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Patients' preferences towards minimally invasive treatment alternatives for implant rehabilitation of edentulous jaws

Key words *dental implants, implant-supported dental prosthesis, quality of life, patient preference, patient satisfaction*

Purpose: To evaluate patient satisfaction, oral health-related quality of life, and patients' preferences towards minimally invasive treatment options for graftless rehabilitation of complete edentulism by means of dental implants.

Material and methods: A MEDLINE search of literature in the English language up to the year 2013 was performed to summarise current evidence from the patient's perspective. The final selection included 37 studies reporting on minimally invasive implant treatment of 648 edentulous maxillae and 791 edentulous mandibles in 1328 patients, via a total of 5766 implants.

Results: Patient satisfaction averaged 91% with flapless implant placement (range: 77 to 100%), 89% with short implants, 87% with narrow-diameter implants (range: 80 to 93%), 90% with a reduced number of implants (range: 77 to 100%), 94% with tilted implant placement (range: 58 to 100%), and 83% with zygomatic fixtures (range: 50 to 97%). Indirect comparison yielded patient preference towards tilted implant placement compared to a reduced number of implants ($P = 0.036$), as well as to zygomatic implants ($P = 0.001$).

Conclusions: While little evidence on patients' preferences towards minimally invasive treatment alternatives vs. bone augmentation surgery could be identified from within-study comparison, it may be concluded that patient satisfaction with graftless solutions for implant rehabilitation of completely edentulous jaws is generally high. Comparative effectiveness research is needed to substantiate their positive appeal to potential implant patients and possible reduction of the indication span for invasive bone graft surgery.

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■ Introduction

During the past decade, there has been an obvious trend in oral health care towards techniques attempting to provide optimum service for patients with the minimal amount of treatment[1]. Interest for minimally invasive procedures as standard treatment is notably growing in the field of oral implantology[2]. While modification of the patient's jaw anatomy by bone augmentation surgery to allow placement of longer and wider implants has been generally considered the best treatment strategy in the past, adaptation of implant dimensions and positions to the existing anatomy may represent a more appropriate solution in cases of severe atrophy of the residual alveolar bone[3]. The option of a minimally invasive

Table 1 Outcome measures to evaluate oral implant treatment.

Implant-related outcome measures	
implant survival rate	percentage of implants in situ
implant success rate	percentage of implants fulfilling certain criteria of success
marginal bone remodelling	radiologic peri-implant crestal bone position (marginal bone level) or alterations (marginal bone resorption)
peri-implant mucosal health	pocket probing depth, bleeding on probing, sulcus bleeding index, and presence of keratinised mucosa
peri-implant mucosal aesthetics	professional rating of "pink" aesthetics, e.g. via the Pink Esthetic Score[23]
Denture-related outcome measures	
denture survival rate	percentage of dentures in situ (in spite of potential implant loss in cases of sustained usability)
technical complications	frequency of mechanical damage of the implant components and suprastructures or maintenance work
objective masticatory function	masticatory performance in terms of bite force, food break-down, mastication time or electromyographic jaw muscle activity[24]
objective phonetic function	speech intelligibility, articulation and oromyofunctional behaviour[25]
Patient-related outcome measures	
oral health-related quality of life (OHRQoL)	hierarchy of functional, psychological and social parameters assessed, e.g. via the Oral Health Impact Profile (OHIP)
patient satisfaction	subjective visual analogue scale (VAS) ratings regarding stability, chewing efficiency, phonetics, aesthetics, or ease of cleaning
patient preference	patients' choice of preferred treatment

technique – per definition – appeals to a greater number of potential implant patients and is frequently associated with economic benefits[4]. Implant surgery may be termed 'minimally invasive' referring to avoidance of bone grafts[5], and/or prevention of intra- and postoperative patient morbidity in terms of pain[6], swelling[7], bleeding[8], or expended operating time[9]. Transmucosal healing modality[10] or immediate implant placement[11], by contrast, may reduce the number of surgical interventions, however, circumvent only insignificant trauma and do not strictly reflect the concept of minimal invasion. The same is true for prosthetic concepts, such as immediate provisionalisation or early loading[12] in spite of their inherent advantages of reduced treatment duration relevant to patients. Reduction of surgical invasion may thus be achieved by either:

- reduction in the extent of mucosal flap elevation: flapless implant placement frequently combined with CAD/CAM surgical templates[13] or intraoperative navigation[14]
- reduction of the size of implants used: short implants less than 10 mm in length[15], or narrow-diameter implants less than 3.75 mm in width[16]
- reduction of the number of implants placed[17], or
- maximum use of anatomical buttresses: tilted[18] or zygomatic implants[19].

Patient satisfaction represents one of the most fundamental goals to achieve in oral rehabilitation[20]. Treatment evaluation in evidence-based medicine and dentistry should thus embrace the opinion and attitude of patients as a variable of therapeutic success[21]. Outcomes of oral implant therapy have traditionally been described in terms of survival rates, clinical and radiological surrogate parameters and durability of implant superstructures[22], however, patient-based outcome measures are considered essential to complement the clinical component for more comprehensive assessment of health status and the impact on the recipient (Table 1)[23-25]. Complete edentulism can substantially affect oral and general health, as well as overall quality of life[26]. Patients may suffer pain in the denture-bearing area, impaired chewing efficiency and nutrition due to limited retention and stability of conventional prostheses[27]. As Professor Per-Ingvar Brånemark famously put it[28]: "The edentulous patient is an

amputee, an oral invalid, to whom we should pay total respect and rehabilitation ambitions." The aim of the present systematic review was to evaluate patient satisfaction, oral health-related quality of life, and patients' preferences towards minimally invasive treatment options for graftless rehabilitation of complete edentulism.

Materials and methods

The authors searched for clinical scientific literature in the English language via the US National Institutes of Health free digital archive of biomedical and life sciences journal literature (Pubmed MEDLINE). The last search was performed on 23 December 2013. The search term 'dental implant' was combined with 'patient satisfaction', 'patient perspective', 'patient preference', 'minimally invasive', 'flapless', 'short', 'reduced diameter', 'narrow diameter', 'tilted' and 'zygomatic'. After exclusion of 65 duplicates, a total of 424 abstracts were screened. Studies were considered if they met the following eligibility criteria: 1) clinical investigations; 2) reporting on patient-based outcome measures (patient satisfaction, oral health-related quality of life, or patient preference); 3) of minimally invasive 4) graftless implant treatment 5) in completely edentulous patients.

A total of 81 papers were screened in full text, of which 33 did not fulfil eligibility criterion 2, 14 did not fulfil eligibility criterion 3, and 18 did not fulfil eligibility criterion 5 (listed in the APPENDIX; available online). After exclusion of 1 duplicate publication reporting on a patient cohort already included, 15 studies were selected as preliminary candidates. Moreover, the references of all eligible original publications as well as those of relevant review articles and meta-analyses[29-72] were screened, resulting in an additional 22 included studies. Study selection was performed in duplicate (BP and GW) and disagreements were resolved by consensus.

Descriptive analysis of study characteristics included: study design; number of patients and jaws treated; number of implants placed per jaw and in total; length of follow-up; scale used for outcome assessment; and performance of within-patient comparison (pre-vs. post-implantation). Weighted mean rates of patient satisfaction were calculated for each treatment strategy after conversion of individual study results to per cent scale (i.e. a rating of 4 in a 5-point Lickert scale was expressed as 80%). Likewise, Oral Health Impact Profile (OHIP) ratings were divided by the maximum total value (i.e. 196 for the full version OHIP-49 using a 0-4 Lickert scale) to achieve normalisation of OHIP versions and enable outcome comparison[73].

Results

The final selection included 37 studies reporting on minimally invasive graftless implant treatment of 648 edentulous maxillae and 791 edentulous mandibles in 1328 patients via a total of 5766 implants. Patient-based outcome measures constituted of treatment satisfaction (34 studies), oral health-related quality of life (4 studies) or patient preferences (2 studies). The following minimally invasive treatment options were investigated: flapless implant placement (5 studies, 90 patients, 427 implants); short implants (1 study, 19 patients, 76 implants); narrow-diameter implants (7 studies, 152 patients, 523 implants); reduced number of implants (7 studies, 320 patients, 992 implants); tilted implant placement (11 studies, 660 patients, 3266 implants); and zygomatic fixtures (6 studies, 87 patients, 482 implants).

Flapless implant placement

Hof and co-workers (2014)[74] investigated 22 patients (16 women, 6 men, mean age: 61 years) with 20 edentulous maxillae and 11 edentulous mandibles in a cross-sectional questionnaire-based interview survey. Inclusion criteria involved patients seeking implant treatment without history of previous implant surgery. Patient preferences were assessed by polar questions regarding their disposition to receive flapless guided implant placement. A total of 77% were keen to avoid open flap surgery, while the remainder did not favour one treatment strategy over the other (Table 2).

Nkenke and co-workers (2007)[75] investigated 10 patients (2 women, 8 men, mean age: 65 years) all with edentulous maxillae in a prospective comparative study with a follow-up of 1 year. Inclusion criteria involved the placement of 6 implants into

Table 2 Studies on patient satisfaction with flapless implant placement in edentulous jaws (mx = maxilla, md = mandible): study design (cross = cross-sectional study, pro = prospective study), number of patients (Patient no.), implants placed per patient (Impl/pat), length of follow-up (in years), assessment scale (+/– = polar questions), and within-patient comparison pre- vs. post-implantation.

	Study design	Jaw	Patient no.	Impl/ pat	Follow- up	Scale	Within patient
Hof et al, 2014[74]	cross	20 mx 11 md	22			+/-	no
Nkenke et al, 2007[75]	pro	mx	5	6	1 a	100-0	no
Papaspyridakos & Lal, 2013[76]	pro	6 mx 10 md	14	5-8	3 a	+/-	no
van Steenberghe et al, 2005[77]	pro	mx	24	6-8	1 a	0-10	no
Wittwer et al, 2007[78]	pro	md	20	4		+/-	no

native anterior maxillary bone and matched patients' demographics (equal gender, maximum age difference: 5 years, maximum weight difference: 10 kg) between the two treatment groups: 5 patients were subjected to flapless implant placement using CAD/CAM surgical templates after virtual treatment planning in a computed tomographic scan (Procera; Nobel Biocare, Zurich, Switzerland), while in the remaining 5 patients mucoperiosteal flaps were elevated. Patient satisfaction was assessed on a visual analogue scale (VAS) regarding the following questions: 1) Would you have this procedure done again?; 2) Did you recognise bleeding during surgery?; 3) Was the duration of surgery acceptable?; and 4) Would you recommend this procedure to a friend? (0 = maximal agreement to 10 = maximal disagreement). VAS-ratings regarding pain and discomfort differed significantly ($P < 0.01$) between open (57.2, 61.2, and 23.6) and flapless implant placement (11.6, 9.6, and 4.6), 6 h, 1 day and 7 days after surgery, respectively. Patients subjected to flap elevation were less likely to repeat the procedure, recognise intraoperative bleeding, accept the duration of surgery, and recommend the procedure to a friend.

Papaspyridakos and Lal (2013)[76] investigated 14 patients (10 women, 4 men, mean age: 58) with 6 edentulous maxillae and 10 edentulous mandibles in a prospective study with a mean follow-up of 3 years. Inclusion criteria involved mouth opening of at least 50 mm to accommodate for the surgical instrumentation. Flapless placement of 103 implants was performed using virtual planning software (NobelGuide, Nobel Biocare) and stereolithographic surgical templates. The patients received 14 full arch and 2 segmented porcelain fused to zirconia implant fixed prostheses (Procera, Nobel Biocare). Patient satisfaction was assessed by polar questions regarding aesthetic outcome and occlusal function. Great patient satisfaction with function and aesthetics was recorded for all these patients that had undergone flapless surgery.

van Steenberghe and co-workers (2005)[77] investigated 27 patients (mean age: 63 years) with edentulous maxillae in a prospective multicentre study, of which 24 patients completed the 1-year follow-up. Inclusion criteria involved sufficient bone volume to harbour at least 6 implants of at least 10 mm in length. A total of 184 implants (Brånemark MK III TiU, Nobel Biocare) were placed according to the Teeth-in-an-Hour concept using double-scan spiral computed tomography, 3D treatment planning software (NobelGuide, Nobel Biocare) and stereolithographic surgical templates to allow for guided flapless implant placement. Immediate provisional restoration was performed using prefabricated customised fibre-reinforced acrylic full-arch fixed prostheses. Patient satisfaction was assessed at 3 months and after 1 year of loading (0 = poor to 10 = excellent outcome) regarding speech, oral function, aesthetics and tactile sensation. While after 3 months half of the patients were not completely satisfied with their speech, at the 1-year follow-up, 88% judged aesthetics as either excellent or good. Function and tactile sense was perceived as excellent or good by all patients after 1 year.

Wittwer and co-workers (2007)[78] investigated 20 patients (6 women, 14 men, mean age: 64 years) with edentulous mandibles in a prospective

Table 3 Studies on patient satisfaction with short implants in the edentulous mandible (md): study design (pro = prospective study), number of patients (Patient no.), implants placed per patient (Impl/pat), length of follow-up (in years), assessment scale (+/– = polar questions), and within-patient comparison pre- vs. post-implantation.

	Study design	Jaw	Patient no.	Impl /pat	Follow-up	Scale	Within patient
Stellingsma et al, 2003[79]	pro	md	19	4	1 a	0-10 +/-	yes

pilot study. Inclusion criteria involved residual bone height of more than 15 mm in the anterior mandible and complete edentulism for at least 1 year prior to surgery. Flapless placement of 4 implants (Ankylos, Dentsply Friadent, Mannheim, Germany) in the interforaminal region was performed using the VISIT implant planning and navigation software (University of Vienna), allowing for real-time navigation after matching the patient's computed tomographic scans with a point-to-point registration. All patients received bar-retained overdentures. Patient satisfaction was assessed by a dichotomous variable: the procedure was claimed to be well tolerated by all 20 patients (100%).

Short implants

Stellingsma and co-workers (2003)[79] investigated 60 patients (50 women, 10 men, mean age: 59 years) with edentulous mandibles in a prospective comparative study with a follow-up of 1 year. Inclusion criteria involved long-term edentulism (patients wearing their third complete lower denture on average). While the other 2 groups in the study were subjected to bone augmentation (19 patients) or transmandibular implants (20 patients), the remaining 19 patients received 4 short implants (IMZ, Friatec) in the anterior mandible. However, implant lengths were 8 or 11 mm, thus not all met the generally accepted definition of short implants of less than 10 mm in length[15]. Patient satisfaction was assessed on a 10-point rating scale (0 = completely dissatisfied to 10 = completely satisfied). In addition, denture satisfaction was assessed using a validated questionnaire[80] consisting of eight items focusing on the function of upper and lower dentures, and on specific features such as aesthetics, retention and functional comfort (5-point rating scale). Patients' experiences in the surgical phase were more negative than expected for 25% of short implant patients vs. 50% of augmentation patients. Postoperative pain lasting longer than 1 week also differed significantly (20% vs. 85%). Overall satisfaction with short implant therapy increased significantly from 4.4 before treatment to 8.9 after implant placement (+45%), but however, did not differ significantly (increase from 4.3 to 7.9) compared to the augmentation group (Table 3).

Narrow-diameter implants

Brandt and co-workers (2012)[81] investigated 24 patients (age range: 35 to 75 years) with edentulous mandibles in a 2-year follow-up study. Inclusion criteria involved presence at the follow-up examinations. A total of 96 narrow-diameter implants (MDL, Intra-Lock) with a diameter of 2.0 mm and an O-ball attachment were placed in the anterior mandible and loaded immediately. Patient satisfaction was assessed on a scale from 1 = extremely poorer than before, 2 = considerably poorer than before, 3 = slightly poorer than before, 4 = the same as before, 5 = slightly better than before, 6 = considerably better than before, to 7 = extremely better than before: 1) How well can you bite with your present dentures after occlusal adjustments as compared with before implant placement?; 2) Rate your satisfaction from your present dentures after implant placement as compared with before implant placement?; 3) How secure do you feel with your present dentures after implant placement compared with your present dentures before implant placement?; and 4) How much have your present dentures, after implant placement, affected your speech compared with your present denture before occlusal adjustements? Mean patient satisfaction was 3.8 (54%) prior to implant placement was 6.5 (93%) after 2 years of loading (Table 4).

Table 4 Studies on patient satisfaction with narrow-diameter implants in edentulous jaws (mx = maxilla, md = mandible): study design (RCT = randomised controlled trial, pro = prospective study, retro = retrospective study), number of patients (Patient no.), implants placed per patient (Impl/pat), length of follow-up (in years), assessment scale (OHIP = Oral Health Impact Profile, +/– = polar questions), and within-patient comparison pre- vs. post-implantation (*both ratings assessed after implant treatment).

	Study design	Jaw	Patient no.	Impl /pat	Follow-up	Scale	Within patient
Brandt et al, 2012[81]	retro	md	24	4	2 a	1–7	yes*
Cho et al, 2007[82]	retro	md	10	2–4	0.2 a	0–10	yes*
Griffitts et al, 2005[83]	pro	md	24	4	0.5 a	1–10	yes*
Jofre et al, 2013[84]	RCT	md	15	2	1 a	OHIP	yes
Morneburg & Pröschel, 2008[86]	pro	md	37	2	6 a	0–10	yes
Šćepanović et al, 2012[87]	pro	md	30	4	1 a	OHIP 0–10	yes
Veltri et al, 2008[89]	pro	mx	12	5-8	1 a	+/-	no

Cho and co-workers (2007)[82] investigated 10 patients (7 women, 3 men, mean age: 58 years) with edentulous mandibles in a retrospective study with a mean follow-up of 22.8 months (range: 14 to 36 months). Inclusion criteria involved dissatisfaction with conventional prostheses due to lack of stability. A total of 34 one-piece narrow-diameter implants (Atlas; Dentatus, New York, NY, USA) with a diameter of 2.4 mm were placed in the interforaminal region. Existing mandibular dentures were relined to establish adequate retention and allow immediate function. Patient satisfaction with complete as well as implant-retained prostheses was assessed 2 months after surgery using the following patient satisfaction questionnaire: 1) Does your lower denture stay in place during function?; 2) Are you comfortable with your lower denture?; 3) How well does your lower denture fit?; 4) Do your upper and lower dentures fit well together?; 5) Are you satisfied with your lower denture?; 6) How well do you speak with your lower denture?; 7) How well do people understand you when you speak?; 8) How happy are you with your facial appearance with your dentures in place?; and 9) Do you feel comfortable with your social life with your dentures? (0 = very dissatisfied to 10 = very satisfied). Patients rated implant-retained dentures better than their previously worn conventional dentures in all categories: 7.8 vs. 3.0 for question 1 (+48%), 8.1 vs. 3.4 for question 2 (+47%), 8.6 vs. 2.2 for question 3 (+54%), 9.0 vs. 4.0 for question 4 (+50%), 8.2 vs. 1.6 for question 5 (+66%), 9.3 vs. 5.4 for question 6 (+39%), 9.4 vs. 7.6 for question 7 (+18%), 8.4 vs. 7.2 for question 8 (+12%), and 8.4 vs. 5.6 for question 9 (+28%), however, no statistical comparison was attempted.

Griffitts and co-workers (2005)[83] investigated 24 patients (mean age: 67 years) with edentulous mandibles in a prospective questionnaire study with a mean follow-up of 0.5 years. No further inclusion criteria were stated. In each patient 4 narrow-diameter implants 10 to 18 mm in length and 1.8 mm in diameter (Sendax MDI, IMTEC; 3M ESPE, Seefeld, Germany) were placed between the mental foramina. The complete dentures were retrofitted with the MDI housings and the implants were immediately loaded. Patient satisfaction regarding comfort, retention, chewing ability and speaking ability was assessed on a scale of 1 = poor to 10 = excellent. The patients rated satisfaction before as well as after surgery when receiving the questionnaire 6 months after surgery. Significant improvement was noted in all 4 categories: pre- vs. postoperative scores were 2.2 vs. 9.4 for comfort (+71%), 1.7 vs. 9.6 for retention (+79%), 2.3 vs. 9.3 for chewing ability (+73%) and 5.3 vs. 8.5 for speaking ability (+32%).

Jofre and co-workers (2013)[84] investigated 15 patients (10 women, 5 men, mean age: 75 years) with edentulous mandibles in a randomised controlled trial with a follow-up of 1 year. Inclusion criteria involved being aged between 45 and 90 years, experience with instability of conventional prostheses and absence of temporomandibular disorders. The test group received a total of 30 narrow-diameter implants, 1.8 x 15 mm (Sendax MDI,

IMTEC) using surgical guides and immediate loading with a pre-fabricated bar attachment, while the control group comprised 15 patients with complete mandibular dentures. Oral health-related quality of life was assessed using a version of the Oral Health Impact Profile (OHIP-EDENT) with 19 items[85] prior to intervention as well as 1 year after surgery. While no differences in the baseline OHIP scores could be seen between test (37) and control (37) group, a significant effect of implant treatment could be observed. Treatment with narrow-diameter implants significantly reduced OHIP-scores by 26 points, i.e. 34.2%, to an average score of 11.

Morneburg and Pröschel (2008)[86] investigated 37 patients (mean age: 69 years) with edentulous mandibles in a prospective study with a mean follow-up of 6 years. Inclusion criteria involved severe ridge resorption (either completely level or only slightly raised). In a two-stage procedure, a total of 74 implants with a diameter of 2.5 mm (MicroPlant, Komet Brasseler Group, Lemgo, Germany) were placed in the mandibular canine/lateral incisor region. All patients received overdentures with either magnetic or O-ring attachments. Patient satisfaction was assessed prior to implant surgery as well as 6 weeks after overdenture connection, ranging from 0 = totally dissatisfied to 10 = excellent with respect to denture retention and chewing ability. Pre- and postoperative ratings were 2.0 vs. 8.4 regarding denture retention (+64%), and 2.1 vs. 9.1 regarding chewing ability (+70%), both showing highly significant increase.

Šćepanović and co-workers (2012)[87] investigated 30 patients (16 women, 14 men, age range: 45 to 63) with edentulous mandibles in a prospective observational study with a follow-up of 1 year after implant placement and immediate loading. Inclusion criteria involved patients edentulous in both jaws, mandibular bone height of at least 15 mm and minimum residual bone width of 5 mm. In each patient 4 one-piece mini-implants, 1.8 mm in diameter and 13 mm in length (MDI, 3M ESPE) were placed and the O-ball heads were connected to the metal housings in the mandibular overdentures within 24 h after surgery. Patient satisfaction was assessed on a VAS (labelled as 'completely dissatisfied' to 'completely satisfied') with regards to comfort, stability, speaking ability, ability to maintain hygiene, aesthetics and general chewing ability, as suggested by Awad and Feine[88]. In addition, subjective chewing efficiency was also assessed on a VAS (labelled 'impossible to chew' to 'not hard to chew at all') regarding six types of food: carrots; apples; cheese; bread; sausages and lettuce. Oral health-related quality of life was assessed using a version of the Oral Health Impact Profile (OHIP-EDENT) with 19 items[85] using a six-point Lickert scale (1 = never to 6 = always) 15 weeks after they received conventional prostheses as well as 15 weeks after implant placement (while blinded to their baseline scores). Patient satisfaction increased significantly before vs. after implant treatment regarding comfort (5.4 vs. 7.5, +21%), stability (5.3 vs. 8.3, +30%), speaking ability (7.0 vs. 8.6, +16%), and chewing ability (5.5 vs. 7.6, +21%), while no difference regarding hygiene (7.2 vs. 7.5, +3%) and aesthetics (8.4 vs. 8.7, +3%) could be noted. Subjective ability to chew carrots (5.4 vs. 7.0, +16%), apples (5.9 vs. 8.1, +22%), cheese (7.1 vs. 8.6, +15%), bread (5.9 vs. 8.4, +25%), sausages (5.4 vs. 8.4, +30%), as well as lettuce (6.2 vs. 8.1, +19%) improved significantly. Mean OHIP-scores improved from 74.1 pre- to 50.6 post-implantation (mean paired difference: 23.5).

Veltri and co-workers (2008)[89] investigated 12 patients (8 women, 4 men, mean age: 58 years) with edentulous maxillae in a prospective study with a follow-up of 1 year after loading. Inclusion criteria involved knife-edged resorption with maxillary bone width below 4 mm, however, sufficient residual bone height. A total of 73 implants of 3.5 mm diameter (MicroThread, Astra Tech; Dentsply, York, PA, USA) were placed according to a two-stage surgical protocol. Implant lengths between 9 and 17 mm were used. After 6 months of healing, all patients were rehabilitated with fixed metal acrylic prostheses. Patient satisfaction was assessed by occurrence of imperfect pronunciation (polar question). One year after rehabilitation, 10 patients (83%) were satisfied with the phonetic outcome.

Reduced number of implants

Burns and co-workers (2011)[90] investigated 30 patients (11 women, 19 men, mean age: 59 years) with edentulous mandibles in a prospective randomised clinical trial. Inclusion criteria involved

Table 5 Studies on patient satisfaction with a reduced number of implants in edentulous jaws (mx = maxilla, md = mandible): study design (RCT = randomised controlled trial, pro = prospective study, co = cross-over design), number of patients (Patient no.), implants placed per patient (Impl/pat), length of follow-up (in years), assessment scale (OHIP = Oral Health Impact Profile, +/– = polar questions), and within-patient comparison pre- vs. post-implantation.

	Study design	Jaw	Patient no.	Impl /pat	Follow- up	Scale	Within patient
Burns et al, 2011[90]	RCT (co)	md	30	2 4	1 a	3–0 +/-	yes
De Bruyn et al, 2001[91]	pro	md	20	3	1 a	1–6	yes
De Kok et al, 2011[92]	RCT	md	10 10	2 3	1 a	OHIP 0–100	yes
Slot et al, 2013[94]	RCT	mx	25 25	4 6	1 a	1–10	yes
Visser et al, 2005[95] = Meijer et al, 2009[96]	RCT	md	29 29	2 4	5 a	3–0	yes
Walton et al, 2009[97]	RCT	md	38 37	1 2	1 a	0–100	yes
Weinländer et al, 2010[98]	pro	md	21 46	2 4	5 a	1–5	no

adequate bone quantity to minimally accommodate 4 implants of 3.75 mm diameter and at least 1 year of previous conventional complete denture treatment history. Four implants (Brånemark, Nobel Biocare) were placed in the anterior mandible and subjected to submucosal healing for 4 to 6 months. Following a crossover study design, 3 different overdenture attachment types were delivered to each patient for 1 year, each in randomised treatment sequences: 4-implant bar attachment; 2-implant bar attachment; and 2-implant O-ring attachments (Ball Attachment, Nobel Biocare). Patient satisfaction was assessed via a 40-item denture complaint questionnaire (0 = not at all, 1 = a little, 2 = quite a lot, 3 = extremely) that did not demonstrate equivalence of treatment modalities. Treatment preference was assessed in the following categories: overall best satisfied (64% vs. 32%); selected treatment (68% vs. 32%); easiest to get used to (56% vs. 20%); best denture retention (52% vs. 32%); best able to chew (56% vs. 24%); best able to speak (40% vs. 20%); greatest movement (64% vs. 8%); and easiest to clean (56% vs. 1%), revealing significantly higher patient acceptance with prostheses supported by 2 vs. 4 implants (Table 5).

De Bruyn and co-workers (2001)[91] investigated 20 patients (12 women, 8 men, mean age: 64 years) with edentulous mandibles rehabilitated by fixed prostheses on 3 implants only in a prospective multicentre study with a follow-up of 1 year. Inclusion criteria involved enough bone volume for the insertion of implants 13 to 15 mm in length and edentulism in the mandible for at least 6 months. The 3 implants (1 in the symphysis area and 2 anterior to the mental foramina) with a regular platform of 3.75 or 4 mm and 13 to 15 mm length (Nobel Biocare) were placed in each patient to support titanium milled frameworks mounted with acrylic teeth after a mean healing period of 1 month (range: 4 to 53 days). Patient satisfaction was assessed on a 6-grade scale ranging from 'negative' to 'positive' or 'never' to 'always' regarding general satisfaction, phonetic problems and comfort problems related to eating. Satisfaction was 77% in general, 85% with phonetics and 85% with eating (compared to 7%, 10% and 25% prior to surgery wearing complete prostheses, respectively). No statistical comparison was attempted.

De Kok and co-workers (2011)[92] investigated 20 patients (11 women, 9 men, mean age: 63 years) with edentulous mandibles in a randomised controlled pilot trial with a follow-up of 1 year. Inclusion criteria involved mandibular bone height of at least 10 mm in the parasymphysis area and complete edentulism for at least 3 months. Two-implant-supported overdentures were compared to three-implant-supported dentures. A total of 50 implants (OsseoSpeed, Astra

Tech; Dentsply) were placed. Patient satisfaction was assessed on a visual analogue scale (complete dissatisfaction to complete satisfaction) regarding general satisfaction, denture satisfaction, ease of cleaning, stability, retention, comfort, ease of chewing, ease of speaking and aesthetics. Oral health-related quality of life was assessed using the full version of the Oral Health Impact Profile (OHIP) with 49 items[93]. In both groups, all VAS-ratings as well as the OHIP-scores improved significantly compared to baseline. No difference between 3-implant and 2-implant groups were found regarding general satisfaction (95% vs. 94%), denture satisfaction (96% vs. 96%), stability (96% vs. 94%), retention (97% vs. 95%), comfort (98% vs. 95%), ease of chewing (94% vs. 92%), ease of speaking (89% vs. 91%), aesthetics (98% vs. 95%), as well as oral health-related quality of life (18.9 vs. 20.2). However, ease of cleaning was significantly worse with 3 vs. 2 implants (89% vs. 97%).

Slot and co-workers (2013)[94] investigated 50 patients (27 women, 23 men, mean age: 59 years) with edentulous maxillae in a randomised controlled study on bar-retained overdentures, of which 49 completed the 1-year follow-up. Inclusion criteria involved lack of retention and stability of the upper complete denture and sufficient bone volume in the anterior maxilla (at least 12 mm in height and 5 mm in width). Half of the patients received 4 implants (OsseoSpeed, Astra Tech, Dentsply), in the remainder 25 patients 6 implants were placed. After 3 months of submucosal healing both groups received milled bar-retained overdentures without palatal coverage. Patient satisfaction was assessed by a questionnaire consisting of 54 items (each rated between 0 = no complaints and 3 = severe complaints) divided into 6 subscales: 9 items concerning functional problems of the lower denture; 9 items concerning functional problems of the upper denture; 18 items concerning functional problems/complaints in general; 3 items concerning facial aesthetics; 3 items concerning accidental lip, cheek and tongue biting (neutral space); and 12 items concerning denture aesthetics. In addition, a Chewing Ability Questionnaire rating 9 different kinds of food (0 = good to 2 = bad) was filled out. Patients' overall denture satisfaction was expressed on a 10-point rating scale (1 = very bad to 10 = excellent). There was significant improvement after vs. before implant placement in all scales, both in the 4-implant group (8.9 vs. 4.0) and the 6-implant group (8.9 vs. 4.1). However, there were no significant differences between the groups.

Visser and co-workers (2005)[95] investigated 60 patients (39 women, 21 men, mean age: 55 years) with edentulous mandibles in a randomised controlled trial, of which 56 patients completed the 5-year follow-up. Inclusion criteria involved residual bone height of 12 to 18 mm in the anterior mandible and an edentulous period of at least 2 years prior to surgery. Half of the patients received 2 implants (IMZ, Friedrichsfeld, Mannheim, Germany); in the other 30 patients, 4 implants were placed. After 3 months of submucosal healing, bar-retained mandibular overdentures and new maxillary complete dentures were delivered. Patient satisfaction was assessed by the same 54-item questionnaire used by Slot and co-workers (2013)[94]. Significant improvement of patient satisfaction after 5 years of loading could be observed only in the first subscale concerning overdenture function: mean pre-treatment scores were 2.2 in both groups and improved to 0.3 in both groups without any differences between the 2-implant vs. the 4-implant group. Meijer and co-workers (2009)[96] published 10-year results of the same patient group, again without revealing differences between the groups (score 0.4 vs. 0.5, 3 patients with 4 implants and 7 patients with 6 implants lost to follow-up).

Walton and co-workers (2009)[97] investigated 86 patients (43 women, 43 men, mean age: 67 years) with edentulous mandibles in a randomised controlled trial, of which 74 patients completed the 1-year follow-up. Inclusion criteria involved a residual bone height of at least 6 mm in the anterior mandible and at least 6 month's experience with conventional complete dentures that were aesthetically satisfactory to the patient and technically acceptable in the judgement of the study prosthodontists. Thirty-eight patients were randomised to the single-implant group, while 37 patients received 2 implants (ITI Solid Screw SLA, Straumann, Waldenburg, Switzerland) to retain overdenture via ball attachments (ITI spherical stud, Straumann) after a healing period of 6 weeks. Patient satisfaction was assessed by VAS-ratings in 8 denture-related issues, both prior to as well as 1 year after rehabilitation: pain; comfort; appearance; function; stability; speech; hygiene and overall satisfaction. While baseline satisfaction scores

Table 6 Studies on patient satisfaction with tilted implant placement in edentulous jaws (mx = maxilla, md = mandible): study design (pro = prospective study, retro = retrospective study), number of patients (Patient no.), implants placed per patient (Impl/pat), length of follow-up (in years), assessment scale (+/– = polar questions), and within-patient comparison pre- vs. post-implantation.

	Study design	Jaw	Patient no.	Impl /pat	Follow-up	Scale	Within patient
Agliardi et al, 2009[100]	pro	mx	20	6	1 a	1–5	no
Antoun et al, 2012[101]	retro	13 mx 31 md	44	4–5	1.5 a	0–10	yes
Babbush, 2012[102]	retro	167 mx 113 md	250	4	-	1–5	no
Capelli et al, 2007[103]	pro	41 mx 24 md	65	4–6	2.0 a	+/-	no
Fortin et al, 2002[104]	retro	mx	45	3–7	5 a	+/-	no
Maló et al, 2012[105]	pro	79 mx 133 md	142	4	2.2 a	+/-	no
Mattsson et al, 1999[106]	pro	mx	15	4–6	3.8 a	+/-	no
Peñarrocha et al, 2010[107]	retro	mx	12	4	1 a	1–10	no
Rosén & Gynther, 2007[108]	retro	mx	19	4–6	8–12 a	+/-	no
Testori et al, 2008[109]	pro	mx	28	6	1 a	1–5	no
Weinstein et al, 2012[110]	pro	md	20	4	0.5 a	1–5	no

differed between the single-implant (VAS = 29%) and double-implant group (VAS = 51%), however not significantly; no difference in patient satisfaction after 1 year of loading could be found (93% vs. 94%). Improvement in overall satisfaction was highly significant in both groups; however, differences between the groups may be related to differences in the baseline values.

Weinländer and co-workers (2010)[98] investigated 76 consecutive patients (42 women, 34 men, mean age: 60 years) with edentulous mandibles in a prospective comparative study with a minimum follow-up of 5 years. Inclusion criteria involved atrophic mandibles (Cawood and Howell[99]-class III to V). Twenty-one patients received 2 interforaminal implants (IMZ, Frialoc or Camlog) with an ovoid bar; 22 patients received 4 implants with multiple ovoid bars (implant-retained overdenture); and 24 patients received 4 implants with a milled bar (implant-supported prosthesis). Patient satisfaction was assessed as not satisfactory, adequate, satisfactory, good, or excellent (score ranging from 1 to 5) regarding general satisfaction, chewing ability, denture stability, speech, and aesthetics. Mean ratings did not differ between the groups (5.0 for general satisfaction, 5.0 for chewing ability, 5.0 for denture stability, 4.6 for speech, and 4.5 for aesthetics).

Tilted implant placement

Agliardi and co-workers (2009)[100] investigated 20 consecutive patients (9 women, 11 men, mean age: 57 years) with edentulous maxillae rehabilitated by fixed prostheses on 4 implants in a prospective study with a mean follow up of 27.2 months (range: 18 to 42 months). Inclusion criteria involved sufficient bone for the placement of implants at least 10 mm long and 4 mm in diameter. A total of 120 implants were placed (30 Brånemark MK IV and 90 NobelSpeedy Groovy, Nobel Biocare), the posterior implants were tilted between 30 and 45 degrees. Acrylic resin provisional prostheses were delivered within 4 h after surgery. Patient satisfaction was rated as excellent, very good, good, sufficient, or poor, regarding aesthetics, phonetics and masticatory function at baseline at 6 months (all patients) and 1 year after surgery (8 patients lost to follow-up). Excellent or very good ratings were given in 85%, 85%, and 83% regarding aesthetics, in 80%, 70%, and 92% regarding phonetics, and in 75%, 65%, and 75% regarding mastication, respectively (Table 6).

Antoun and co-workers (2012)[101] investigated 44 patients (32 women, 12 men, mean age: 70 years) with 13 edentulous maxillae and 31 edentu-

lous mandibles in a retrospective study with a mean follow-up of 17.6 months (range: 3 to 56 months). Inclusion criteria involved favourable occlusal context (restriction to Angle Class I and II). A total of 78 implants (Brånemark TiUnite, Nobel Biocare) were placed in the maxilla (All-on-Six concept) and 124 in the mandible (All-on-Four concept). All patients received screw-retained full-arch acrylic resin provisional prostheses within 24 h after surgery. Patient satisfaction was assessed (0 to 10) before intervention and at the last follow-up visit. Overall, patients were satisfied or very satisfied with the procedure. Aesthetics, mastication, and comfort increased from 3.6 to 8.5 (+49%), from 3.0 to 8.3 (+53%) and from 2.8 to 8.8 (+60%), respectively. Pain, swelling, and haematoma was unpleasant for 20%, 33%, and 53%, respectively. However 98% declared they would recommend this treatment to others.

Babbush (2012)[102] investigated 250 patients (143 women, 107 men) with 167 edentulous maxillae and 113 edentulous mandibles in a retrospective study. Patients received immediate provisional fixed prostheses on 4 implants (NobelActive, Nobel Biocare) according to the All-on-Four concept in one or both jaws with the 2 posterior implants tilted distally. After treatment they completed the 20-question Edentulous Patient Impact Questionnaire (EPIQ). Patient satisfaction was 95% (74% extremely satisfied, 21% satisfied) and 98% would recommend similar treatment to a friend or colleague. Some 75% rated their postsurgical discomfort as being less than expected and 70% reported less swelling than expected. And 60% reported better chewing and 32% better speaking capabilities with the temporary prosthesis then they experienced preoperatively.

Capelli and co-workers (2007)[103] investigated 65 consecutive patients (43 women, 22 men, mean age: 59 years) with 41 edentulous maxillae and 24 edentulous mandibles in a prospective multicentre study with a mean follow-up of 24.3 months. Inclusion criteria involved severe atrophy of posterior jaw regions that would have necessitated bone augmentation surgery. A total of 246 implants were placed in the maxilla (6 per jaw) and 96 implants in the mandible (4 per jaw), while posterior implants were tilted between 25 and 35 degrees (Osseotite NT, Biomet 3i, Palm Beach Gardens, FI, USA). Temporary fixed prostheses were delivered within 48 h. Patient satisfaction was assessed by polar questions regarding aesthetics, phonetics, ease of maintenance and functional efficiency. All patients were totally satisfied with all aspects of treatment.

Fortin and co-workers (2002)[104] investigated 45 consecutive patients (30 women, 15 men, 96% between 31 and 70 years of age) with edentulous maxillae in a retrospective study with a follow-up of 5 years. The inclusion criteria involved sufficient bone for implants with a minimum diameter of 3.75 mm and necessity of lip support or position of the lip when smiling requiring a flange extension to the prosthesis. A total of 245 implants (Brånemark system, Nobel Biocare) were placed, of which 90 posteriorly placed implants were tilted to avoid the maxillary sinus. All patients received full-arch, double-structure Marius implant prostheses. Patient satisfaction regarding phonetics, aesthetics and psychological and functional aspects was assessed by polar questions. All patients were satisfied with each of the four aspects.

Maló and co-workers (2012)[105] investigated 142 patients (86 women, 56 men, mean age: 54 years) with 79 edentulous maxillae and 133 edentulous mandibles in a prospective cohort study with a mean follow-up of 2.2 years. Inclusion criteria involved the possibility of placing implants at least 10 mm length. According to the All-on-Four concept (30 to 45 degrees tilting of the posterior implants) 4 implants per jaw were placed (Brånemark MK III, Brånemark MK IV, or NobelSpeedy, Nobel Biocare). Full-arch acrylic resin prostheses were delivered on the day of surgery. Patient satisfaction was assessed by polar questions regarding aesthetic complaints, phonetic complaints, comfort complaints and hygienic complaints. No complications were registered during the study period.

Mattsson and co-workers (1999)[106] investigated 15 patients (11 women, 4 men, mean age: 59 years) with edentulous maxillae rehabilitated by fixed prostheses on 4 implants in a prospective study with a mean follow-up of 3.8 years. Inclusion criteria involved maxillary bone dimension not more than 10 mm in the vertical aspect and more than 4 mm thickness (Cawood and Howell[99]-class V or VI). A total of 86 implants (Brånemark, Nobel Biocare) were placed, the two posterior of 4 to 6 implants per patient were angulated according to the

anatomy of the anterior-medial wall and floor of the maxillary sinus. After a submerged healing period of at least 6 months fixed superstructures were made of cobalt-chromium (6 patients), silver-palladium (6 patients) or titanium (3 patients). Patient satisfaction was assessed by polar questions regarding aesthetics and phonetics. The aesthetic outcome was considered to be satisfactory for all patients (100%). Phonetic problems were initially reported by 4 patients (27%), but no longer perceived as socially limiting at the 1-year recall.

Peñarrocha and co-workers (2010)[107] investigated 12 patients (10 women, 2 men, mean age: 61 years) with edentulous maxillae in a retrospective case series with 1-year follow-up. Inclusion criteria involved severe maxillary resorption (Cawood and Howell[99]-class V). A total of 48 implants (Impladent or Straumann) were placed in tilted, palatal positions in the anterior maxillary buttress. Overdentures were fabricated 3 to 4 months after implant surgery. Patient satisfaction was assessed on a 10-cm visual VAS using the anchor words 1 = totally dissatisfied to 10 = completely satisfied in the following categories: general satisfaction with the implant-retained prosthesis; comfort and stability; ability to speak; ability to perform oral hygiene; aesthetics; self-esteem; and function. The mean general level of satisfaction was 8.5, comfort and stability 8.0, ability to speak 9.0, ease of cleaning 8.5, aesthetics 8.5 and function 8.5 after 1 year of loading.

Rosén and Gynther (2007)[108] investigated 19 patients (13 women, 6 men, mean age: 60 years) with edentulous maxillae in a retrospective long-term follow-up study (8- to 12-year follow-up). Inclusion criteria involved severe resorption (Cawood and Howell[99]-class V or VI) and posterior implants tilted in an angle of more than 30 degrees. In total, 103 implants (Brånemark MK II, Nobel Biocare) were placed in the anterior maxilla, 4 to 6 in each patient. Second-stage surgery was performed after 6 months and all patients received metal-acrylic fixed full-arch prostheses. Patient satisfaction was assessed by polar questions regarding pre- or postoperative disorders or problems, including paraesthesia, infection of the maxillary sinus, oral hygiene difficulties, temporomandibular joint disorders, problems with biting or chewing, and phonetic or aesthetic problems. One patient had problems with biting (5%), 8 patients reported speaking differently (42%) and 7 patients reported aesthetic problems (37%).

Testori and co-workers (2008)[109] investigated 41 patients (26 women, 15 men, mean age: 59 years) with edentulous maxillae in a prospective multicentre study, of which 28 patients (68%) completed the 1-year follow-up. Inclusion criteria involved severely resorbed maxillae with at least 4 mm height and 6 mm width in the first premolar region that would have needed bone augmentation for placing implants in a more posterior location. In each patient 6 implants were placed (Osseotite NT, Biomet 3i), with the 2 posterior implants tilted between 30 and 35 degrees. Provisional screw-retained full-arch prostheses were delivered within 48 h after surgery. Patient satisfaction was assessed by rating aesthetics, phonetics, ease of maintenance and functional efficiency as either excellent, very good, good, sufficient or poor. Patients were satisfied with aesthetics, phonetics, maintenance, and function (ratings excellent or very good) in 75%, 86%, 36%, and 69%, respectively. All patients affirmed that their quality of life had improved after the treatment.

Weinstein and co-workers (2012)[110] investigated 20 patients (12 women, 8 men, mean age: 61 years) with edentulous mandibles in a prospective observational study (mean follow-up: 31 months, range: 20 to 48 months) on the effect of fixed prostheses on 4 implants. Inclusion criteria involved residual bone height of at least 10 mm and bone width of at least 4 mm and patients who manifested a clear preference for fixed implant-supported rehabilitation, but refused any kind of bone augmentation procedure. Two anterior implants were placed axially and 2 posterior implants were tilted (Brånemark System MK IV or NobelSpeedy Groovy, Nobel Biocare) with an insertion torque of at least 30 Ncm. All patients received immediately loaded full-arch fixed prostheses. Patient satisfaction was assessed on a 5-point Lickert-type scale (1 = poor to 5 = excellent) by means of a questionnaire delivered at the 6-, 12-, and 24-month visit. All patients completed the 6-month follow-up and 18 patients (90%) responded after 1 year. The mean ratings regarding function, aesthetics and phonetics were 3.9, 3.4, and 3.7 after 6 months and 4.0, 3.7, and 3.8 after 1 year, respectively. No significant differences were noted between the 6-months and 1-year evaluation.

Table 7 Studies on patient satisfaction with zygomatic fixtures (zyg) in combination with regular implants (reg) in edentulous maxillae (mx): study design (pro = prospective study, retro = retrospective study), number of patients (Patient no.), implants placed per patient (Impl/pat), length of follow-up (in years), assessment scale (OHIP = Oral Health Impact Profile, +/– = polar questions), and within-patient comparison pre- vs. post-implantation (*both ratings assessed after implant treatment).

	Study design	Jaw	Patient no.	Impl /pat	Follow- up	Scale	Within patient
Bothur & Garsten, 2010[111]	retro	mx	7	2–5 zyg 0–3 reg	0.3 a	0–10	yes
Davó & Pons, 2013,[112]	pro	mx	17	4 zyg	3 a	OHIP	no
Farzad et al, 2006[114]	retro	mx	11	2 zyg 2–4 reg	1.5-3.8 a	0–10	yes*
Peñarrocha et al, 2007[115]	retro	mx	23	1–2 zyg 3–6 reg	1 a	0–10	no
Peñarrocha et al, 2009[116] = 2013[117]	retro	mx	13	0–2 zyg 2–7 reg	5.8 a	0–10	no
Sartori et al, 2012[118]	pro	mx	16	5.9	1 a	+/-	no

Zygomatic fixtures

Bothur and Garsten (2010)[111] investigated 7 patients (5 women, 2 men, mean age: 64 years) with edentulous maxillae in a retrospective case series with a follow-up of 4 months. Inclusion criteria involved severe atrophy of the maxilla (Cawood and Howell[99]-class VI) with extensive resorption into the basal bone. The patients received a total of 28 zygomatic fixtures and 5 conventional implants (Brånemark System, Nobel Biocare) to support fixed prostheses after a mean healing period of 6.5 months. Patients judged their speaking ability prior to implant treatment as well as 4 months after surgery on a scale of 0 to 10. Mean subjective ratings were 6.9 before surgery, 5.9 after one week and 7.1 after 4 months of loading (Table 7).

Davó and Pons (2013)[112] investigated 17 consecutive patients (10 women, 7 mean, mean age: 58 years) with edentulous maxillae in a prospective study with a follow-up of 3 years. Inclusion criteria involved severe maxillary atrophy (Cawood and Howell[99]-class IV or V). In each patient 4 zygomatic fixtures (Brånemark System, Nobel Biocare) of 30 to 52.5 mm length were placed and subjected to immediate loading (15 fixed screw-retained prostheses and 2 overdentures). Oral health-related quality of life was assessed using a short version of the Oral Health Impact Profile (OHIP) with 14 items[113]. The average OHIP-score was 2.7 after 3 years of loading (no baseline value was available for comparison).

Farzad and co-workers (2006)[114] investigated 11 patients (10 women, 1 man, mean age: 58 years) with edentulous maxillae in a retrospective study with a follow up of 18 to 46 months. Inclusion criteria involved insufficient bone volume for routine implant placement in the posterior maxilla. A total of 22 zygomatic fixtures and 42 conventional implants (Nobel Biocare) were placed. After a healing period of 6 to 11 months all patients were provided with fixed prostheses (Procera Implant Bridge titanium framework, Nobel Biocare). Patient satisfaction was assessed on a 10-cm VAS regarding the following questions: 1) How is your chewing ability today?; 2) How was your chewing ability before treatment?; 3) How do you experience the aesthetic results of the treatment?; 4) How did you feel about the overall appearance of your teeth before treatment?; 5) How is your speech today?; 6) How was your speech before treatment? (endpoints of the scale were defined as 'best possible' and 'worst possible'). Significant improvement was seen with regards to chewing and aesthetics, however not for speech with mean differences before vs. after treatment of 4.3, 4.0 and 1.0, respectively.

Peñarrocha and co-workers (2007)[115] investigated 23 patients (12 women, 11 men, mean age: 53 years) with edentulous maxillae in a retrospective clinical study with a follow-up of 1 year. No further inclusion criteria were stated. Patients received 1 to 2 zygomatic fixtures (Nobel Biocare) and 3 to 6 additional implants (Defcon; Impladent, Barcelona, Spain) in the anterior maxilla – in total

144 implants. All patients received fixed prostheses. Patient satisfaction was assessed on a 10-cm visual analogue scale ranging from 0 = totally dissatisfied to 10 = completely satisfied with regards to general satisfaction with the implant-retained prosthesis, comfort and stability, ability to speak, ease of cleaning, aesthetics, self-esteem and functionality. Mean patients' ratings were 9.7 for general satisfaction, 9.8 for comfort and stability, 9.8 for aesthetics, 9.8 for ease of cleaning, 9.8 for ability to speak, 9.8 for self-esteem and 9.7 for functionality. Ratings regarding aesthetics were significantly better than in the control group without zygomatic implants (8.9).

Peñarrocha and co-workers (2009)[116] investigated 13 patients (8 women, 5 men, mean age: 55 years) with edentulous maxillae in a retrospective study and reported the results after a mean follow-up of 70 months (range: 24 to 132 months) in a subsequent article in 2013[117]. Inclusion criteria involved severe maxillary atrophy (Cawood and Howell[99]-class IV or V) and implants placed in the nasopalatine canal. A total of 6 zygomatic fixtures and 72 conventional implants (Impladent or Straumann). All patients received fixed screw-retained full-arch prostheses after 12 weeks of submerged healing. Patient satisfaction was assessed on a 10-cm visual analogue scale regarding general satisfaction with the implant-retained prosthesis, comfort and stability, ability to speak, ease of cleaning, aesthetics, self-esteem, and function (anchor words: 'totally dissatisfied' and 'completely satisfied'). Average patient ratings were 9.0 for general satisfaction, 9.7 for comfort and stability, 9.5 for ability to speak, 8.5 for function, aesthetics and self-esteem, and 9.0 for ease of cleaning.

Sartori and co-workers (2012)[118] investigated 16 patients (10 women, 6 men, age range: 38 to 77 years) with edentulous maxillae in a prospective clinical study with a follow-up of 1 year. No further inclusion criteria were stated. Patients received either zygomatic fixtures alone or combined with conventional implants. In total 37 zygomatic fixtures and 58 conventional implants (Alvim Cone Morse, Neodent) were placed. All patients were rehabilitated with fixed prostheses on titanium cylinders and acrylic teeth within 48 h after surgery. Patient satisfaction was assessed by a self-designed questionnaire: 1) Satisfaction with treatment (a = completely satisfied, b = satisfied but with some complaints, c = had different expectation of treatment, d = unsatisfied); 2) If unsatisfied, the reason is as follows (a = aesthetics, b = discomfort when chewing, c = pain, d = phonetics, e = hygiene); 3) Number of clinical sessions required to solve problems after insertion of prosthesis in addition to scheduled follow-up visits (a = 0 sessions, b = <3 sessions, c = >3 sessions); 4) The complication was related to the following (a = prosthesis, b = implants). Half of the patients were completely satisfied, the other half were satisfied but with some complaints. Dissatisfaction was related to aesthetics, chewing, phonetics and hygiene in 4 (25%), 1 (6%), 4 (25%) and 4 cases (25%), respectively. Eight patients required no sessions to solve problems (50%), 6 patients fewer than 3 sessions (38%) and 2 patients more than 3 sessions (13%). Complications were related to the prosthesis in 5 patients (31%) and to the implants in 3 patients (19%).

■ Discussion

The present systematic review summarises current evidence in the literature regarding minimally invasive treatment options for edentulism from the patient's perspective. Patient satisfaction averaged 91% with flapless implant placement (range: 77 to 100%), 89% with short implants, 87% with narrow-diameter implants (range: 80 to 93%), 90% with a reduced number of implants (range: 77 to 100%), 94% with tilted implant placement (range: 58 to 100%), and 83% with zygomatic fixtures (range: 50 to 97%). Indirect comparison yielded patient preference towards tilted implant placement compared to a reduced number of implants ($P = 0.036$) as well as to zygomatic implants ($P = 0.001$) while no differences could be seen between other treatment options. It may be concluded that patient satisfaction with graftless solutions for implant rehabilitation of completely edentulous jaws is generally high and compares well with implant survival of 97 to 99% reported in reviews of literature (Table 8).

However, no studies comparing patient satisfaction with minimally invasive treatment alternatives vs. bone augmentation surgery could be identified in

Table 8 Patient satisfaction (results from the present review) and implant survival rates (results from literature reviews) with minimally invasive treatment alternatives for graftless rehabilitation of edentulous jaws (n.d. = no data).'

Minimally invasive treatment option	Mean patient satisfaction rate (range)	Mean implant survival rate (range)[119-121]
flapless implant placement	91% (77–100)	97% (92–100)
short implants	89%	97% (74–100)
narrow-diameter implants	87% (80–93)	99% (89–100)
reduced number of implants	90% (77–100)	n.d.
tilted implant placement	94% (58–100)	98% (89–100)
zygomatic implants	83% (50–97)	98% (82–100)

the current literature. It thus remains unexplored to what extent graftless therapeutic options are actually preferred by patients or whether they offer significant advantages from the patients' point of view at all. The inherent difficulty of this comparison is certainly due to the fact that it is not possible to perform two – or even more – alternative implant procedures in the same patient (with the possible exception of split-mouth trials that are not easy to conduct as the left and right patient side rarely present with truly comparable baseline situations with regards to residual alveolar bone volume and anatomy), particularly when investigating rehabilitation of complete edentulism. Comparative effectiveness research, i.e. within-study comparison in randomised controlled clinical trials, is needed to substantiate the positive appeal of graftless options to potential implant patients and their possible reduction of the indication span for invasive bone augmentation surgery.

Clinical heterogeneity within the studies included in the present literature review arises from a variety of sources involving patient demographics, diverging inclusion criteria (Cawood and Howell[99] – classes of atrophy, residual bone volume, period of edentulism, satisfaction with as well as stability of previous removable prostheses), use of virtual treatment planning software and surgical templates, implant treatment protocols as well as timing of surgical and prosthodontic interventions. Multiple confounding factors (such as the type of implant superstructure) may carry the potential to significantly influence patient opinion while not being directly related to the question under focus, that is amount of surgical invasion. Due to the lack of consensus guidelines regarding the absolute necessity of bone augmentation in defined clinical situations, it remains hard to judge whether minimally invasive procedures actually represent an alternative to bone graft surgery or merely options associated with reduced patient morbidity.

The major challenge in trying to compare literature results on patient-related outcomes in the present review was the diversity of outcome assessment throughout the included studies. While the majority of investigations evaluated subjective treatment satisfaction (92%), only a few examined oral health-related quality of life (11%) or actual patient preferences towards therapeutic options (5%). Methodology and outcome definitions varied extensively with regards to questions asked, scale items and endpoint definitions, anchor words of visual analogue scales, and performance of within-patient comparison. In fact, only a single study[87] utilised a validated instrument[88] for assessment of patient-centred treatment satisfaction. Conversion of outcome formats to a uniform per cent scale was thus necessary to facilitate outcome comparison, however, must be suspected to have introduced bias to some extent. Future research may pay special attention to uniform and standardised use of validated instruments (such as the Oral Health Impact Profile[73]) for the assessment of patient opinion as a variable of treatment preference.

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