Professional and patient-reported outcomes of two surgical approaches for implant supported single-crown restoration

1-year results of a randomized controlled clinical trial

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Author contributions:

Helle Baungaard Nielsen and Thomas Starch-Jensen conceived the ideas; Helle Baungaard Nielsen collected the data; Niels Henrik Bruun analysed the data and Helle Baungaard Nielsen, Thomas Starch-Jensen and Søren Schou led the writing.

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Abstract

Objectives: To test if there is a difference in professional and patient-reported outcome measures (PROM) after single-crown restoration supported by short implants (SI) (6 mm) compared with standard length implants (SLI) (13 mm) in conjunction with maxillary sinus floor augmentation (MSFA) after one year of functional implant loading.

Material and Methods: Forty patients were randomly allocated to SI or SLI/MSFA. PROM included Oral Health Impact Profile (OHIP-14) questionnaire and subjective assessment of the peri-implant soft tissue (A), implant crown (B), implant function (C), and overall implant treatment outcome (D) using visual analogue scale (VAS). Professional assessment included Pink Esthetic Score (PES) and White Esthetic Score (WES).

Results: No significant differences in professional or PROM between the two treatment modalities were revealed at any time point ($P > 0.05$). OHIP-14 score decreased at baseline and one year after functional implant loading compared with preoperative measurements indicating improved quality of life with both treatment modalities. The 1-year mean VAS score was 9.4 (A), 9.3 (B), 9.6 (C) and 9.3 (D) for SI compared with 9.3 (A), 9.6 (B), 9.7 (C) and 9.2 (D) for SLI. The 1-year mean PES/WES score were 11.3 and 8.1 for SI compared with 11.2 and 8.1 for SLI/MSFA.

Conclusions: Prosthetic rehabilitation of the posterior part of the maxilla with SI or SLI/MSFA revealed no significant differences in professional and PROM after one year of implant loading.

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1 | INTRODUCTION

Prosthetic rehabilitation of the posterior part of the maxilla with short implants or standard length implants in conjunction with maxillary sinus floor augmentation (MSFA) have demonstrated comparable short-term implant treatment outcome, as documented in systematic reviews and meta-analyses (Nielsen, Schou, Isidor, Christensen, Starch-Jensen, 2018; Ravidà, et al. 2018; Yan, Wu, Su, Hua, Shi, 2019). Survival of suprastructure and implant, health status of the peri-implant tissues, and radiographic peri-implant marginal bone loss are the most frequently used criteria to assess the implant treatment outcome. However, these clinical and radiographic parameters do not necessarily reflect patients' perception or satisfaction with the surgical intervention or appearance of the final implant-supported restoration and peri-implant soft tissue. Hence, assessment of the implant treatment outcome should not be judged solely on these traditional clinical and radiographic parameters, but should also include professional as well as patient-reported outcome measures (PROM).

Validated questionnaires often combined with visual analog scale (VAS) or ordinal scale analyses are commonly used to evaluate patient´s satisfaction with the function and aesthetic of the implant-supported restoration as well as the peri-implant soft tissue (Wittneben, Wismeijer, Brägger, Joda, Abou-Ayash, 2018; Toia, et al. 2019). Oral Health Impact Profile (OHIP) is the most frequently used questionnaire to assess oral health-related quality of life (OHRQoL) (Alzarea, et al. 2016; Nicolaisen, Bahrami, Schropp, Isidor, 2016). Originally, OHIP consists of 49 items, but a shortened 14-item questionnaire has been introduced by Slade and co-workers (Slade, et al. 1997). OHIP-14 is organised into seven subscales, including functional limitation, physical discomfort, psychological discomfort, physical disability, psychological disability, social disability, and handicap to assess the degree of disability and discomfort due to oral conditions. The OHIP-49 questionnaire has previously been used for assessment of PROM after single-crown restorations in the posterior maxilla supported by short implants compared with standard length implants in conjunction with MSFA (Thoma, et al. 2015; Thoma, et al. 2018). Short-term evaluation of standard length implants in conjunction with MSFA demonstrated a significant decrease in OHIP dimensions score between suture removal and baseline, whereas no significant difference was disclosed with short implants (Thoma, et al. 2015). However, a recently published long-term study revealed no significant differences in OHIP-49 dimensions score

between the two treatment modalities after five years (Thoma, et al. 2018). The OHIP questionnaire evaluate patient's overall oral impairment without taking the specific surgical intervention or other variables into consideration. Self-administered questionnaire including VAS are therefore frequently used to assess patient satisfaction with the final implant-supported restoration and peri-implant soft tissue (Bonde, Stokholm, Schou, Isidor, 2010; Bonde, Stokholm, Schou, Isidor, 2013; Elsyad, 2016). However, studies assessing PROM using VAS after single-crown restoration of the posterior maxilla supported by short implants compared with standard length implants in conjunction with MSFA is lacking.

Various indices and parameters have previously been used for professional assessment of aesthetics in implant dentistry (Belser, et al. 2009; McGrath, Lam, Lang, 2012; Bonde, et al. 2013). Pink Esthetic Score (PES) and White Esthetic Score (WES) are frequently used for professional assessment of the final implant-supported restoration and peri-implant soft tissue in the anterior aesthetic zone (Furhauser, et al., 2005; Belser, et al., 2009; Bonde, et al. 2010; Hartlev, et al. 2013; Tettamanti, et al. 2016). A clinically acceptable implant treatment outcome has been defined as PES > 6 and WES > 6, including a total PES/WES score of 14.4 (60%) (Belser, et al. 2009; Bonde, et al. 2013; Huynh-Ba, et al. 2019). However, professional assessment of single-crown restorations in the posterior part of the maxilla supported by short implants compared with standard length implants in conjunction with MSFA using PES/WES has never previously been conducted. Therefore, the objective of the present randomized controlled trial was to test if there is a difference in professional and PROM after single-crown restorations supported by short implants (6 mm) compared with standard length implants (13 mm) in conjunction with MSFA after one year of functional implant loading.

2 | MATERIAL AND METHODS

Detailed description of material and methods of the present study has previously been reported (Nielsen, Schou, Bruun, Starch-Jensen, 2020).

In summary, the study was conducted at the Department of Oral and Maxillofacial Surgery, Aalborg University Hospital, Denmark and approved by The North Denmark Region Committee on Health Research Ethics (Approval No.: 20160047). The study was performed in accordance with the

declaration of Helsinki II and Consolidated Standards of Reporting Trials (CONSORT) statement (Fig. 1). Patients were recruited by public invitation through Facebook or admitted to the Department of Oral and Maxillofacial Surgery, Aalborg University Hospital, Denmark for implant placement in the posterior part of the maxilla, and consecutively enrolled between November 2016 and May 2018. Potential participants received verbal and written information about the study by the principal investigator (HBN). An informed consent was signed before enrolment.

2.1 | Study population

Forty patients with partial edentulism in the posterior part of the maxilla were randomly allocated to single-crown restoration supported by short implants (6 mm) (Astra Tech Implant System Osseospeed 4.2EV; Dentsply Sirona Implants, Mölndal, Sweden) or standard length implants (13 mm) (Astra Tech Implant System Osseospeed 4.2EV; Dentsply Sirona Implants, Mölndal, Sweden) in conjunction with MSFA using 50% particulated autogenous mandibular bone graft from the ascending mandibular ramus mixed with 50% Bio-Oss (Geistlich Pharma AG, Wolhusen, Switzerland) with a particle size 1-2 mm.

Patients were considered for study inclusion if they were 20 years of age or older, and in the need of one implant in the posterior part of the maxilla to be replaced by means of an implant. Neighboring teeth had to be periodontally healthy. In addition, a sufficient buccolingual bone width ($\geq$ 8 mm) and a sufficient mesial-distal dimension (7-9 mm) were required. Patients were excluded from the study if they were currently smoking more than 10 cigarettes per day, had general contradictions to implant surgery, had significant untreated periodontal disease, acute infection in the area intended for implant placement, had poor oral hygiene, and/or parafunctional habits.

2.2 | Randomization

An independent block randomization schedule was generated in blocks of four (divisible by the number of study group) and designed to ensure a balanced distribution of included patients within the two treatment groups. The randomized treatment code was available in closed identical non-transparent sealed envelopes, and the patients were randomly assigned to single-crown restoration supported by a short implant or a standard length implant in conjunction with MSFA by pulling an

envelope one week before surgery. Afterwards, the patient was informed about the surgical procedure to be applied. Blinding was not applicable due to the trial design.
Enrolment and all surgical treatment procedures were performed by the principal investigator (HBN).

2.3 | Description of surgical procedures

Short implants

A 6 mm short implant (Astra Tech Implant System Osseospeed EV 4.2; Dentsply Sirona Implants, Mölndal, Sweden) was inserted in local anesthesia using Lidocaine (2%) with 1:200,000 adrenaline (Xylocaine, Amgros I/S, Denmark). An implant bed was successively prepared by a standard implant protocol at 1.200 rpm with saline irrigation according to manufacturer´s recommendations. A short implant with cover screw was inserted before suturing. The sutures were removed 7-10 days after surgery. No provisional restoration was allowed during the healing period.

Standard length implants in conjunction with MFSA

A 13 mm standard length implant (Astra Tech Implant System Osseospeed EV 4.2; Dentsply Sirona Implants, Mölndal, Sweden) in conjunction with MSFA was inserted in local anesthesia using Lidocaine (2%) with 1:200,000 adrenaline. As an option, oral sedation (Apozepam, 5-10 mg, Teva, Denmark) or general anesthesia with nasotracheal intubation was used. A 1 x 1 cm window to the maxillary sinus was created with metal and diamond burrs with focus on maintaining an intact Schneiderian membrane. The Schneiderian membrane was carefully elevated from the maxillary sinus floor as well as the lateral sinus wall creating a compartment for placement of the grafting material. An implant bed was successively prepared following the manufacturer's recommendations at 1.200 rpm and a 13 mm implant with cover screw was inserted.

A 3 x 2 x 0.5 cm predominantly cortical bone graft was harvested from the outer cortex of the mandibular ramus. The autogenous bone graft was milled using a bone-mill (Roswitha Quétin Dentalprodukte, Germany) with 3-mm perforations to obtain bone graft particles with a size of 0.5-2 mm^3. The created cavity in the maxillary sinus around the implant was loosely packed with a standardized equal distribution (50 %) of the graft material and Bio-Oss (Geistlich Pharma AG, Wolhusen, Schwizerland) with a particle size of 1-2 mm. The created window to the maxillary sinus

was covered by a resorbable collagen barrier membrane (25 x 25 mm, Bio-Gide, Geistlich Pharma AG, Wolhusen, Schwizerland) before suturing. The sutures were removed 7-10 days after surgery. No provisional restoration was allowed during the healing period.

Healing abutment connection

Healing abutment connection was performed in local anesthesia using Lidocaine (2%) with 1:200,000 adrenaline six months after implant placement. The sutures were removed after 7-10 days and the prosthetic restoration was initiated three weeks after healing abutment connection.

2.4 Patient-reported outcome measures

A standard Danish translated version of OHIP-14 questionnaire was used. Detailed instructions for completing the OHIP-14 were given to the patients before they completed the questionnaire by themselves, to prevent being influenced by the surgeon or nurses' opinions and wills. OHIP-14 was filled in at enrolment, baseline, and after one year of functional implant loading. Response format of OHIP-14 was as follows: All the time = 4; Very often = 3; Fairly often = 2; Sometimes = 1; Never = 0. OHIP-14 scale ranged from 0 to 56, with higher scores indicating poorer OHRQoL. OHIP-14 is divided into seven areas of investigation according to the type of question: Q1-Q2 (Functional limitation); Q3-Q4 (Physical pain); Q5-Q6 (Psychological discomfort); Q7-Q8 (Physical disability); Q9-Q10 (Psychological disability); Q11-Q12 (Social disability); Q13-Q14 (Handicap). In each patient, OHRQoL was defined by estimating the OHIP-14 summary score.

Visual analogue scale (VAS) was included to assess the patient's evaluation of the peri-implant soft tissue, implant crown, implant function, and overall implant treatment, at baseline and after one year of functional implant loading. Each question was scored on a 100 mm VAS with 0 indicating extreme dissatisfaction and 100 indicating complete satisfaction. The VAS scores were measured to the nearest mm by a ruler.

2.5 Professional evaluation

The professional aesthetic treatment outcome was evaluated using PES and WES. Digital clinical photos of the treated implant region including the anterior premolar or molar were taken at baseline

and one year after functional implant loading using Canon EOS 10D with a MR-14EX Macro Ring Lite and EF 100 mm 1:2.8 USM Macro Lens (Canon, Tokyo, Japan). Photos of the implant crown and the peri-implant tissue were taken using two projections, one facial projection perpendicular to the facial implant crown and one occlusal projection. PES and WES was determined by the first author (HBN). Assessment was conducted using the anterior molar/premolar as reference.

PES includes 7 different variables: Mesial papilla, distal papilla, soft-tissue level, soft-tissue contour, alveolar process deficiency, soft-tissue colour, and texture. Each variable was assessed with a 0, 1, or 2 score, with 0 being the poorest score and 2 the best according to the degree of match or mismatch compared with the anterior premolar or molar. The highest possible PES was 14. WES includes 5 different variables: Crown form, volume, colour, translucency, and texture. Each variable was assessed with a 0, 1, or 2 score, with 0 being the poorest score and 2 the best according to the degree of match or mismatch compared with the anterior premolar or molar. The highest possible WES was 10.

2.6 Correlation of the aesthetic outcome and oral health-related quality of life

The association between the aesthetic treatment outcome as evaluated by professional (PES and WES) and PROM (VAS analysis) was assessed at baseline and one year after functional implant loading.

2.7 Statistical analyses and sample size

Data management and analysis was performed using STATA (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.). Level of significance was 0.05. Scores were reported as means and standard deviations. Differences in scores from baseline to follow-up for scores OHIP-14, VAS, PES and WES were calculated and means of the differences were compared using Ordinary Least Square (OLS) regression with robust variance estimation to compensate for non-normal residuals. Correlations between score totals were reported as Spearmans Rho. Sample size was determined using a power calculation based on differences in PIMBL changes performed in a previously published study involving replacement of a single tooth with 2 different protocols of implant treatment (Schropp, Isidor, 2008). The calculation was based on the observed changes in

PIMBL from insertion of the implant to abutment connection (A change of 0.65 mm and a standard deviation of 0.65), 17 patients in each group reached a power of 97% at the 5%-level. With 15% to cover drop-outs, each treatment group included 20 patients.

The power calculation was therefore based on the primary outcome, which is PIMBL after three years. Hence, the reported outcome measures of the present study are considered secondary outcome measures.

3 | RESULTS

3.1 Demographics

Forty patients (17 men and 23 women, mean age 52 years, range: 23-72 years) were considered eligible and consecutively enrolled. Of the 40 patients enrolled, 37 completed the study. As previously reported, there were no statistically significant differences between the two treatment modalities regarding patient demographics, pre-operative periodontal health status, and presence of a posterior tooth. According to crown-to-implant ratio, a statistically significant difference was found between the two treatment modalities ($P < 0.05$). Detailed description has previously been reported (Nielsen, et al. 2020) and details are outlined in Figure 1.

3.2 Patient-reported outcome measures

Results of the OHIP-14 questionnaires at enrolment, baseline, and after one year of functional implant loading are outlined in Tables 1 and 2. For all questions, the scores decreased from baseline and after one year of functional implant loading compared with the scores from enrolment. Hence, patients in both groups reported improved scores from enrolment and after one year of functional loading without significant differences between the groups ($P > 0.05$). The total difference of means between short implant and standard length implants in conjunction with MSFA of changes from baseline to year one was 0.700 ($P > 0.05$). Evaluation of the peri-implant soft tissue, implant crown, implant function, and overall implant treatment using VAS scores at baseline and after one year of functional implant loading is outlined in Table 3 and Figure 2-5. In general, patients were overall very satisfied in both treatment groups. None of the differences between the two groups were statistically significant ($P > 0.05$).

3.3 Professional evaluation using PES and WES

PES and WES were assessed at baseline and after one year of functional implant loading. The total mean scores of PES and WES for short implants was 10.1 and 8.0 at baseline and 11.3 and 8.1 after one year of functional loading, respectively. Corresponding scores for standard length implants in conjunction with MSFA was 10.2 and 8.0 at baseline and 11.2 and 8.1 after one year of functional implant loading, respectively. There were no significant differences in PES and WES between the two treatment modalities neither at baseline ($P > 0.05$) nor after one year of functional implant loading ($P > 0.05$). The professional evaluations based on PES and WES are outlined in Table 4.

3.4 Correlation of the aesthetic outcome and oral health-related quality of life

Correlation analysis between PROM (VAS analysis) and professional evaluation (PES and WES) revealed no significant differences between the two treatment modalities neither at baseline nor after one year of functional implant loading ($P > 0.05$). The results are outlined in Table 5.

4 | DISCUSSION

Professional evaluation and PROM after single-crown restoration supported by short implants (6 mm) compared with standard length implants (13 mm) in conjunction with MSFA were assessed at enrolment, baseline, and one year after functional implant loading. OHIP-14, self-administrated VAS questionnaire, PES, WES as well as clinical acceptability revealed no significant differences in professional and PROM between the two treatment modalities. Moreover, no statistically significant correlation was observed between professional evaluation or PROM and impaired OHRQoL. However, placement of standard length implants in conjunction with MSFA was associated with significant higher incidence of biological complications and persistent neurosensory disturbance of the inferior alveolar nerve after harvesting of autogenous bone graft from the ascending mandibular ramus (Nielsen, et al. 2020). Thus, prosthetic rehabilitation of the posterior maxilla with short implants seems to be preferably from a patient's perspective after one year of functional implant loading.

Prosthetic rehabilitation of totally or partial edentulous patients with implants significantly improves OHRQoL, as reported in a recently published systematic review (Ali, Baker, Shahrbaf, Martin, Vettore, 2019). However, patient's perception of a specific treatment modality and OHRQoL are influenced by various sociodemographic and clinical factors, including age, gender, malocclusion, self-esteem, pain, psychological discomfort, psychological disability, morbidity, complications, financial aspects, and duration of treatment time (Øzhayat & Gotfredsen, 2019). Consequently, these aspects should be included in the overall assessment of the implant treatment outcome. It has been reported in a long-term randomized controlled trial assessing OHRQoL after prosthetic rehabilitation of the posterior part of the maxilla with short implants compared with standard length implants in conjunction with MSFA that the overall OHIP-49 scores improved significantly with both treatment modalities (Thoma, et al. 2018). However, placement of standard length implants in conjunction with MSFA was predominantly associated with more postoperative complications compared with short implants (Thoma, et al. 2015). In a recently published long-term randomized controlled trial, high patient satisfaction after prosthetic rehabilitation of the posterior part of the maxilla with short implants and standard length implants in conjunction with MSFA was reported with no significant differences between the two treatment modalities (Guljé, Raghoebar, Vissink, Meijer, 2019). These long-term results seem to be in accordance with the results of the present short-term study.

In the present study, PROM and patient satisfaction with the implant-supported restoration and peri-implant soft tissue was assessed by OHIP-14 and self-administrated questionnaires using VAS. The OHIP-14 scores decreased at baseline and one year after functional implant loading compared with the preoperative measurements indicating improved OHRQoL with both treatment modalities. Moreover, the OHIP-14 scores after one year of functional implant loading was comparable to reported scores of healthy subjects without need for treatment (John, Micheelis, Biffar, 2004). Similar results have been reported in previous long-term studies assessment OHRQoL after prosthetic rehabilitation of the posterior maxilla with short implants or standard length implants in conjunction with MSFA (Thoma, et al. 2018). The observed OHIP values then tend to reach values comparable to the ones of healthy subjects without any need for treatment (John, Micheelis, Biffar, 2004), thereby revealing an increased patient satisfaction.

In a recently published systematic review and meta-analysis it was concluded that placement of standard length implants in conjunction with MSFA involving higher incidence of biological complications automatically lead to diminished patient satisfaction and poorer OHRQoL compared with short implants (Mokcheh, Jegham, Turki, 2019). However, PROM and patient satisfaction are potentially influenced by various patient-based factors, which are not necessarily related to the surgical intervention (Holmes, Lewith, Newell, Field, Bishop, 2017). However, no significant difference in PROM and patient satisfaction was disclosed between the two treatment modalities. These results are in accordance with previous studies demonstrating comparable PROM and patient satisfaction after placement of standard length implants in conjunction with MSFA compared with short implants (Guljé, et al. 2014; Bechara, et al. 2016; Pohl, et al. 2017). Consequently, PROM and patient satisfaction seems to be influenced by various parameters including age, gender, education level, and cost of implant treatment, but not necessarily the surgical intervention and incidence of biological complications.

A recently published systematic review concluded that PROM should include an aesthetic evaluation of the implant-support restoration and peri-implant mucosa (Wittneben, Wismeijer, Brägger, Joda, Abou-Ayash, 2018). However, studies focusing on aesthetic assessment of the implant-supported restoration after prosthetic rehabilitation of the posterior part of the maxilla with standard length implants in conjunction with MSFA compared with short implants are missing. In the present study, both treatment modalities demonstrated high patient satisfaction and clinically acceptable implant treatment outcome as evaluated by PES and WES including a total PES/WES score over 14.4. However, patient perception of the aesthetic implant treatment outcome may not necessarily be correlated with the professional assessment, since various elements of the total aesthetic treatment outcome may be weighted differently by patients and professionals (Nicolaisen, et al. 2016). Previous studies have shown that patient satisfaction primarily focus on the appearance of the suprastructure with less awareness to the peri-implant mucosa (Suphanantachat, Thovanich, Nisakapultorn, 2012; Bonde, et al. 2013; Kokich, Kokich, Kiyag, 2006). Moreover, several studies have revealed a significant discrepancy between PROM and professional assessment of the implant treatment outcome (Esposito, et al. 2009; Tymstra, et al. 2010; Bonde, et al. 2013).

The present study is characterized by various limitations, including small sample size, short-term observation period, and no calculation of financial aspects or duration of treatment time. Moreover, influence of gender, age, and length of surgery on PROM as well as association between OHRQoL and social, educational, and cultural background were not examined. In addition, only partially edentulous patients were included and a generalization of the results and recommendations for use of short dental implants are limited to the present clinical indication. Therefore, conclusions drawn from the results of this study should be interpreted with caution.

5 | CONCLUSION

Professional and PROM after single-crown restoration supported by short implants (6 mm) compared with standard length implants (13 mm) in conjunction with MSFA were evaluated at enrolment, baseline, and one year after functional implant loading revealing no significant differences in professional and PROM with the two treatment modalities at any time point.

CONFLICT OF INTEREST

Helle Baungaard Nielsen and Thomas Starch-Jensen have received implants and biomaterials from Dentsply Sirona for the present study and other studies assessing MSFA with different graft materials. However, none of the authors have economical interest in the company or product related to this study or other studies.

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Table 1. Oral Health-Related Quality-14 following placement of short implants in the posterior part of the maxilla

Dimension	Variables	Enrolment						Baseline						1-year					
		0	1	2	3	4	Mean	0	1	2	3	4	Mean	0	1	2	3	4	Mean
Functional limitation Q1-2	Have you had trouble pronouncing any words because of problems with your teeth, mouth or dentures?	1	11	8	0	0	1.35	10	8	2	0	0	0.60	16	4	0	0	0	0.20
	Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures?	4	13	3	0	0	0.95	11	8	1	0	0	0.50	15	5	0	0	0	0.25
Physical pain Q3-4	Have you had painful aching in your mouth?	0	6	12	2	0	1.80	2	11	7	0	0	1.25	11	9	0	0	0	0.45
	Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?	1	7	12	0	0	1.55	5	15	0	0	0	0.75	13	7	0	0	0	0.35
Psychological discomfort Q5-6	Have you been self-conscious because of your teeth, mouth or dentures?	0	1	6	9	4	2.80	4	6	9	1	0	1.35	10	10	0	0	0	0.50
	Have you felt tense because of problems with your teeth, mouth or dentures?	0	5	11	4	0	1.95	5	12	2	1	0	0.95	16	4	0	0	0	0.20
Physical disability Q7-8	Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?	1	9	10	0	0	1.45	5	13	2	0	0	0.85	14	6	0	0	0	0.30
	Have you had to interrupt meals because of problems with your teeth, mouth or dentures?	2	11	5	2	0	1.35	8	10	2	0	0	0.70	15	5	0	0	0	0.25
Psychological disability Q9-10	Have you found it difficult to relax because of problems with your teeth, mouth or dentures?	1	9	10	0	0	1.45	5	11	4	0	0	0.95	12	8	0	0	0	0.40
	Have you been a bit embarrassed because of problems with your teeth, mouth or dentures?	1	1	7	10	1	2.45	2	9	7	2	0	1.45	10	10	0	0	0	0.50

Social disability Q11-12	Have you been a bit irritable with other people because of problems with your teeth, mouth or dentures?	3	9	8	0	0	1.25	9	11	0	0	0	0.55	15	5	0	0	0	0.25
	Have you had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures?	20	0	0	0	0	0.00	20	0	0	0	0	0.00	20	0	0	0	0	0.00
Handicap Q13-14	Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?	14	3	3	0	0	0.45	19	1	0	0	0	0.05	20	0	0	0	0	0.00
	Have you been totally unable to function because of problems with your teeth, mouth or dentures?	20	0	0	0	0	0.00	20	0	0	0	0	0.00	20	0	0	0	0	0.00
Total Q1-14		68	85	95	27	5	18.8	125	115	36	4	0	8.95	207	73	0	0	0	3.65

Table 2. Oral Health-Related Quality-14 following placement of standard length implants in conjunction with maxillary sinus floor augmentation

Dimension	Variables	Enrolment						Baseline						1-year					
		0	1	2	3	4	Mean	0	1	2	3	4	Mean	0	1	2	3	4	Mean
Functional limitation Q1-2	Have you had trouble pronouncing any words because of problems with your teeth, mouth or dentures?	2	10	5	0	0	1.18	8	9	0	0	0	0.53	13	4	0	0	0	0.24
	Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures?	3	11	3	0	0	1.00	8	9	0	0	0	0.53	15	2	0	0	0	0.12
Physical pain Q3-4	Have you had painful aching in your mouth?	2	7	6	2	0	1.47	4	11	2	0	0	0.88	11	5	1	0	0	0.41
	Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?	5	7	5	0	0	1.00	4	12	1	0	0	0.82	11	6	0	0	0	0.35
Psychological discomfort Q5-6	Have you been self-conscious because of your teeth, mouth or dentures?	0	0	2	9	6	3.24	1	8	7	1	0	1.47	14	3	0	0	0	0.18
	Have you felt tense because of problems with your teeth, mouth or dentures?	1	2	7	7	0	2.18	3	7	7	0	0	1.24	11	5	1	0	0	0.41
Physical disability Q7-8	Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?	1	3	8	5	0	2.00	2	8	7	0	0	1.29	8	9	0	0	0	0.53
	Have you had to interrupt meals because of problems with your teeth, mouth or dentures?	5	11	1	0	0	0.76	11	6	0	0	0	0.35	14	3	0	0	0	0.18
Psychological	Have you found it difficult to relax because of problems with your teeth, mouth or dentures?	1	10	6	0	0	1.29	2	14	1	0	0	0.94	11	5	1	0	0	0.41

disability Q9-10	Have you been a bit embarrassed because of problems with your teeth, mouth or dentures?	1	1	7	8	0	2.29	2	6	9	0	0	1.41	11	6	0	0	0	0.35
Social disability Q11-12	Have you been a bit irritable with other people because of problems with your teeth, mouth or dentures?	3	6	8	0	0	1.29	6	10	1	0	0	0.71	16	1	0	0	0	0.06
	Have you had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures?	17	0	0	0	0	0.00	17	0	0	0	0	0.00	17	0	0	0	0	0.00
Handicap Q13-14	Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?	14	0	3	0	0	0.35	14	3	0	0	0	0.18	16	0	1	0	0	0.12
	Have you been totally unable to function because of problems with your teeth, mouth or dentures?	17	0	0	0	0	0.00	17	0	0	0	0	0.00	17	0	0	0	0	0.00
Total Q1-14		72	68	61	31	6	18.05	99	103	35	1	0	10.35	185	49	4	0	0	3.36

Table 3. Subjective evaluation of treatment outcome using VAS questionnaire

Dimension	Variables	Short implants Mean (SD)		Standard length implants + MSFA Mean (SD)		P*
		Baseline	1-year	Baseline	1-year	
Peri-implant soft tissues	Are you satisfied with the appearance of the peri-implant soft tissues?	9.3 (0.7)	9.4 (0.6)	9.4 (0.6)	9.5 (0.5)	0.87
	Are you satisfied with the shape of the peri-implant soft tissues?	9.2 (0.6)	9.3 (0.5)	9.0 (0.6)	9.2 (0.5)	0.83
	Are you satisfied with the colour of the peri-implant soft tissues?	9.3 (0.8)	9.4 (0.6)	9.0 (0.5)	9.2 (0.5)	0.60
	Average score	9.3 (0.7)	9.4 (0.6)	9.1 (0.6)	9.3 (0.5)	0.88
Implant crown	Are you satisfied with the appearance of the implant crown?	9.3 (0.9)	9.4 (0.6)	9.8 (0.4)	9.9 (0.2)	0.08
	Are you satisfied with the shape of the implant crown?	8.9 (0.6)	9.2 (0.6)	8.8 (0.6)	9.4 (0.9)	0.65
	Are you satisfied with the colour of the implant crown?	9.1 (0.4)	9.2 (0.5)	9.4 (0.5)	9.4 (0.5)	0.89
	Average score	9.1 (0.7)	9.3 (0.6)	9.3 (0.6)	9.6 (0.7)	0.65
Implant function	The implant is functioning well	9.4 (0.5)	9.6 (0.5)	9.5 (0.5)	9.6 (0.5)	0.83
	The implant does not cause problems when I speak	9.4 (0.6)	9.6 (0.5)	9.8 (0.4)	9.9 (0.3)	0.33
	The implant does not cause problems when I eat	9.3 (0.6)	9.4 (0.5)	9.2 (0.7)	9.4 (0.5)	0.37

	The implant does not cause problems when I brush	9.8 (0.4)	9.9 (0.3)	10.0 (0.0)	10.0 (0.0)	0.87
	Average score	9.5 (0.6)	9.6 (0.5)	9.6 (0.6)	9.7 (0.5)	0.83
Total implant treatment	Are you satisfied with the total implant treatment in general?	9.2 (0.6)	9.3 (0.5)	9.2 (0.6)	9.2 (0.6)	0.60

Abbreviations: MSFA, maxillary sinus floor augmentation; SD, standard deviation; VAS, visual analog scale.

* P-value for same expected change from baseline to follow-up.

Table 4. Professional evaluation of implant treatment outcome using PES and WES

PES	**Mesial papilla**		**Distal papilla**		**Level of soft tissue margin**		**Soft tissue contour**		**Alveolar process**		**Soft tissue colour**		**Soft tissue texture**		**Total**	
	Base line	1-year	Base line	1-year	Base line	1-year	Base line	1-year	Base line	1-year	Base line	1-year	Base line	1-year	Base line	1-year
SI Mean (SD)	1.5 (0.5)	1.8 (0.4)	1.4 (0.5)	1.6 (0.5)	1.1 (0.4)	1.6 (0.6)	1.4 (0.6)	1.4 (0.6)	1.6 (0.5)	1.6 (0.5)	1.4 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	10.1 (1.1)	11.3 (1.3)
SLI/MSFA Mean (SD)	1.6 (0.5)	1.8 (0.4)	1.4 (0.5)	1.8 (0.4)	1.4 (0.5)	1.5 (0.5)	1.4 (0.5)	1.5 (0.5)	1.6 (0.5)	1.6 (0.5)	1.4 (0.5)	1.5 (0.5)	1.5 (0.5)	1.5 (0.5)	10.2 (1.2)	11.2 (1.1)
P*															0.53	

WES	**Tooth form**		**Tooth volume /outline**		**Colour (hue/value)**		**Translucency**		**Soft tissue texture**		**Total**	
	Baseline	1-year	Baseline	1-year	Baseline	1-year	Baseline	1-year	Baseline	1-year	Baseline	1- year
SI Mean (SD)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.8 (0.4)	8.0 (0.9)	8.1 (1.0)
SLI/MSFA Mean (SD)	1.5 (0.5)	1.6 (0.5)	1.6 (0.5)	1.7 (0.5)	1.5 (0.5)	1.5 (0.5)	1.6 (0.5)	1.6 (0.5)	1.7 (0.5)	1.8 (0.4)	8.0 (1.0)	8.1 (1.0)
P*											0.64	

Abbreviations: MFSA, Maxillary sinus floor augmentation; SI, short implants; SLI, standard length implants; PES, pink esthetic score; WES, white esthetic score.

*P-value for same expected change from baseline to follow-up.

Table 5. Correlation analyses

Dimension	Variables	Short implants		Standard length implants + MSFA	
		Baseline	1-year	Baseline	1-year
Patient	Subjective evaluation of appearance of peri-implant soft tissues and appearance of implant crown	0.29 (0.22)	-0.06 (0.82)	0.43 (0.06)	0.05 (0.85)
	Subjective evaluation of peri-implant soft tissues and total implant treatment	0.10 (0.67)	0.27 (0.30)	0.05 (0.83)	-0.13 (0.61)
	Subjective evaluation of implant crown and total implant treatment	-0.11 (0.65)	0.01 (0.96)	0.24 (0.31)	-0.07 (0.79)
Professional	PES and WES	-0.07 (0.76)	-0.24 (0.35)	0.04 (0.86)	0.09 (0.74)
Patient versus professional	Subjective evaluation of appearance of implant crown and WES total	-0.33 (0.15)	-0.23 (0.38)	-0.33 (0.15)	-0.30 (0.25)
	Subjective evaluation of appearance of peri-implant soft tissues and PES total	-0.35 (0.13)	-0.16 (0.55)	0.24 (0.31)	-0.20 (0.45)
	Subjective evaluation of total implant treatment and PES total	-0.19 (0.43)	0.00 (0.99)	-0.41 (0.07)	0.01 (0.98)
	Subjective evaluation of total implant treatment and WES total	0.14 (0.55)	-0.08 (0.77)	-0.36 (0.11)	-0.29 (0.26)

Abbreviations: MSFA, maxillary sinus floor augmentation; PES: pink esthetic score; WES: white esthetic score.

Figure legends

Table 1. Oral Health-Related Quality-14 following placement of short implants in the posterior maxilla.

Table 2. Oral Health-Related Quality-14 following placement of standard length implants in conjunction with maxillary sinus floor augmentation.

Table 3. Patient's evaluation of treatment outcome using VAS questionnaire.

Table 4. Professional evaluation of implant treatment outcome using PES and WES.

Table 5. Correlation analyses of the esthetic treatment outcome between professional and patient-reported outcome measures.

Fig. 1. CONSORT flow diagram.

Fig. 2. The final prosthetic restoration of a short implant in the left side of the maxilla at baseline with high patient satisfaction.

Fig. 3. The final prosthetic restoration of a short implant in the left side of the maxilla one-year after functional loading with high patient satisfaction.

Fig. 4. The final prosthetic restoration of a standard length implant in conjunction with MSFA in the right side of the maxilla at baseline with low patient satisfaction.

Fig. 5. The final prosthetic restoration of a standard length implant in conjunction with MSFA in the right side of the maxilla one-year after functional loading with an improved patient satisfaction.

FIGURE 1

CONSORT Flow Diagram

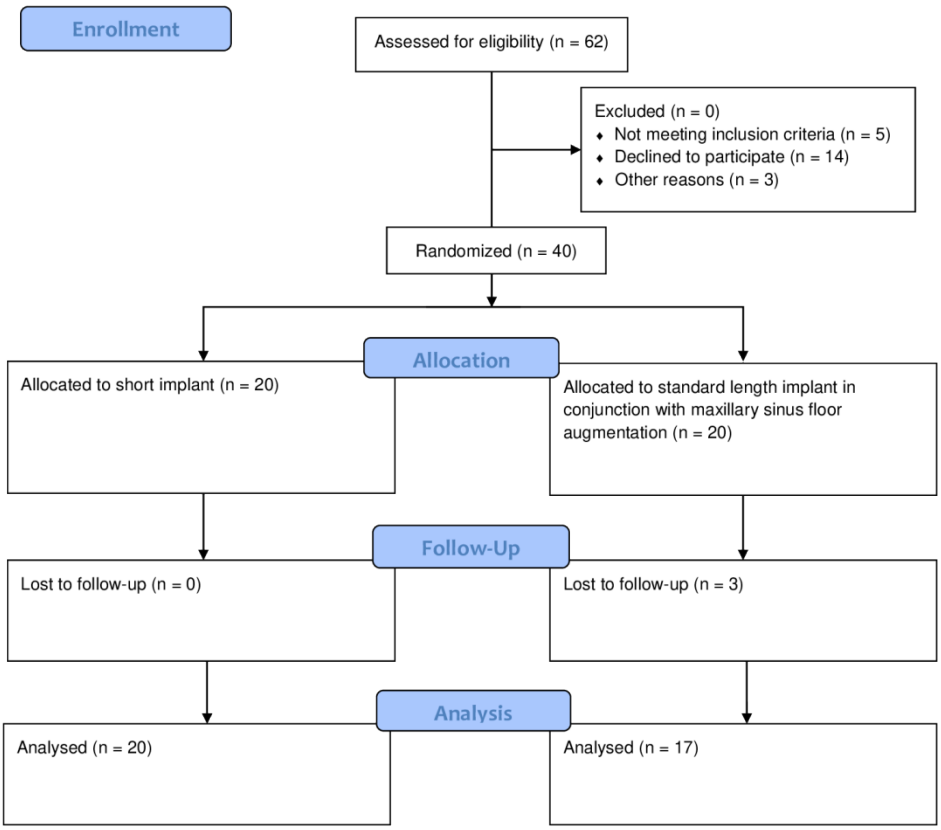

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FIGURE 2

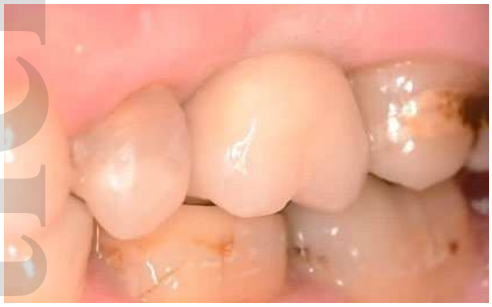

FIGURE 3

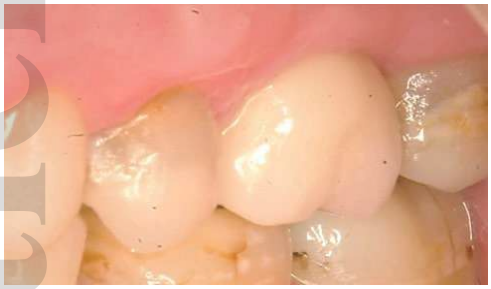

FIGURE 4

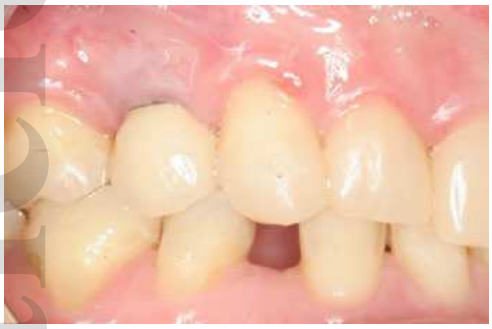

FIGURE 5