Zygoma Implants for Midfacial Prosthetic Rehabilitation Using Telescopes: 9-Year Follow-up

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Purpose: This study presents successful maxillofacial prosthetic rehabilitation using telescopic and crowns on zygoma implants as abutments. **_Materials and Methods:_** Fifteen patients received 36 zygomatic and 24 dental implants and were followed-up for an average of 65 months (range: 13 to 102 months). Machined zygoma implants were positioned classically in the maxillary molar region. In larger defects, premolar and canine implants were also used. Follow-up included implant and prosthetic success parameters as well as the completion of the Oral Health Impact Profile (OHIP14G). **_Results:_** Seventy-three percent of patients during the study period did not encounter notable complications after prosthetic rehabilitation. There was an 89% cumulative 8-year zygoma implant survival rate and a 100% survival rate for the dental implants. Three losses occurred due to overloading and persistent infection; each was immediately replaced. Five successfully osseointegrated implants had to be removed in two patients due to recurrences of disease; one patient died. Peri-implant bleeding and plaque index scores decreased. After prosthetic treatment with electroplated gold or galvanotelescopes, all patients who had participated in the follow-up declared function (ie, retention, speech, and mastication) and esthetics as having improved. Other positive aspects mentioned were good hygiene, comfortable usage, and a decrease in sore spots. OHIP scores were 25 ± 12 on a scale of 0 (no impairment) to 56 (maximum impairment). **_Conclusion:_** Within the limitations of this study (a variable evaluation period), it was observed that zygomatic implants are reliable retention for maxillofacial prostheses. Losses were diagnosed as occuring primarily from chronic infection and overloading. A trapezoid prosthesis design support is recommended with a sufficient number of implants.
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Patients suffering from major maxillary and midfacial defects can significantly benefit from the reestablishment of their mastication, speaking, and soft tissue projection to permit a functional esthetic rehabilitation, and overall social reintegration. When defects are very large, free bone graft and sinus elevation is not possible. The treatment of choice then becomes a vascularized soft/hard tissue graft to close the defect, with the intent being a complete comprehensive rehabilitation with an implant-supported maxillofacial prosthesis.[1–4] Yet some patients avoid reconstructive procedures due to limited general health conditions, donor site morbidity, and fear of concealment of a tumor recurrence beneath such a reconstruction.

Natural tooth– or tissue-borne removable obturator prostheses are then incorporated as an alternative. When extensive palatomaxillary loss of tissue occurs and

Table 1 Benchmark Patient Data, Diagnoses, Extent of Resection, and Eventual Chemotherapy as Postoperative Irradiation

Patient no.	Age at primary operation (y)	Diagnosis	Defect size	Chemotherapy	Irradiation (Gy)	Indication	Time gap to implantation (mo)*
1	20	Amelogenesis imperfecta, long-time complete denture	Total absence of maxillary alveolus due to high atrophy			Local osteoplasty failure	> 60
2	2	Bilateral cleft lip and palate, long-time complete denture	Defect of 40% of the median hard palate, scarring			Soft tissue insufficiency for palate reconstruction high risk for osteoplasty resorption	> 60
3	19	Maxillary and orbital osteosarcoma T4N0M0	Two-thirds maxillectomy	Carboplatin-etoposidphosphate	45	Concealment of recidive by free flap	59
4	71	Maxillary squamous cell carcinoma T4N1M0	Hemimaxillectomy, soft tissue palate reconstruction		61.5	Age and cardiopulmonary disease	6
5	58	Palate adenoid cystic carcinoma, T4N0M0	Hemimaxillectomy			Tooth loss due to overloading after 4.5 ys. from tooth-borne obturator	54
6	77	Recurrent maxillary mixed salivary carcinoma T4N0M0	Total maxillectomy			Age and cardiopulmonary disease	0
7	57	Maxillary squamous cell carcinoma T4N1M0	Hemimaxillectomy	Neo-adjuvant cisplatin–embolization	51.3	Cardiopulmonary disease	10
8	60	Maxillary squamous cell carcinoma T4N0M0	Hemimaxillectomy, soft tissue palate reconstruction	Neo-adjuvant cisplatin-embolization, 4 cycles of Doxetacel postoperatively	58	Cardiopulmonary disease	9
9	77	Maxillary squamous cell carcinoma T4N0M0	Hemimaxillectomy, soft tissue palatal reconstruction	Neo-adjuvant cisplatin-embolization		Age and cardiopulmonary disease	6
10	46	Maxillary ameloblastoma	Three-fourths maxillextomy			General anxiety disorder	14
11	52	Maxillary squamous cell carcinoma T4N1M0	Hemimaxillectomy	Neo-adjuvant cisplatin-embolization	51.3	Cardiopulmonary disease	11
3	19	Maxillary osteosarcoma recurrence T4N0M0	Three-fourths maxillectomy, palatal soft tissue reconstruction		45	Concealment of recidive by free osteocutaneous flap	15
6	79	Malignant mixed salivary tumor recurrence T2N0M0	Total maxillectomy			Age and cardiopulmonary disease, concealment of tumor recurrence	0
12	60	Maxillary squamous cell carcinoma T4N0M0	Hemimaxillectomy, soft tissue palate reconstruction	Neo-adjuvant cisplatin-embolization		Depressive disorder	3
13	46	Maxillary malignant salivary gland tumor	Three-fourths maxillectomy	Neo-adjuvant cisplatin-embolization	51.3	Concealment of recidive by free flap	36
14	72	Bilateral cleft lip and palate, long-time partial prosthesis on residual teeth, lost due to overloading and severe attachment loss	Large median defect, 40% of the hard palate and alveolus, severe scarring			Severe mucoperiosteal scarring, high risk for osteoplasty resorption	0
15	45	Bilateral cleft lip and palate, long-time partial prosthesis on residual teeth	Large median defect, 40% of the hard palate and alveolus, severe scarring			Severe mucoperiosteal scarring, high risk for osteoplasty resorption	0

*The time-gap between operation or irradiation to the implant insertion. Patients 3 and 6 are listed twice because they had two procedures of zygoma implant insertion and therefore different lengths of follow-up.

anatomic structures such as oronasal communication prevail, obturators have less than optimal functional rehabilitations and residual teeth (eg, telescoped or splinted) are frequently overloaded. When these teeth are lost due to overloading, compromised adhesion and cohesion in edentulous obturators prevails due to a lack of ability to bring about retention. This is caused by oroantral and/or oronasal communication and the frequent problem of xerostomia, secondary to pre- or postoperative radiation-induced loss of salivation. This finally leads to a functionally and esthetically disadvantageous situation with severe psychological, social, and functional impairments to the patient.[5,6]

Standard implant–retained obturator prostheses develop long cantilevers to anterior implants due to a lack of dorsal support. This may result in implant overloading, attachment, and implant loss.[7] Indications for zygoma implants include: prosthesis support in various defect types or high-grade total alveolar atrophy, used as an alternative to surgical augmentation or after failure of local augmentation.

Anterior dental implants with individual barclip abutments or cross-arch fixed partial dentures over a residual canine alveolar process have been clinically established with accruing follow-up.[8–11] This study evaluates telescoped zygoma implants for the first time as prosthetic anchors, which may yield adjustable retention and better overall hygiene.[12] Single standing abutments generally provide better access to the area and easy dental hygiene. This may be the reason why telescope crown fixed dentures have survival rates similar to those of fixed restorations[13] and a favorable clinical prognosis.[14] A generally positive aspect of using telescopes versus bar (clip) abutments or fixed partial dentures is the economic repair if a tooth or implant is lost. This can be done simply by filling the secondary crown with resin. Circumferential holding of the tooth or abutment ensures the axial transmitting of masticatory forces into the bone and reduces extra-axial forces. Another feature initiated on zygoma implants is the design of conically shaped telescopes. In previous reports, use of this design has been known to adjust the removal force of the prosthesis by changing the degree of the cone angle (not yet evaluated in zygoma implants).[15] The cone shape ensures that the retention force is only reached when the secondary crown is in a terminal position. A long-lasting extruding force on the implant or the abutment tooth is then reduced. This, however, is controversial since zygoma implants are generally recommended and used for cross-arch solutions. These can either be fixed partial dentures that do not permit adequate hygiene in obturator situations with oronasal communication, or cross-arch bar abutments.[7–11]

A modification to the conventional telescope system is the use of electroformed secondary gold crowns on primary ceramic crowns. This modified system was combined with the intraoral joining technique to create a passive fit between the primary crowns and suprastructure. Retention is reached by the interaction of ceramic primary crowns, saliva, and pure gold secondary crowns.

Materials and Methods

Fifteen patients (10 females and 5 males) received 36 zygoma implants (Zygomaticus-Fixture, Brånemark System, Nobel Biocare). Twenty-four additional dental implants (various brands: MKII and IV Brånemark Fixture, Nobel Biocare; Nobel-Speedy, Nobel Biocare; or ITI Straumann SLA, Institut Straumann), were placed in residual alveolar processes when present. Mean patient age at primary operation (eg, tumor removal or cleft palate closure) was 48 years (range: 2 to 79 years); mean age at implantation was 58 years (range: 24 to 79 years) (Table 1).

The first patient suffered from amelogenesis imperfecta, complete tooth extraction at the age of 20 years, and total atrophy of the maxillary alveolar process. Osteoplasty and Le Fort I osteotomy both failed, resulting in complete bone-transplant resorption. This made regular implant placement impossible in anywhere but the paranasal maxillary pillars.

Patients 2, 14, and 15 each suffered from a congenital cleft lip and palate as well as scarred soft tissues of the hard and soft palates, presenting a complex defect with concomitant alveolar atrophy due to long-term edentulousness or a severely reduced dentition with attachment loss. Local osteoplasty was considered to be of unfavorable prognosis after multiple reconstructive surgeries and severe scar formation. On the other hand, free tissue transfer with microvascular anastomosis was considered overtreatment.

Patient 3 was a maxillary osteosarcoma patient who, although young and of good cardiopulmonary health, refused free-flap reconstruction after tumor resection, preoccupied with masking a tumor recurrence. The initial two-thirds maxillectomy was followed by a three-fourths maxillectomy (first recidive); combined cranial base resection, including 3 unilateral completely osseointegrated zygomatic fixtures (second recidive); and resection of half of the temporomandibular joint and zygomatic arch, and free reanastomosed iliac soft tissue and bone reconstruction (third recidive) in order to maintain the prosthesis with a reduced volume. Should the patient remain recidive-free for longer than 2 years, the insertion of zygoma implants into the iliac crest will be considered. Therefore, this patient, along with patient 6, are listed in 2 lines with their repeated implant insertions and different follow-ups but identical patient numbers in each. The residual implants retained the current prosthesis by use of telescopes.

Patient 4 had a hemimaxillectomy to combat palatal squamous cell carcinoma and cardiopulmonary disease at 71 years of age, precluding major reconstruction.

Patient 5 had a palatal adenoid-cystic carcinoma ablation with a hemimaxillectomy and initially successful rehabilitation by a tooth-retained obturator (braces). However, retained teeth were lost due to cantilever overloading and a lack of dorsal prosthesis support, ie, cross-arch support or support from the defect itself. New obturator retention without major surgery was requested by the patient because major reconstructive surgery was considered to be overtreatment.

Patient 6 had a recurrent malignant mixed salivary carcinoma and cardiopulmonary disease at 77 years of age. The tumor recurred during follow-up, resulting in a total maxillectomy. Later on, 2 unilateral perfectly osseointegrated implants were removed due to a local recurrence and the residual implants retain the current prosthesis by telescopes, similar to patient 3.

Patients 7, 8, 9, and 11 had hemimaxillectomies due to palatal and maxillary sinus squamous cell carcinoma ablations and, as complicating diagnoses, cardiopulmonary diseases. Patient 10, who was suffering from ameloblastoma, was undergoing a three-fourths maxillectomy and was diagnosed with an anxiety disorder precluding major reconstructive surgery. Patient 12 had a depressive disorder, making elaborate reconstructive operations a high-risk intervention. Patient 13 had a malignant salivary gland tumor and three-

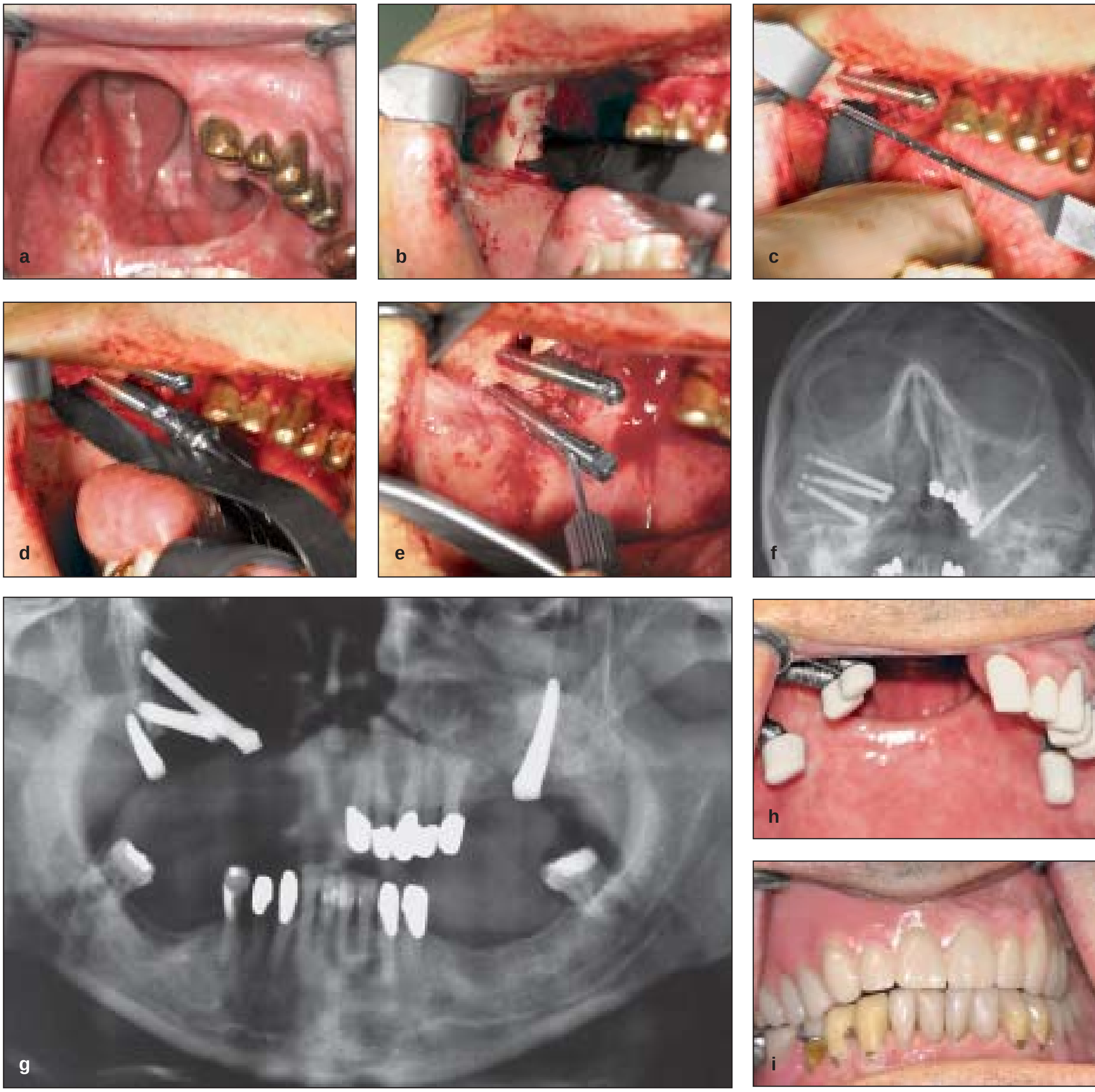

Fig 1 Patient 13: **(a)** the preoperative state; **(b)** during the intraoperative exposition of the zygoma after a former complete tumor resection; **(c)** with the most anterior first implant in place and the depth gauge within the second most posterior implant burhole; **(d)** placement of the second implant; **(e)** removal of the straight insertion post unveiling the 45 degree angulated platform; **(f)** and **(g)** postoperative radiographic controls; **(h)** the postoperative situation; and **(i)** the occlusal aspect with obturator prosthesis in place.

fourths maxillary resection and preferred zygoma implants to permit surveillance of eventual recurrences.

Implants were inserted from the time of the primary operation (eg, tumor removal) up to longer than 10 years after (cleft lip and palate cases), with an average time of 27 months after initial surgery. For example, patient 6 received zygoma implants immediately after tumor resection, when frozen margins were tumor free. Seven tumor patients received preoperative chemotherapy and 7 patients were roentgen irradiated postoperatively. Cytostatic agents and total doses of irradiation to the local resection area in the maxillary region are given in Table 1. Hyperbaric oxygen therapy was never used. Implants were inserted on average after an 18-month remission, the earliest being 3 months after the end of irradiation.

The implantation (Fig 1) was performed under general anesthesia. One gram of Cephtriaxone (Rocephin, Roche) was given intraoperatively and 250 mg of oral Cefuroxim (Elobact, Cascan) postoperatively twice for 5 days. Resorbable sutures were used.

Implant insertion was performed according to standard protocol.[7,8] A vestibular Le-Fort I incision

Table 2 Dental Status, Surgical Data, and Prosthetic Treatment*

Patient no.	Age at implantation (y)	Dentition	No. of zygoma implants	Implant site(s)	Zygoma implant length(s) (mm)		Anatomy	Manufacturer	Location	Prosthetic treatment after 6-mo osseointegration interval
1	47	Edentulous	2	16, 26	45	45	Bilateral single zygoma implant, one implant at 23, mandible edentulous	1 Brånemark MKII 10 × 4 mm implant	23	3 telescopes and overdenture
2	68	Edentulous	2	16, 26	45	45	Bilateral single zygoma implant, no alveolus present, mandible edentulous			2 telescopes and overdenture
3	24	Partially dentate	2	16, 15	35	30	Dentate residual alveolus at 23-27, mandible completely dentate			2 telescopes and partial denture with braces to retaining teeth
4	72	Edentulous	2	16, 26	35	35	No alveolus present, median dental implant insertion including the nasal spine, mandible edentulous	1 median Brånemark MKII 10 × 4 mm implant		3 telescopes and overdenture
5	62	Partially dentate	1	26	45		Teeth 24, 25 were lost due to overloading and dorsal cantilever force, residual maxilla and mandible dentate	2 Brånemark MKIV 4 × 13 mm implants	24,25	3 telescopes and overdenture
6	77	Edentulous	2	16, 26	45	45	No alveolus after total maxillectomy (apart from the orbital floor), mandible edentulous			2 telescopes and overdenture
7	58	Edentulous	1	16	30		Severe alveolar atrophy dental implant insertion only possible including the nasal spine, mandible edentulous	1 median Brånemark MKII 10 × 4 mm implant		2 telescopes and overdenture
8	61	Edentulous	1	26	35		Sufficient anterior alveolar bone for additional dental implant placement, mandible edentulous	5 ITI SLA solid screws 12 × 4.1 mm	15,13, 11,21,23	6 telescopes and overdenture
9	77	Partially dentate	2	15, 16	30	35	Anterior dentate patient, with edentulous alveolus anterior to the zygoma-implant, mandible edentulous	2 ITI SLA solid screws	11,13	4 telescopes and overdenture
10	47	Edentulous	2	25, 26	30	35	Contralateral edetulous alveolus, mandible edentulous	4 ITI SLA solid screws	12,13, 14,15	4 telescopes and overdenture
11	53	Partially dentate	2	15, 16	30	35	Contralateral edetulous alveolus, residual maxillary incisors mandible edentulous	4 ITI SLA solid screws	11,21, 23,25	6 telescopes and overdenture
3	27	Partially dentate	4	16, 15, 13, 23	35 35	40 40	Residual alveolus at teeth 24–27, mandible completely dentate	1 Brånemark MKIV 15mm fixture	26 between residual teeth	6 telescopes on implants and residual teeth after earlier bar clip abutment removal for tumor recurrence
6	79	Edentulous	3 26	15, 25, 40	40	45 40	No alveolus after total maxillectomy (apart from orbital floor), mandible edentulous			4 telescopes and overdenture
12	60	Edentulous	2	16, 26	35	35	Edentulous anterior alveolus present, mandible edentulous, 4 interforaminal ITI-implants with telescoped overdenture	2 ITI SLA solid screws	13,23	4 telescopes and overdenture earlier bar clip abutment were removed for lack of retention
13	49	Partially dentate	4	16, 15, 13, 27	35 30	50 35	Dentate left anterior alveolus present, mandible dentate			9 telescopes and overdenture
14	72	Edentulous	3	16, 23, 26	45	50 50	Left-sided double zygoma-implant, right side single plus one implant in residual alveolus, mandible dentate	1 Brånemark speedy 4 × 13 mm implants	13	4 telescopes and overdenture
15	45	Partially dentate	2	16, 26	35	45	Bilateral single zygoma-implants and telescoped residual 13, 14, 23, 24, mandible dentate			6 telescopes, telescoped residual teeth and overdenture

*Patients 3 and 6 required zygoma implant replacement due to chronic inflammation in conjunction with overload and consecutive loosening.

Table 3 Follow-up Data Including the Complications, Losses, and Periodontal Parameters

Patient no.	Follow-up (mo)	Complications	Periotest value at end follow-up				Bleeding Index (% only implants)	Plaque Index (% only implants)	Infraorbital nerve sensitivity (Weber two-point test)	Zygomaticofacial nerve function (Weber two-point test)
1	102		1	0			0	0	Bilateral positive	Bilateral positive
2	99		-1	5			0	0	Bilateral positive	Bilateral positive
3	24	Chronic inflammation both zygoma implants, explantation at 24 months	> 15	> 15			100	100	Right side resected	Right side resected
4	100		11	6			0	0	Bilateral positive	Bilateral positive
5	90		6				0	0	Left side resected	Bilateral positive
6	90	Chronic inflammation left zygoma implant, explantation at 11 months, reimplantation immediately	> 15	4			100	100	Bilateral positive	Bilateral positive
7	81		10				50	50	Right side resected	Bilateral positive
8	69		5				50	32	Left side resected	Bilateral positive
9	68		–6	2			50	50	Bilateral positive	Bilateral positive
10	68	Zygomatic implant not loaded due to insufficient compliance	–3	–1			100	50	Bilateral positive	Bilateral positive
11	68	Zygomatic implant not loaded due to insufficient compliance, died from recidive	–4	–3			50	50	Right side resected	Bilateral positive
3	68	Resection of 3 fully osseo-integrated zygoma implants at 44 mo follow-up due to a recidive	–3	–3	–2	0	0	0	Right side resected	Right side resected
6	68	Resection of 2 right sided fully osseointegrated implants due to a recidive at 38 mo follow-up due to a recidive	6	5	6	5	25	100	Bilateral positive	Bilateral positive
12	64		–1	–2			25	50	Bilateral positive	Bilateral positive
13	15		–1	–3	1	3	25	0	Bilateral positive	Bilateral positive
14	13		–1	–1	0		0	0	Bilateral positive	Bilateral positive
15	13		0	–1			0	0	Bilateral positive	Bilateral positive

extending from the canine to the molar area was made and local mucoperiosteal mobilization was performed. A window was then created in the anterior sinus wall with a diamond bur, and the sinus mucosa was mobilized. Alternatively, direct intraoral access to the zygomatic buttress was created with local mucosal flaps in cases of maxillary resection. Implant placement was performed under direct vision and transcutaneous palpation through 1 or 2 mm of the punctured zygomatic cortex. The patient's individual number of zygoma implants, implant lengths, positions, diameters, brands, and telescope types are listed in Table 2. Complications and follow-up procedures can be found in Table 3.

All zygoma implants were first generation implants, had electropolished surfaces, and were allowed to heal for 6 months before loading. Initially, soft tissue cover was preferred. However, if this was not possible due to the local anatomy, zygoma implants were left unloaded to undergo transmucosal or transgingival healing. Eventually, some early incremental loading may have occurred by accidental loading when temporary obturator prostheses were incorporated for 6 months of osseointegration; however, no abutment connections existed.

The abutment procedure was completed under local anesthesia and, if necessary, combined with a peri-implant soft-tissue reduction (3 patients). All patients were seen at 1- to 6-month intervals depending on their primary affliction. The mean Periotest values,[16] peri-implant bleeding indices (PBI), and plaque indexes (PI)[17] were measured after implant loading at 6 months, after 1 year, and at yearly intervals after that. When bulky local flaps and sinus mucosa hypertrophy altered the local anatomy, probing depths could not be measured at the point of mucosal penetration of zygoma implants. Follow-up radiographs taken 12 months postoperatively (6 months after loading) and at 1, 3, and 5 years were evaluated for peri-implant radiolucencies. Dental tomograms were substituted with occipito-mental Water's projection in preoperative, postoperative, and follow-up exams. The dental implants, however, were judged based on dental tomograms.

Weber two-point discrimination determined the infraorbital skin sensitivity; an 8-mm distance between 2 points had to be recognized as 2 separate points for a positive score.[18] Negative results were recorded when it was known that the nerve had been intraoperatively cut.

Fig 2 Patient 12: **(a)** intraoral aspect after resection of the left dorsal maxilla due to tumor, ceramic/gold galvano telescopes in trapezoid distribution; **(b)** telescoped overdenture in occlusion; **(c)** the maxilla post-treatment; and **(d)** postoperative control radiograph.

A Kaplan-Meier analysis of implant success adapted from Buser et al[19] included the following criteria: telescoped prosthetic loading, clinical mobility grade of 0 to 1, no peri-implant radiolucency, no prevalent peri-implant infection with purulent secretion, and no pain, discomfort, or dysesthesia related to the implant placement. Survival referred simply to whether or not the implant was in situ.

All patients were prosthetically restored based on the concept of electroformed and conically shaped telescopes.[20,21] Therefore, galvanized conically-shaped telescopes have to be precisely produced. The primary crowns were made out of yttrium-stabilized zirconium dioxide or high gold alloy, which were milled at a conic angle between 2 and 6 degrees. On the primary crown, a thin and homogeneous layer of silver conductive was sprayed and a secondary crown was formed by galvanizing the primary crown with gold.[20] In patients 12, 13, and 14, a ceramic primary crown (patrix or male part) and a perfect fitting secondary crown (matrix or female part) of pure gold were produced with a space less than 5 μm thick in between them.[20,21]

After final cementation of the primary crowns, the mesostructure (Chromium-Cobalt-Molybdenum) was placed on the secondary crowns, allowing a buffer zone for cementation. The mesostructure had to be solidly dimensioned since all forces are absorbed and transmitted to the implants or abutment teeth. These forces are as high as a normal fixed partial denture would have to resist.[12–14] The mesostructure was bonded intraorally by Nimetic Cem (3M ESPE) to the secondary crowns. The intraoral bonding eliminates any discrepancy between the master cast and oral situation and enables a precise fit over long distances with and a lack of kinetic motion of the prosthodontic structure.[22] Only conically shaped telescopes are usable for oral bonding. The use of 2 different types of materials, metal and ceramic, and fit accuracy ensure that there is no abrasion[23] so durable retention and a long-living prosthodontic treatment are achieved.

After surgical/prosthetic treatment, all patients were questioned to evaluate their satisfaction concerning the prosthetic rehabilitation relative to their situation before the primary operation in free interviews using the Oral Health Impact Profile German version with 14 items (OHIP14G) by an unbiased study nurse.[24] Cleft patients were not evaluated retrospectively to their condition prior to the primary operation.

Results

Intraoperative and follow-up photographs of typical cases are shown in Figs 1 to 3. With a follow-up of 13 to 102 months, the Kaplan-Meier cumulative 9-year telescoped zygoma implant survival/in-situ rate was 89% (Table 3 and Fig 4). Individual rehabilitation was successful in 73% of patients who had no zygoma implant loss and a successful immediate prosthetic rehabilitation, as reported in a previous part of this study.[25]

Chronic infection occurred in 3 patients (11%) and all infected implants were lost. One loss occurred within the first year, probably due to local overloading from tilting forces (patient 6). Once explanted, 2 replacement zygoma implants were immediately inserted anterior and dorsal to the original implant position. Contralaterally, a parallel zygoma implant was positioned anterior to the implant position in order to support the premolar region.

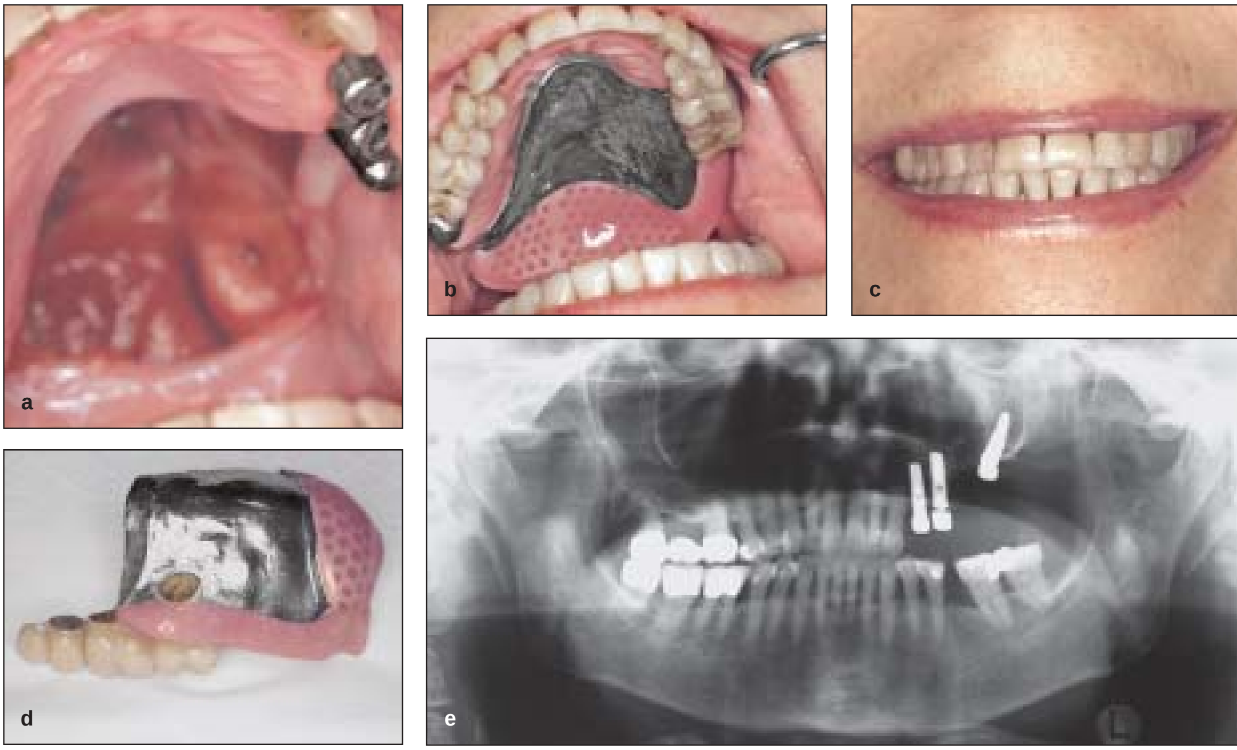

Fig 3 Patient 5: **(a)** the defect situation after tumor removal and overloading of the left first and second premolars, which were splinted by the former prosthetic restoration and replaced by regular dental implants. These were substituted by a zygoma implant at the left first molar region; **(b)** the prosthesis in place; **(c)** occlusal view of the prosthesis; **(d)** the obturator after 7 years in use; and **(e)** post-operative radiograph.

Seven paired and parallel zygoma implants were inserted into 6 patients in an identical manner to reduce the prosthetic leverage and support the premolar area. The patient facing 2 implant losses in the second year (patient 3) had chronic infection around 2 zygomatic implants that were covered by granulation tissue. After replacement by a right-sided pair of parallel zygoma implants, an additional zygoma implant was positioned anterior on each side to support the canine region. A second and third recidive enforced resection of the right zygomatic bone with 3 successfully osseointegrated zygoma implants. A dental implant in the first right molar region and a zygoma implant in the right canine region supported the current obturator prosthesis before, and in modified fashion after, the third recidive (Fig 5).

Triple unilateral zygoma implants were repeated in patient 13 (Fig 1) to reduce leverage on the dorsal zygoma implants and consecutive overloading from anterior biting and mastication, as addressed in patient 6. Insufficient zygoma implant length within flap reconstructions was prone to recurrent local infection by pocketing and overgrowth of granulating tissue (ie, patients 3 and 10). In patient 10, 2 implants could not become integrated in the prosthetic rehabilitation for the same reason. Although these implants were osseointegrated and had survived, they could not be counted as successes.

Longer implants were free of soft tissue complications yet prone to overloading because of unfavorable leverage forces. Plaque indices and peri-implant bleeding indexes at the end of the follow-up can be seen in Table 3. These numbers varied considerably interindividually and it is ackowledged that their relationship to successful osseointegration outcomes remains unclear. No peri-implant soft tissues showed signs of infection at the end of follow-up. Peri-implant radiolucencies were not observed on Water projections at the end of follow-up. Due to overprojection of the cranial base, perizygoma implant bone loss could not be evaluated.

The zygomaticofacial nerve sensitivity was intact in all cases except in patient 3, where resection was performed upon tumor removal. The infraorbital nerve was not disturbed by any zygoma implant placement, yet 5 of the 15 patients had primary nerve resection during tumor ablation (Table 3). No patient reported foreign-body sensation, dysesthesia coming from the implants, or pain on implant percussion.

A zygoma implant success rate of 85% was reached when the 3 losses and 2 zygoma implants that could not

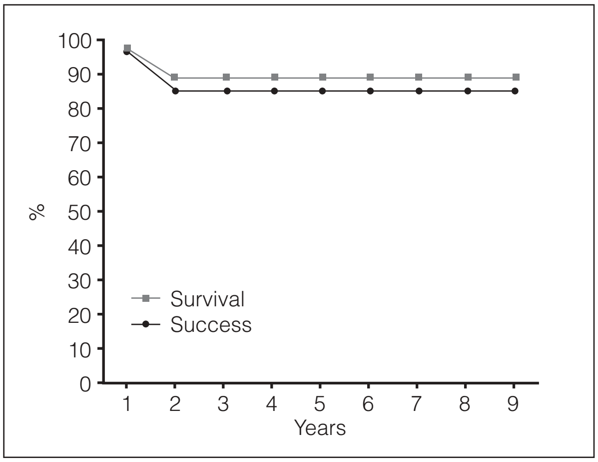

Fig 4 Kaplan Meier analysis of zygoma implant survival and success over 9 years.

be loaded were taken out of the equation. Assuming intraindividual dependence, 73% of patients had immediately successful treatment.[26] All dental implants survived and 92% were seen as successes. Four patients required a second prosthesis due to implant removal (2) and tumor recurrence ablation without implant loss (2). Two had initial bar abutments that were replaced after 1 year with telescopes (patients 3 and 12).

The telescopic crown fixed dentures showed a high patient acceptance in the functional parameters of retention, mastication, and phonetics as in- and excorporation were improved. The OHIP14G results showed scores of 25 ± 12 after prosthetic rehabilitation and 14 ± 6 upon retrospective evaluation (before tumor illness in tumor patients). Although the OHIP scored marked impairment of oral health–related quality of life, the patients claimed high functional acceptance and satisfied esthetics demands with their implants in a free interview, also documented in other clinical studies.[25,27]

Discussion

The use of zygomatic bone as an implant site in conjunction with extensive maxillary atrophy or ablative tumor surgery has been well documented.[8,28–34] Alternative autologous bone grafting or free osteomyocutaneous tissue transfer imply major surgeries and distinct donor site morbidity may occur in spite of satisfactory success rates.[2,35–41] Survival rates of 65% to 82% were reported for zygoma implants placed after ablative tumor surgery with other types of abutments, such as individual bar abutments.[25,34,41] An 89% zygoma implant survival rate was found in the present study using telescopes and Kaplan-Meier analysis in a cumulative 9-year follow-up. This indicates no detriment to zygoma implants with telescoped abutments and does not suggest long-lasting extruding force on the implants. Newly included patients, additional to the formerly published collective, and follow-up were treated with more success. Therefore, the overall success rate increased.[25]

Multicenter studies or alternatively structured review articles will provide more cases in adequate numbers for defect and abutment-specific success profiles but, according to the authors' knowledge, such studies exist merely for atrophy patients, not defect patients.[11] On the other hand, the value of homogenous collectives for clinical use is limited, as most surgeons face individual defect dimensions in a minor number of patients. Extended maxillary resections due to neoplasms are different for each patient. Different safety margins of resection are used for different neoplasms at different centers. Large maxillary cleft-palate defects, as seen in 3 patients in this collective, are a sequel of early treatment standards in elderly patients. Detailed analysis of multiple cases, with examination of the technical possibilities using zygomatic implants, broadens the indication range. However, typical defect types and indications become apparent (ie, maxillectomy, osteoplasty as sinuslift failure, avoidance of osteoplasty, and alternative to sinus-lift).

Implant positioning within the alveolar crest may become modified to a more cranial or lateral position in larger maxillary defects (Fig 1). Ideally, the platform rests close to residual bone-reducing leverage, but not submerged in soft tissue to reduce local infection risk. Overlying soft tissues should be kept to the minimum as flaps tend to create peri-implant pockets and therefore, soft tissue inflammation occurs.

The intimacy of bone-to-implant contact and marginal bone loss was difficult to evaluate.[11] Water's projection seemed reliable for judging peri-implant radiolucency when compared to computed tomographs (CTs) and dental tomograms. In the present evaluation, 13% of patients faced zygoma implant losses; however, uneventful and successful replacement was documented. Parel et al[7] reported that zygoma implant-borne dorsal defect prosthesis support decreased the leverage on the remaining teeth and anterior dental implants. This concept is supported since isolated molar region zygoma implants are overloaded in the absence of anterior support. Parallel anterior zygoma implants enable trapezoid rest. Alternatively, zygoma implant-mediated support can be attempted in the canine region.[25]

In this study, factors of zygoma implant failure were overloading from leverage in bigger defects, burial in soft tissue inhibiting abutment connection, and chronic inflammation triggered by the aforementioned circumstances (the latter compelled zygoma implant removal in 2 patients). No implant fatigue fractures due to long-lever arms occurred.

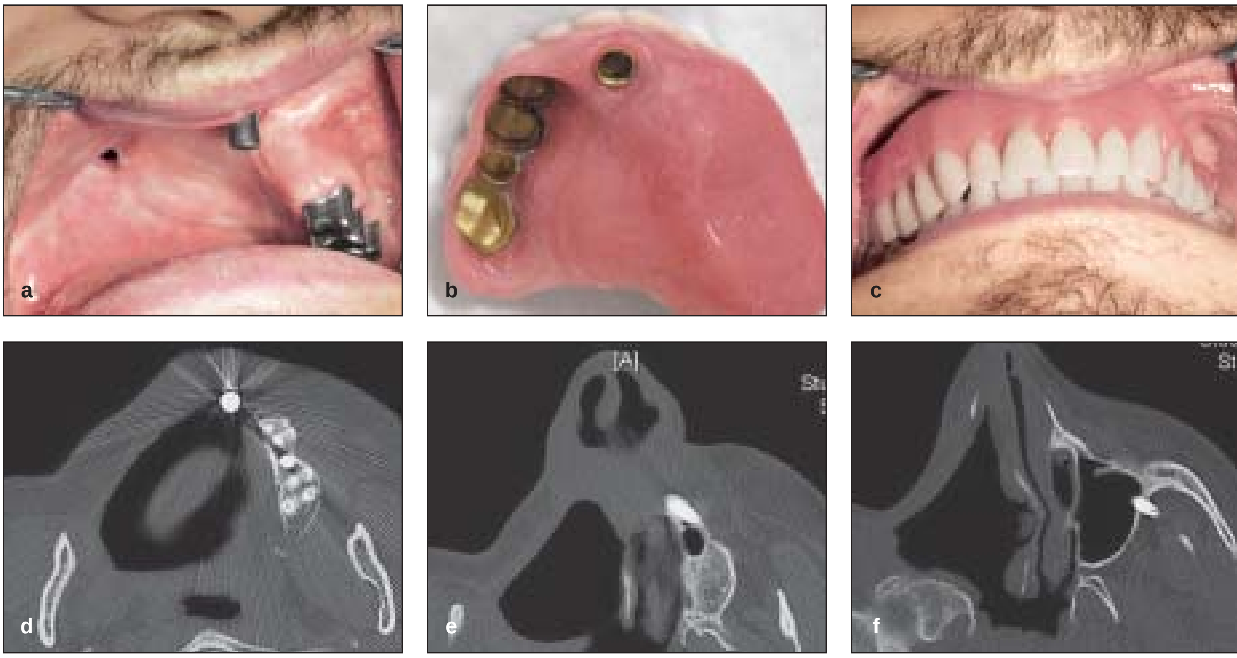

Fig 5 Patient 3: **(a)** after a threefold tumor recidive and complete loss of the right zygoma. Three unilateral zygoma implants had to be removed en bloc; **(b)** the residual left zygoma implant in the canine and a dental implant in the molar region were used for further telescopes including residual teeth; **(c)** the prosthesis in place; **(d)** intraoral position of the teeth and implants; **(e)** the anchoring of the zygoma implant in the paranasal region; and **(f)** the tip at the dorsal maxillary sinus wall.

Microporous implant surfaces have proven enhanced primary stability and accelerated osseointegration and should be a mainstay for immediate loading. However, this requires further evaluation in controlled studies when telescoped defect prostheses are constructed. Immediate loading has proven effective in regular atrophy cases as well as irradiated minor defect cases.[42,43] SLA dental implants (Straumann) were used in patients 8 to 12 when Nobel (Nobel Biocare) did not provide a microporous surface. However, in patient 14, the Nobel-speedy design was used in the dental implant.

Wide opening of the mouth with tongue protrusion, mandatory for zygoma implant insertion, yields increased risk of intraoperative contamination. The vicinity to sinus mucosa and mucosa around the platform are complicating factors. Microporous surfaces could become restricted to the zygoma implant tip as the authors prefer. Yet, fully microporous-surfaced implants have been unproblematic in short follow-up cases (3 years), possibly due to soft tissue tolerance. Clinical practice showed free implant convolutions with microporous surfaces to be at no higher risk of infection when compared to the polished surfaces.[44,45]

Zygomatic bone diameter is reported to be of a high trabecular quality.[46] Employment of four cortical portions is recommended for maximum primary stability, ie, the alveolar process at the molar region and the cortex of the zygomatic bone. Zygoma implant positioning across the temporal fossa may include 2 or more cortical fractions from the zygomatic arch.[30] Several authors have used computer and CT-assisted navigation to determine exact implant placement with less than 1 mm and 3 degrees of absolute error[47,48] in patients and cadavers.[49]

Unilateral insertion of 3 zygoma implants was repeatedly achieved in the present study with the manual technique without navigation, and development of an off-site navigation system is currently under evaluation.[45] On-site navigation is expensive and prolongs the operation time, though theoretically it supports exact placement of the implant and optimal bone use. In this clinical experience, zygoma implants were always primarily stable, even when inserted into only 2 zygomatic cortical portions. The inherent angle of 45 degrees proved adequate and was readily connected to abutments in all cases.[50]

One positive aspect of conically shaped telescopes is the adjustable retention seen before insertion by choosing the milling degree of the conical angle between 2 and 6 degrees. The single accessible abutments of zygoma implants ensure a single evaluation[51,52] of the bone integrity of each implant and a high oral hygiene level. Also, the ceramic structure of the primary crown and the galvano formed secondary crown positively affect the hygienic aspect of the telescope, as ceramic has a very low plaque accumulation[52,53] and an excellent mucosa compatibility.[54] Another positive aspect is that the circumferential holding avoids tilting and loading forces are then evenly distributed on implants and teeth.[55] Telescopes offer a stable position of the denture in contrast to jointed attachments[56] and show good long-term performance.[57,58] The secondary splinting of single units is so rigid and stable that it has also been successfully used in the immediate loading of implants.[59,60] The loss of an abutment tooth or implant is easy to fix without compromising the function and esthetics by simply filling in the secondary crown with relining material.

Over the long-term, telescope crown–retained dentures are more cost effective compared to the use of bar-retained dentures.[55] The abrasion is minimized by using 2 different material classes (ceramic and metal) and an accurate passive fit. The missing kinetics reduces the need of relining the prosthesis due to bone resorption.

Various methods have been described for alternative surgical large defect closure[61–63] and the experiences were catalogued as algorithms.[64,65] To the deep circumflex iliac artery flap[66] came the rectus abdominis and radial flap,[64] fibula[67] and subscapular artery flaps.[68] Dental implants can be inserted into revascularized bone. However, in many cases, resorption is high unless prefabricated transplants are used.[3,35] Donor site and overall morbidity has been variably reported and the patient then needs to adapt to the prevalent reconstruction. If the patient's general health and consent permit, prefabricated free transplants should be considered first, but these also require further follow-up.[69]

Telescoped zygoma implants, however, can be used very reliably, even in a total maxillectomy, yet severe defects involving the orbitonasal complex should remain a primary indication for reconstructive surgery. The complication rates lie within those reported for cross-arch fixed partial dentures similarly reported by other authors according to chronic maxillary sinusitis, which led to the removal of 10% of zygoma implants[8] and 11% in the present study.

Lately, immediate prosthetic loading has been ventured in single patients with fair results.[44,45] However, this option should not become transferred to telescoped solutions unless sound documentation in a large collective with long-term results has been sufficiently evaluated in the blocked acrylic or individual titanium fixed partial denture.

Patients obtained oronasal sealing, speech, feeding, midfacial projection as upper lip projection according to subjective perception. No patient complained of the excessive manual dexterity required for incorporation and removal of the prosthesis and all yielded chewing and speech.

The personal high satisfaction and comfort felt by this study's patients became somewhat reflected in the OHIP14G results. In a reference study of patients with removable dentures, 50% had summary scores of ≤ 7 and 90% had scores ≤ 17; for complete dentures, 50% had scores ≤ 8 and 90% had scores ≤ 25. Within the framework upon evaluation, retrospective summary scores of 14 ± 6 prior to tumor resection (cleft cases excluded) represented the fact that the majority of patients had already had removable dentures. A summary score of 25 ± 12 after prosthetic rehabilitation represents a result that is comparable in the lower 20% to 50% range of patients with conventional full dentures of adequate quality.[24]

Conclusion

Within the limitations of this observational study's variable evaluation period, it was observed that zygomatic implants are reliable abutments for specifically designed maxillofacial prosthesis—trapezoid prosthesis design supported by a sufficient number of implants. Treated patients reported comfort and satisfaction with their prostheses.

References

1. Triplett RG, Schow SR. Autologous bone-grafts and endosseous implants: Complementary techniques. J Oral Maxillofac Surg 1996;54:486–494.
2. Swartz WM, Banis JC, Newton ED, Ramasastry SS, Jones NF, Acland R. The osteocutaneous scapular flap for mandibular and maxillary reconstruction. Plast Reconstr Surg 1986;77:530–545.
3. Rogers SN, Lakshmiah SR, Narayan B, et al. Comparison of the long-term morbidity following deep circumflex iliac and fibula free flaps for reconstruction following head and neck cancer. Plast Reconstr Surg 2003;112:1517–1525.
4. Rogers SN, Lowe D, McNally D, Brown JS, Vaughan ED. Health-related quality of life after maxillectomy: A comparison between prosthetic obturation and free flap. J Oral Maxillofac Surg 2003;61:174–181.
5. Keller EE, Van Roeckel NB, Desjardins RP, Tolman DE. Prosthetic-surgical reconstruction of the severely resorbed maxilla with iliac bone grafting and tissue-integrated prostheses. Int J Oral Maxillofac Implants 1987;2:155–165.
6. Sakuraba W, Kimata Y, Ota Y, et al. Simple maxillary reconstruction using free tissue transfer and prostheses. Plast Reconstr Surg 2003;111:594–598.
7. Parel SM, Brånemark PI, Ohrnell LO, Svensson B. Remote implant anchorage for the rehabilitation of maxillary defects. J Prosthet Dent 2001;86:377–381.
8. Becktor JP, Isaksson S, Abrahamsson P, Sennerby L. Evaluation of 31 zygomatic implants and 74 regular dental implants used in 16 patients for prosthetic reconstruction of the atrophic maxilla with cross-arch fixed bridges. Clin Implant Dent Relat Res 2005;7:159–165.
9. Bedrossian E, Stumpel LJ 3rd. Immediate stabilization at stage II of zygomatic implants: Rationale and technique. J Prosthet Dent 2001;86:10–14.

10. Bedrossian E, Stumpel LJ 3rd, Beckely M, Indresano T. The zygomatic implant: Preliminary data on treatment of severely resorbed maxillae. A clinical report. Int J Oral Maxillofac Implants 2002;17:861–865.
11. Malevez C, Abarca W, Durdu F, Daelemans P. Clinical outcome of 103 consecutive zygomatic implants: A 6-48 months follow-up study. Clin Oral Implants Res 2004;15:18–22.
12. Besimo C, Graber G. A new concept of overdentures with telescope crowns on osseointegrated implants. Int J Periodontcs Restorative Dent 1994;14:486–495.
13. Scurria MS, Bader JD, Shugars DA. Meta-analysis of fixed partial denture survival: Prostheses and abutments. J Prosthet Dent 1998;79:459–464.
14. Piwowarczyk A, Köhler KC, Bender R, Büchler A, Lauer HC, Ottl P. Prognosis for abutment teeth of removable dentures: A retrospective study. J Prosthodont 2007;16:377–382.
15. Körber K. Telescoping Crowns - The Rational Telescope System. Introduction to Clinic and Technique. Heidelberg:Hüthig-Verlag, 1988.
16. Lukas D, Schulte W. Periotest-A dynamic procedure for the diagnosis of the human periodontium. Clin Phys Physiol Meas 1990;11:65–75.
17. Löe H. The Gingival Index, the Plaque Index and the Retention Index Systems. J Periodontol 1967;38:610–616.
18. Dellon AL. The moving two-point discrimination test: Clinical evaluation of the quickly adapting fiber/receptor system. J Hand Surg 1978;3:474–481.
19. Buser D, Weber HP. Lang NP. Tissue integration of non-submerged implants. 1-year results of a prospective study with 100 ITI hollow-cylinder and hollow-screw implants. Clin Oral Implants Res 1990;1:33–40.
20. Klaus G. Electroforming technique–Electroforming as alternative to casting technique? [in German] Quintessenz Zahntech 1988;14:556–558.
21. Weigl P, Schlegel KA, Fichtner G, et al. A New Abutment and Prosthetic Procedure for Telescopic Denture Supported by Brånemark Implants. Proceedings 2nd World Congress of Osseointegration. Rome, 1996;285-290.
22. Janko S, Weigl P, Lauer HC. Long term behaviour of intraoral adhered rigid taper crown anchorage (Abstract 267). J Dent Res 1998:77:1240.
23. Weigl P, Kirchner T, Hopp M, Lauer HC. Qualities of direct electroplated gold copings used as telescope retainer (Abstract 263). J Dent Res 1998;77,1239.
24. John MT, Micheelis W, Biffar R. Reference values in oral health-related quality of life for the abbreviated version of the Oral Health Impact Profile [in German]. Schweiz Monatsschr Zahnmed. 2004;114:784–791.
25. Landes CA. Zygoma implant-supported midfacial prosthetic rehabilitation: A four-year follow-up study including assessment of quality of life. Clin Clin Oral Implants Res 2005;16:313–325.
26. Chuang SK, Tian L, Wie LJ, Dodson TB. Kaplan-Meier analysis of dental implant survival: A strategy for estimating survival with clustered observations. J Dent Res 2001;80:2016–2020.
27. Bergman B, Ericson A, Molin M. Long-term clinical results after treatment with conical crown-retained dentures. Int J Prosthodont 1996;9:533–538.
28. Parel SM, Holt GR, Brånemark PI, Tjellström A. Osseointegration and facial prosthetics. Int J Oral Maxillofac Implants 1986;1:27–29.
29. Vuillemin T, Raveh J, Lädrach K, Roux M. Reconstruction after a hemimaxillectomy. The functional restoration of the maxilla after a hemimaxillectomy. Schweiz Monatsschr Zahnmed 1990;100:1082–1087.
30. Jensen OT, Brownd C, Blacker J. Nasofacial prostheses supported by osseointegrated implants. Int J Oral Maxillofac Implants 1992;7:203–207.
31. Izzo SR, Berger JR, Joseph AC, Lazow SK. Reconstruction after total maxillectomy using an implant-retained prosthesis: A case report. Int J Oral Maxillofac Implants 1994;9:593–595.
32. Roumanas E, Nishimura RD, Beumer J, Moy PK, Weinlander M, Lorant J. Craniofacial defects and osseointegrated implants: Six-year follow-up report on the success rates of craniofacial implants at UCLA. Int J Oral Maxillofac Implants 1994;9:579–586.
33. Evans JH, Schweiger JW, Wright RF. Craniofacial osseointegration of a large midfacial bone anchored in combination maxillofacial prosthesis: A clinical report. J Prosthet Dent 1996;75:483–486.
34. Weischer T, Schettler D, Mohr C. Titanium implants in the zygoma as retaining elements after hemimaxillectomy. Int J Oral Maxillofac Implants 1997;12:211–214.
35. Breine U, Brånemark PI. Reconstruction of alveolar jaw bone. An experimental and clinical study of immediate and performed autologous bone grafts in combination with osseointegrated implants. Scand J Plast Reconstr Surg 1980;14:23–48.
36. Isaksson S. Evaluation of three bone grafting techniques for severely resorbed maxillae in conjunction with immediate endosseous implants. Int J Oral Maxillofac Implants 1994;9:679–688.
37. Hürzeler MK, Kirsch A, Ackermann KL, Quiñones CR. Reconstruction of the severely resorbed maxilla with dental implants in the augmented maxillary sinus: A 5-year clinical investigation. Int J Oral Maxillofac Implants 1996;11:466–475.
38. Lekholm U, Wannfors S, Isaksson S, Adielsson B. Oral implants in combination with bone grafts. A 3-year retrospective multicenter study using the Brånemark implant system. Int J Oral Maxillofac Surg 1999;28:181–187.
39. Rogers SN, Gwanne S, Lowe D, Humphris G, Yueh B, Weymuller EA Jr. The addition of mood and anxiety domains to the University of Washington quality of life scale. Head Neck 2002;24:521–529.
40. Rogers SN, Laher SH, Overend L, Lowe D. Importance-rating using the University of Washington quality of life questionnaire in patients treated by primary surgery for oral and oro-pharyngeal cancer. J Craniomaxillofac Surg 2002;30:125–132.
41. Weingart D, Schilli W, Strub JR. Preprosthetic surgery and implantology. The effect of oral implantology on preprosthetic surgery in edentulous patients. Schweiz Monatsschr Zahnmed 1992;102:1074–1085.
42. Buser D, Schenk RK, Steinemann S, Fiorellini JP, Fox CH, Stich H. Influence of surface characteristics on bone integration of titanium implants. A histomorphometric study in miniature pigs. J Biomed Mater Res 1991;25:889–902.
43. Cochran DL, Nummikoski PV, Higginbottom FL, Hermann JS, Makins SR, Buser D. Evaluation of an endosseous titanium implant with a sandblasted and acid-etched surface in the canine mandible: Radiographic results. Clin Oral Implants Res 1996;7:240–252.
44. Landes CA, Piwowarczyk A, Seitz O, Kovács A F, Lauer HC, Sader R. Immediate function of Zygomaticus-Fixtures combined with 2 anterior dental maxillary implants (Speedy- fixtures) and „all-on-4“ implants in the mandible (Speedy- fixtures) of edentulous patients, preliminary results, Available at: http://download.nobelbiocare.com/webcontent/WorldTour06/followup/Poster_Nobel-Biocareneu.pdf. Accessed 10 January 2008
45. Chow J, Hui E, Lee PK, Li W Zygomatic implants – Protocol for immediate occlusal loading: A preliminary report. J Oral Maxillofac Surg 2006;64:804–811.
46. Nkenke E, Hahn M, Lell M, et al. Anatomic site evaluation of the zygomatic bone for dental implant placement. Clin Oral Implants Res 2003;14:72–79.
47. Schramm A, Gellrich NC, Schimming R, Schmelzeisen R. Computer-assisted insertion of zygomatic implants (Brånemark System) after extensive tumor surgery [in German]. Mund Kiefer Gesichtschir 2000;4:292–295.

48. Watzinger F, Birkfellner W, Wanschitz F, et al. Placement of endosteal implants in the zygoma after maxillectomy: A cadaver study using surgical navigation. Plast Reconstr Surg 2001;107:659–667.
49. Van Steenberghe D, Malevez C, Van Cleynenbreugel J, et al. Accuracy of drilling guides for transfer from three-dimensional CT-based planning to placement of zygoma implants in human cadavers. Clin Oral Implants Res 2003;14:131–136.
50. Uchida Y, Goto M, Katsuki T, Akiyoshi T. Measurement of the maxilla and zygoma as an aid in installing zygomatic implants. J Oral Maxillofac Surg 2001;59:1193–1198.
51. Blickle W, Niederdellmann H. Clinical aspects of implant-supported telescopic crowns in partially edentulous jaw [in German]. ZWR 1991;100:924–927.
52. Adamczyk E, Spiechowicz E. Plaque accumulation on crowns made of various materials. Int J Prosthodont 1990;3:285–291.
53. Chan C, Weber H. Plaque retention on restored teeth with full-ceramic crowns: A comparative study. J Prosthet Dent 1986;56:666–671.
54. Weber HP, Cochran DL. The soft tissue response to osseointegrated dental implants. J Prosthet Dent 1998;79:79–89.
55. Kreissl ME, Heydecke G, Metzger MC, Schoen R. Zygoma implant-supported prosthetic rehabilitation after partial maxillectomy using surgical navigation: A clinical report. J Prosthet Dent 2007;97:121–128.
56. Besimo C, Kempf B. In vitro investigation of various attachments for overdentures on osseointegrated implants. J Oral Rehabil 1995;22:691–698.
57. Hofmann E, Behr M, Handel, G. Frequency and costs of technical failures of clasp- and double crown-retained removable partial dentures. Clin Oral Investig 2002;6:104–108.
58. Wagner B, Kern M. Clincal evaluation of removable partial dentures 10 years after insertion: Success rates, hygienic problems, and technical failures. Clin Oral Investig 2000;4:74–80.
59. Ye ZC, Xu SL. Clinical study of immediate implant-support and mandibular overdentures retained by conical crowns. Shanghai Kou Qiang Yi Xue 2007;16:578–581.
60. Payne AG, Tawse-Smith A, Kumara R, Thomson WM. One-year prospective evaluation of the early loading of unsplinted conical Brånemark fixtures with mandibular overdentures immediately following surgery. Clin Implant Dent Relat Res 2001;3:9–19.
61. Pollice PA, Frodel JL Jr. Secondary reconstruction of upper midface and orbit after total maxillectomy. Arch of Otolaryngol Head Neck Surg 1998;124:802–808.
62. Truitt TO, Gleich LL, Huntress GP, Gluckman JL. Surgical management of hard palate malignancies. Otolaryngol Head Neck Surg 1999;121:548–552.
63. Baumann A, Ewers R. Application of the buccal fat pad in oral reconstruction. J Oral Maxillofac Surg 2000;58:389–393.
64. Brown JS, Rogers SN, McNally DN, Boyle M. A modified classification of the maxillectomy defect. Head Neck 2000;22:17–26.
65. Cordeiro PG, Santamaria E. A classification system and algorithm for reconstruction of maxillectomy and midfacial defects. Plast Reconstr Surg 2000;105:2331–2346.
66. Brown JS. Deep circumflex iliac artery free flap with internal oblique muscle as a new method of immediate reconstruction of maxillectomy defect. Head Neck 1996;18:412–421.
67. Futran ND, Haller JR. Considerations for free-flap reconstruction of the hard palate. Arch Otolaryngol Head Neck Surg 1999;125:665–669.
68. Uglesic V, Virag M, Varga S, Knezevic P, Milenovic A. Reconstruction following radical maxillectomy with flaps supplied by the subscapular artery. J Craniomaxillofac Surg 2000;28:153–160.
69. Jaquiéry C, Rohner D, Kunz C, et al. Reconstruction of maxillary and mandibular defects using prefabricated microvascular fibular grafts and osseointegrated dental implants – A prospective study. Clin Oral Implants Res 2004;15:598–606.

Literature Abstract

Effect of metal type and surface treatment on in vitro tensile strength of copings cemented to minimally retentive preparations

This study evaluated the effect of alloy type and surface pretreatments on tensile strength to minimally retentive preparations on metal copings made of base alloy and noble alloy. Standardized crown preparations were made on recently extracted human third molars with a 3 mm height and 26 degree taper (n = 68). All noble and base alloy copings fabricated for the teeth preparations received heat treatment for oxide formation. Three experimental groups (oxide only, airborne-particle abraded, or metal-primed) were created for each metal type. Copings were luted using a self-adhesive universal resin cement (RelyX Unicem) and were thermal cycled (500 cycles between 5 and 55°C) and stored (24 hours, 37°C) before debonding using a universal testing machine. A 2-way ANOVA was used to verify the interaction between the metal type and surface treatment ($\alpha = .05$). A multinomial logit statistical model was used to describe the effect of metal type and surface treatment on failure site location ($\alpha = .05$). The results indicated: *(1)* no significant influence of any factor on debond load: metal type, surface treatment, or their interaction; *(2)* that the multinomial logit statistical model showed that noble metals and metal primers significantly shifted failures to occur more frequently at the resin/tooth interface or within the tooth itself; *(3)* that airborne-particle abrasion was found to shift debonding more toward root failure than did the oxide layer only. The authors concluded that neither metal type nor surface pretreatment affected bond strength. Alloy type and surface treatment affected debond location.

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