This system contained a suprastructure consisting of a bar made of gold alloy with a retention device for metal-reinforced overdentures. After the successful placement of the implants, the healing abutments were replaced by locator attachments. The height of the attachments was selected according to the gingival height. The locator attachments were fabricated from gold using prosthetic procedures that have been previously described.[36] All overdentures were reinforced using cast frameworks and consisted of 12 acrylic resin teeth.

Clinical Evaluation

A number of parameters were used to evaluate the clinical data: *(1)* Plaque Index[36] (0 = no plaque; 1 = plaque that can be detected by running a probe across the smooth marginal surface of the attachment and implant; 2 = plaque that is visible to the naked eye; 3 = abundant amounts of plaque), *(2)* calculus (1 = the presence of calculus; 0 = the absence of calculus), *(3)* Gingival Index[38] (0 = normal peri-implant mucosa; 1 = mild inflammation, a slight change in color, and slight edema; 2 = moderate inflammation, redness, edema, and glazing; 3 = severe inflammation, marked redness and edema, and ulceration), *(4)* Bleeding Index[37] (0 = no bleeding when using a periodontal probe; 1 = isolated bleeding spots visible; 2 = a confluent red line of blood along the mucosal margin; 3 = heavy or profuse bleeding), and *(5)* the probing depth as measured at four sites on each implant (mesial, labial, distal, and lingual) using a periodontal probe.

The radiographic analysis was completed by performing orthopantomograms and intraoral radiographs. As previously described,[39] standardized intraoral radiographs were obtained for each implant using the long cone technique. The images were displayed on a computer screen and analyzed with computer software (GE eXplore Locus, GE Healthcare Biosciences). Vertical bone loss was calculated by subtracting the bone heights in the baseline radiographs from those in the follow-up radiographs. The initial postoperative radiographs obtained immediately after the insertion of the final overdentures (baseline radiography) were compared with follow-up radiographs obtained 12, 24, and 36 months after functional loading.

Prosthodontic complications and repairs were recorded during the 3-year follow-up period. The following types of implant complications and repairs were recorded: *(1)* implant loss or fracture, *(2)* loosening of the abutment screws, and *(3)* fracturing of the abutment. The following types of prosthesis repairs were recorded: *(1)* prosthetic tooth fracture, *(2)* prosthesis fracture, *(3)* overdenture rebasing, *(4)* matrix (friction) deactivation, *(5)* matrix activation, and *(6)* prosthesis margin adaptation.

All of the above data were collected by a single experienced observer throughout the entire study.

Patient Satisfaction

Patient satisfaction was evaluated with the aid of a questionnaire. The questionnaire was designed on the basis of a scored evaluation (0 = unsatisfied, 1 = partially satisfied, and 2 = fully satisfied) of four parameters (facial contour, the comfort level of the prosthesis, pronunciation, and the functional results of the implant-supported prosthesis).

Statistical Analysis

The means ± SDs were calculated for all data using the SPSS software version 10.0 (IBM). Statistical significance was assessed with analysis of variance followed by the Tukey post hoc test. A P value < .05 was considered statistically significant.

Results

A total of 120 implants were placed in 30 patients, and all implants exhibited ideal osseointegration. Forty implant-supported overdentures of each type (TC, bar, and locator) were placed in each group, which consisted of 10 patients with edentulous maxillae (Table 1). No patients left the study during the follow-up period.

After the removable overdenture loading, a series of parameters were evaluated. No implants were lost during the functional period. The survival and

success rates for all implants were 100%. The mean scores for the bleeding, gingiva, plaque, and calculus indices were low at all evaluation points and did not differ among the three groups. In group A, a Bleeding Index score of 0 was observed in 88% of patients in the first year of the study and decreased to 81% in the third year. In group B, a Bleeding Index score of 0 was observed in 87% of patients during the first year and dropped to 79% in the third year. In group C, a Bleeding Index score of 0 was observed in 90% of patients during the first year and decreased to 85% in the third year. In contrast, the percentage of patients in group A with a Plaque Index score of 1 increased slightly from 25% during the first year to 31% in the third year. The percentage of patients in group B with a Plaque Index score of 1 increased from 26% during the first year to 33% in the third year. The percentage of patients in group C with a Plaque Index score of 1 increased from 23% during the first year to 29% in the third year. In addition, the proportion of patients with a Calculus Index score of 1 increased from 15% during the first year to 18% in the third year for group A, from 18% to 22% for group B, and from 8% to 9% for group C (Table 2).

There were three cases of peri-implant gingival hyperplasia (one in group A and two in group B) during the follow-up period. The two cases of gingival hyperplasia in group B were surgically excised, yielding satisfactory clinical results. There were no notable changes in peri-implant probing depth, and bone resorption during the follow-up period ranged from 0.6 to 0.9 mm in group A, from 0.6 to 1.0 mm in group B, and from 0.5 to 0.9 mm in group C. However, there were no significant differences among the three groups in peri-implant probing depth or bone resorption (Table 3). During this 3-year prospective study, very few prosthetic complications were recorded. A total of 19 maintenance procedures were required. There were 8 procedures in group A (5 and 3 procedures during the first and third years of follow-up, respectively): 1 abutment screw loosening, 1 matrix activation or renewal, 1 prosthetic tooth fracture or renewal, and 5 denture margin adaptations. Seven maintenance procedures were needed in group B (4 and 3 procedures during the first and third years of follow-up, respectively): 1 matrix activation or renewal, 4 denture margin adaptations, and 2 overdenture rebasings. Four maintenance procedures (all denture margin adaptations) were needed in group C. These data demonstrate that the incidence of postoperative maintenance efforts was higher in group A compared with the other groups. The most frequent implemented procedure was prosthesis margin adaptation. During the 3-year follow-up period, the mean annual number of complications or repairs was 0.27 per patient in the TC group, 0.23 per patient in the bar group, and 0.13 per patient in the locator group (Table 4).

All patients were completely satisfied with their facial contours, prosthesis function, and pronunciation, and only one patient (in group B) was partially satisfied with the prosthesis comfort due to the relatively poor adaptability. The patient satisfaction scores are summarized in Table 5. The restoration outcomes for three cases are illustrated in Figs 1 to 3.

Table 2 The Peri-implant Hygienic Parameters

	1 y			2 y			3 y		
Parameter	TC	B	L	TC	B	L	TC	B	L
Patients (n)	10	10	10	10	10	10	10	10	10
Modified PI score (%)									
0	74	72	76	70	68	73	68	64	70
1	25	26	23	29	30	27	31	33	29
2	1	2	1	1	2	0	1	3	1
3	0	0	0	0	0	0	0	0	0
BI score (%)									
0	88	87	90	85	85	88	81	79	85
1	12	12	10	14	14	12	18	20	14
2	0	1	0	1	1	0	1	1	1
3	0	0		0	0	0	0	0	0
GI score (%)									
0	85	85	88	84	83	87	81	81	86
1	15	15	12	16	17	13	19	19	14
2	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	0	0	0
CI score (%)									
0	85	82	92	84	80	91	82	78	91
1	15	18	8	16	20	9	18	22	9

TC = telescopic crown, B = bar, L = locator, PI = Plaque Index, BI = Bleeding Index, GI = Gingival Index, CI = Calculus Index.

Table 3 Peri-implant Parameters Over 3 Years

	1 y			2 y			3 y		
Parameter	TC	B	L	TC	B	L	TC	B	L
Implants (n)	40	40	40	40	40	40	40	40	40
Mean bone loss (mm) (SD)	0.6 (0.6)	0.6 (0.4)	0.5 (0.5)	0.7 (0.6)	0.8 (0.5)	0.8 (0.4)	0.9 (0.3)	1.0 (0.6)	0.9 (0.4)
Mean probing depth (mm) (SD)	2.1 (0.4)	2.2 (0.5)	2.1 (0.5)	2.3 (0.6)	2.6 (0.5)	2.5 (0.4)	3.2 (0.8)	3.3 (0.7)	3.4 (0.5)
Peri-/inter-implant GH (n)	0	0	0	0	0	0	1	2	0

TC = telescopic crown, B = bar, L = locator, GH = gingival hyperplasia.

Table 4 Type of Prosthodontic Maintenance and Complications in Implant-Supported Overdentures*

	1 y			2 y			3 y			Total		
Parameter	TC	B	L	TC	B	L	TC	B	L	TC	B	L
Overdentures (n)	10	10	10	10	10	10	10	10	10	10	10	10
Implant component maintenance (ISO)												
Implant fracture	0	0	0	0	0	0	0	0	0	0	0	0
Abutment/screw loosening	0	0	0	0	0	0	1	0	0	1	0	0
Abutment/bar fracture	0	0	0	0	0	0	0	0	0	0	0	0
Implant prosthodontic maintenance (ISO)												
Matrix activation/renewed	0	0	0	0	0	0	1	1	0	1	1	0
Prosthesis teeth fracture/renewed	0	0	0	0	0	0	1	0	0	1	0	0
Overdenture fracture	0	0	0	0	0	0	0	0	0	0	0	0
Denture margin adaptation	5	4	4	0	0	0	0	0	0	5	4	4
Overdenture rebased	0	0	0	0	0	0	0	2	0	0	2	0
Total	5	4	4	0	0	0	3	3	0	8	7	4

TC = telescopic crown, B = bar, L = locator.
*Interventions per year per patient: TC = 0.27, B = 0.23, L = 0.13.

Table 5 Patient Satisfaction

Patient no.	Age	Sex	Facial contour	Prosthesis comfort	Pronunciation	Prosthesis function
Telescopic crown						
1	52	F	2	2	2	2
2	53	M	2	2	2	2
3	45	F	2	2	2	2
4	50	M	2	2	2	2
5	58	F	2	2	2	2
6	62	M	2	2	2	2
7	54	F	2	2	2	2
8	62	M	2	2	2	2
9	44	F	2	2	2	2
10	57	F	2	2	2	2
Bar						
1	63	M	2	2	2	2
2	65	F	2	2	2	2
3	55	F	2	2	2	2
4	53	M	2	2	2	2
5	48	M	2	2	2	2
6	62	F	2	2	2	2
7	54	F	2	2	2	2
8	64	F	2	2	2	2
9	74	M	2	2	2	2
10	67	M	2	1	2	2
Locator						
1	58	M	2	2	2	2
2	56	F	2	2	2	2
3	48	F	2	2	2	2
4	54	M	2	2	2	2
5	56	M	2	2	2	2
6	67	M	2	2	2	2
7	58	F	2	2	2	2
8	48	M	2	2	2	2
9	74	F	2	2	2	2
10	69	M	2	2	2	2

0 = unsatisfied, 1 = partially satisfied, 2 = fully satisfied.

Discussion

Due to the advantages of implant-supported overdentures, such as low cost, greater surgical freedom, tissue restoration for a severely resorbed arch, and aspect improvement, these prosthetic devices are considered to be an optimal option for restoring oral function in maxillary edentulous patients compared with implant-supported fixed prostheses.[40,41] The results of this prospective study clearly indicate favorable outcomes for four interconnected implants supporting a maxillary overdenture with three different abutments. Although there were no significant differences in clinical effect, probing depth, or bone resorption among the three groups, group C exhibited higher values for peri-implant hygienic parameters and a lower incidence of prosthodontic maintenance and complications compared with the other two groups.

Probing depth and bone resorption were estimated via intraoral radiographs and pocket probing. There were no significant differences among the three groups in the levels of bone resorption and probing depth. However, the locator group displayed superior peri-implant hygienic parameters and a lower incidence of prosthodontic maintenance and complications. Group A experienced the largest number of interventions per year per patient compared with groups B and C. However, there were no significant differences between the groups regarding oral restoration of function or the patients' evaluations. Group B showed more cases of gingival hyperplasia in the third year compared with the other groups. However,

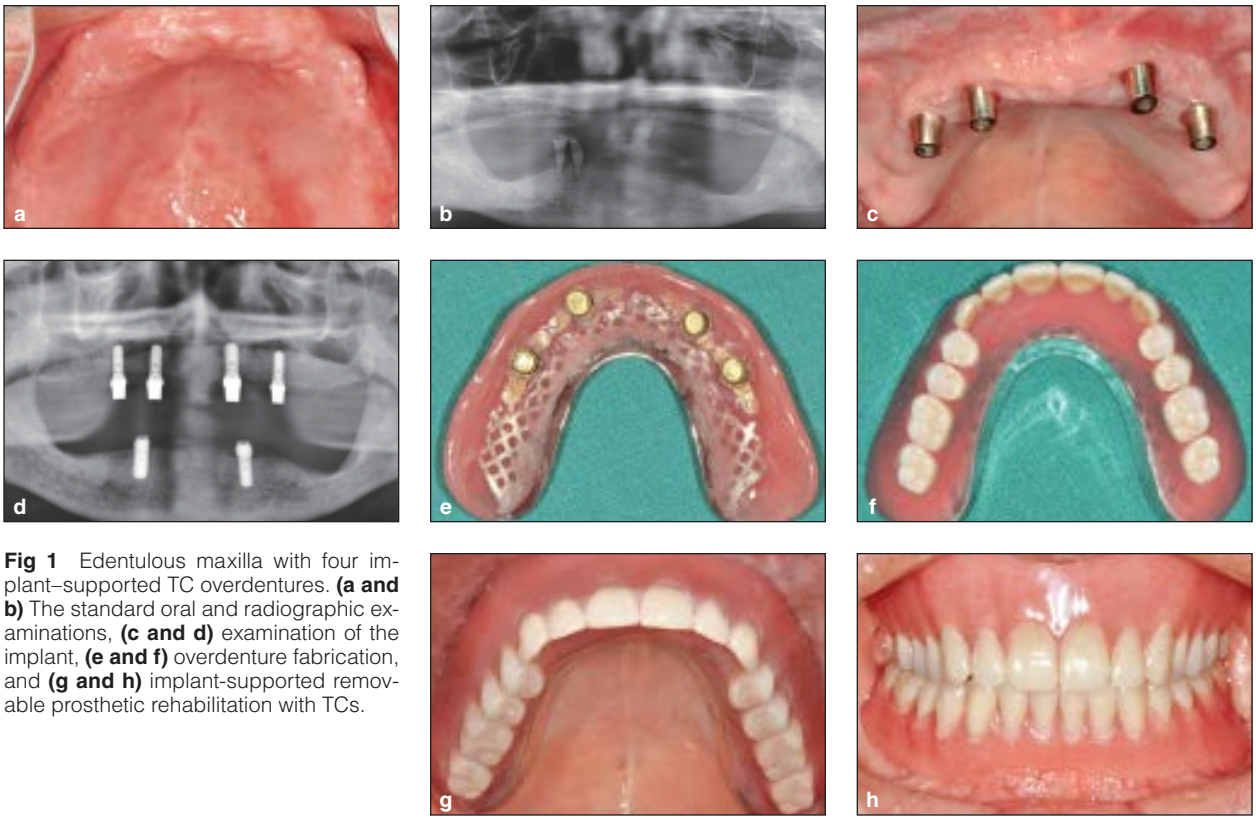

Fig 1 Edentulous maxilla with four implant–supported TC overdentures. **(a and b)** The standard oral and radiographic examinations, **(c and d)** examination of the implant, **(e and f)** overdenture fabrication, and **(g and h)** implant-supported removable prosthetic rehabilitation with TCs.

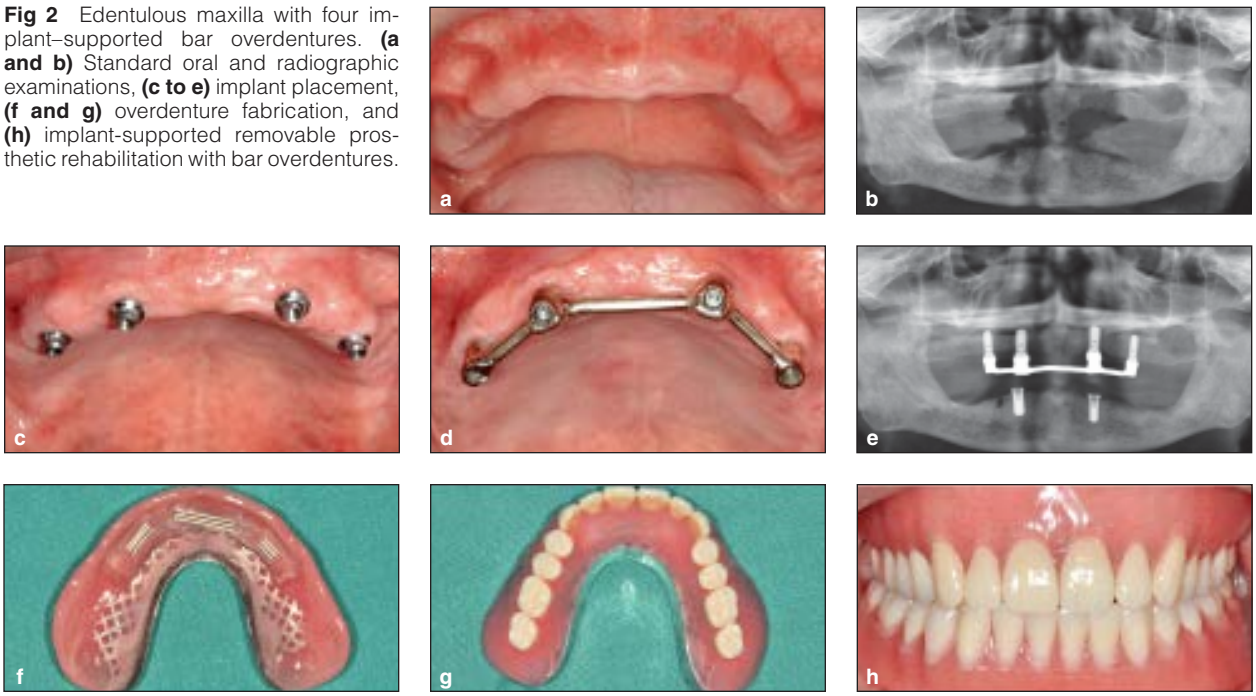

Fig 2 Edentulous maxilla with four implant–supported bar overdentures. **(a and b)** Standard oral and radiographic examinations, **(c to e)** implant placement, **(f and g)** overdenture fabrication, and **(h)** implant-supported removable prosthetic rehabilitation with bar overdentures.

the hyperplasia was soon eliminated by the removal of calculus. In addition, the patients expressed almost the same level of satisfaction for oral function restoration.

The TC, bar, and locator attachment systems are all used in implant-supported overdentures. However, there is a dearth of clinical studies investigating the clinical outcomes of the use of these three abutments

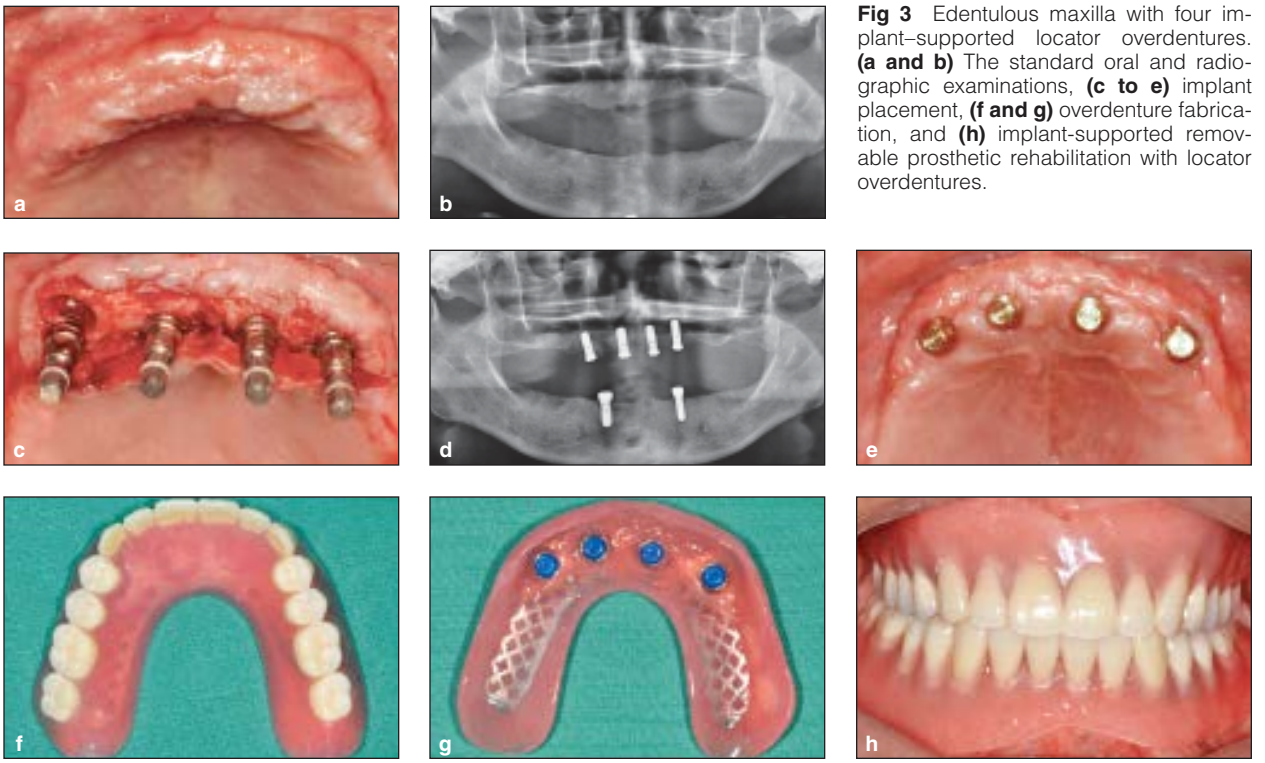

Fig 3 Edentulous maxilla with four implant–supported locator overdentures. **(a and b)** The standard oral and radiographic examinations, **(c to e)** implant placement, **(f and g)** overdenture fabrication, and **(h)** implant-supported removable prosthetic rehabilitation with locator overdentures.

to restore oral function in edentulous patients with implant-supported overdentures, especially in maxillary edentulous patients and patients with limited, four implant–supported overdentures. In this study, four implants were used to restore oral function for maxillary edentulous patients through three abutments of TCs, bars, and locators. The survival and success rates of the dental implants were 100% during the follow-up period. The results show that the type of attachment system used does not influence the success rate of the implants. There were no significant differences in implant failure among the TC, bar, and locator groups. The results are in agreement with earlier reports that bone quality and quantity, as well as arch morphology, appear to play important roles in implant survival rates; the correct placement of the implants affects the maintenance of the attachment system.[18,19] The results of this study verify that all three implant-supported maxillary overdentures lead to good treatment outcomes. However, larger numbers of subjects and longer follow-ups are necessary to confirm the results.

Conclusion

Within the limitations of this study, it can be concluded that all of the attachment systems studied were useful because no significant differences were observed in the implant survival and success rates or in the replacement of attachment fragments and fractured overdentures. However, further studies of implant overdentures, including larger numbers of patients and longer follow-ups, are necessary.

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