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Clinical Paper
Dental Implants

Dental implant placement in alveolar cleft patients: a retrospective comparative study on clinical and aesthetic outcomes

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Abstract. The aim of this retrospective study was to assess the clinical and aesthetic outcomes, and patient satisfaction, following dental implant therapy in cleft patients. Implant survival, changes in marginal bone level, pocket probing depths, plaque and bleeding indices, aesthetics, and patient satisfaction were assessed in 17 alveolar cleft patients and 17 matched controls. At follow-up (mean 72.4 ± 46.4 months), one implant had been lost in the cleft group. Mean marginal bone loss at follow-up was −0.4 ± 0.4 mm in cleft patients and −0.2 ± 0.4 mm in controls. Aesthetics of the peri-implant soft tissues (pink aesthetic score) were less favourable ($P = 0.025$) in cleft patients (5.0 ± 1.9) than in controls (6.5 ± 1.7), while peri-implant parameters were comparable in the two groups. Overall patient satisfaction was 8.6 ± 0.9 in cleft patients and 8.9 ± 1.1 in controls ($P = 0.331$). In cleft patients, no difference in aesthetics was observed between patients who received additional bone augmentation at 3 months prior to implant placement and those who did not ($P = 0.092$). Dental implant therapy in cleft patients is associated with high implant survival, minor marginal bone loss, healthy peri-implant soft tissues, and high patient satisfaction. Only the aesthetics of the soft tissues was worse in cleft patients compared to augmented non-cleft patients.

Key words: cleft lip palate; alveolar bone grafting; dental implants; single tooth; aesthetics; patient satisfaction.

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Tooth deformities, supernumerary teeth, and agenetic teeth are frequently seen in patients with an alveolar cleft. These dental anomalies usually require prosthodontic rehabilitation at a later stage of life[1,2]. The alveolar cleft is generally reconstructed between the ages of 7 and 11 years with an autogenous bone graft from the anterior iliac crest or mandibular symphysis area[3]. This reconstruction is usually performed during the mixed stage of dentition, when half to two-thirds of the root formation of

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the canine is completed[4]. At that age, implant treatment is not yet a good option for the rehabilitation of the diastema in the former cleft area, as patients continue to grow until early adulthood.

The placement of dental implants in the aesthetic region in non-cleft patients is associated with high implant survival rates[5]. Regarding alveolar cleft patients, several studies have been published on dental implant therapy, showing that dental implants are a reliable and viable treatment alternative[6–11]. The study of Kramer et al. is one of the few to compare the results of dental implants in cleft patients to those in non-cleft patients[12]. However, the study group also included edentulous patients. In spite of methodological flaws, such as a small sample size, dental implants have shown predictable results for cleft patients. Several systematic reviews have reported high implant survival rates, at least in the short term, but the level of evidence remains low and insufficient[13–15].

With respect to aesthetics, it is known that scarring of the soft tissues and the absence of interdental papillae in alveolar cleft patients may lead to less favourable aesthetic results[16]. In reaching a satisfactory aesthetic result, optimal three-dimensional implant positioning is crucial, but it is also known that a good aesthetic outcome is the result of the combination of harmonious teeth, gingival appearance, and lip shape[17]. Improvements in gingival aesthetics have been shown to be valuable to patient self-perception and quality of life[18]. Furthermore, in patients without an alveolar cleft, additional bone augmentation before implant placement has been shown to result in less favourable scores on the pink aesthetic scale, when compared with non-augmented sites[19]. These less favourable scores are probably due to a less favourable preoperative situation with the formation of scar tissue. In patients with an alveolar cleft, the implant region is always an augmented site and thus at risk of less favourable aesthetic outcomes. Moreover, it is not uncommon that implant sites in cleft patients are augmented twice (cleft closure, pre-implant augmentation surgery), which might further compromise the implant site.

Therefore, a comparative retrospective study was conducted in which implant survival rates, changes in marginal bone level, clinical outcomes, aesthetic outcomes, and patient satisfaction were assessed and compared between alveolar cleft patients and non-cleft patients who had undergone dental implant therapy, with implants placed in the same region.

Materials and methods

Patients

Between 2001 and 2016, 20 implants were placed in 17 consecutive alveolar cleft patients with residual edentulous spaces in the former cleft area. All patients had received pre-surgical orthodontic treatment and had undergone secondary alveolar grafting with bone from the anterior iliac crest to close the alveolar cleft at a mean age of 11.7 ± 4.4 years. After cessation of growth, 8.2 ± 4.9 years after closure of the alveolar gap, the patients were scheduled for dental implant placement.

Before implant placement, the amount of bone in the previous cleft region was assessed clinically and radiographically. If the bone volume was considered insufficient for direct implant placement, a tertiary bone augmentation procedure was conducted with intraoral bone harvested from the retromolar area ($n = 7$). In these patients, the implants were inserted 3 months after the augmentation procedure.

The surgical implant placement procedures were performed under local ($n = 9$) or general anaesthesia ($n = 8$). One day prior to surgery, patients started taking antibiotics (amoxicillin 500 mg, three times daily for 7 days) and used a 0.2% chlorhexidine mouthwash (two times daily for 2 weeks). Bone-level implants were placed in the reconstructed region of the alveolar cleft with the use of a surgical drill guide. All implants were placed in the former cleft area. To ensure a good emergence profile, the implant shoulder was placed 3 mm apical to the most buccal and cervical aspect of the prospective implant crown and was levelled to the alveolar bone. When part of the implant remained uncovered or when the bone wall thickness labial from the implant was <2 mm, a local augmentation procedure was performed with autogenous bone chips harvested during implant bed preparation and anorganic bovine bone ($n = 15$) (Bio-Oss; Geistlich Pharma AG). The reconstructed area was covered with a membrane (Bio-Gide; Geistlich Pharma AG) and the wound was closed primarily. After 3 months, implants were uncovered and a healing abutment was installed.

Controls

As a control group for the alveolar cleft patients, non-cleft patients needing implants in the same region were matched to the study group. Criteria for matching were implant location and the need for bone augmentation surgery 3 months prior to implant placement. Matching by patient age could not be done, due to the fact that younger non-cleft patients who needed an additional augmentation of the implant region 3 months before implant placement were not available for inclusion. Furthermore, patients with agenetic teeth in the region of the lateral incisor/cuspid were not considered eligible for this study, as in these patients the alveolar process is often underdeveloped and the bone quality has been shown to differ from controls. All of the control patients had participated in prospective clinical studies performed in the Department of Oral and Maxillofacial Surgery (University Medical Centre Groningen, the Netherlands)[19,20]. In all controls, bone augmentation surgery was performed with autogenous bone harvested from the retromolar area. All implants were placed with the use of a surgical drill guide and were bone-level type implants. If any threads of the implant were uncovered or the bone wall thickness labial from the implant was <2 mm, a local augmentation procedure was performed with a mixture of autogenous bone chips and anorganic bovine bone, similarly to the procedure described above for the cleft patients ($n = 8$). After 3 months, the implants were uncovered and a healing abutment was installed.

Data collection

All patients and controls were on a standardized recall schedule. Data on complications during surgery, postoperative healing (inflammation, wound dehiscence, sequestration, and loss of bone particles), and loss of implants were obtained from the patients' medical records. In addition to the data collected during the standard recall visits, all patients were recalled for a clinical and radiographic examination between March and September 2017. After consulting the Medical Ethics Committee of the University Medical Centre Groningen, it was concluded that this retrospective comparative study was not subject to the Medical Research Involving Human Subjects Act (Number M18.242253).

Clinical parameters

The following clinical parameters were assessed: (1) plaque index assessed at four sites per implant/adjacent tooth (mesial, buccal, distal, and lingual) using the modified plaque index[21]. (2) Bleeding index: assessed at four sites per implant/adjacent tooth (mesial, buccal, distal, and lingual) using the modified sulcus

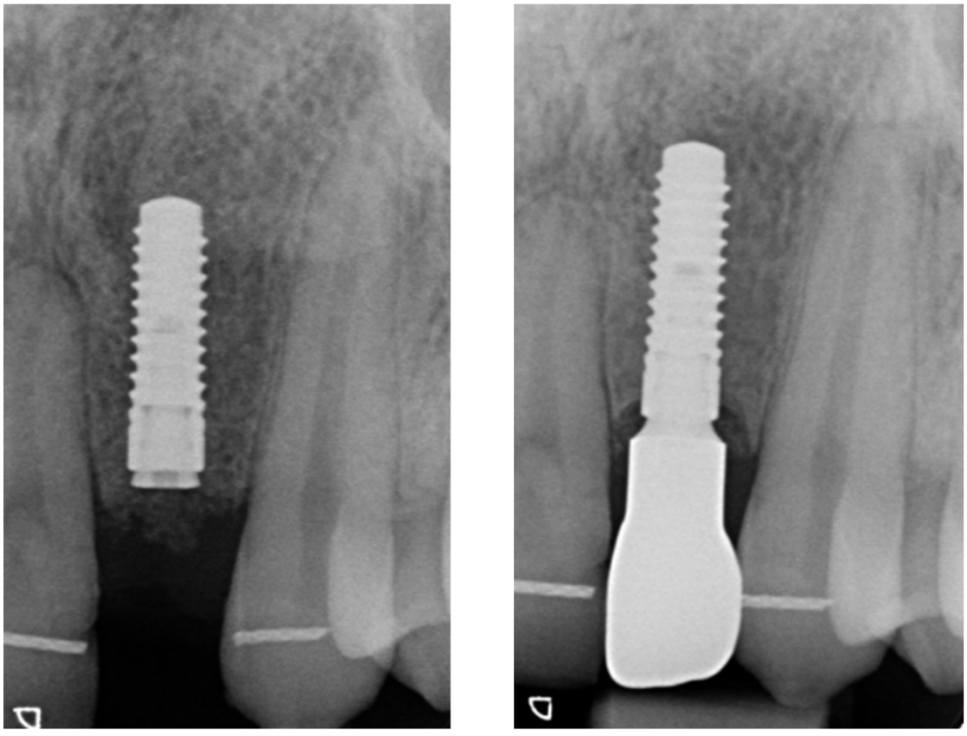

Fig. 1. Intraoral radiographs of a cleft patient showing the implant immediately after placement (left) and 12 months after placement (right).

bleeding index[21]. (3) Probing pocket depth: measured to the nearest 1 mm using a manual periodontal probe (Williams Color-Coded Probe; Hu-Friedy, Chicago, IL, USA) at the mesial, buccal, distal, and lingual aspects of the implant and adjacent teeth. Subsequently, the greatest pocket depth for each implant was included for analysis.

Changes in marginal bone level

The marginal bone level change was measured on standardized digital intraoral radiographs taken at follow-up (Fig. 1). Mesial and distal differences in bone level were calculated from reference radiographs (taken at placement of the restoration) and follow-up radiographs. Subsequently the highest bone loss measurement for each implant was included for analysis.

Aesthetic assessment

The aesthetic outcome at follow-up was determined by assessing the pink aesthetic score (PES) and white aesthetic score (WES)[22]. The PES/WES was assessed by one observer (H.J.A.M.) using photographs taken with a digital camera (Fig. 2).

Patient satisfaction

Self-administered questionnaires, used in other studies assessing the aesthetic region of the maxilla, were given to all subjects included in the study[19,20]. The patients were asked to answer questions about their overall aesthetic satisfaction and satisfaction with the colour and appearance of the crown and surrounding soft tissues. The answers were given on a five-point scale ranging from 'very dissatisfied' (score 1) to 'very satisfied' (score 5). In addition, all subjects were asked to mark their overall satisfaction on a 10-cm visual analogue scale (VAS), with 'very dissatisfied' (0) on the left end of the scale and 'very satisfied' (10) on the right end.

Statistical analysis

The data analysis was performed using IBM SPSS Statistics version 24.0 (IBM Corp., Armonk, NY, USA). Variables with a normal distribution were analysed by independent-samples *t*-test. Between-group comparisons were performed using

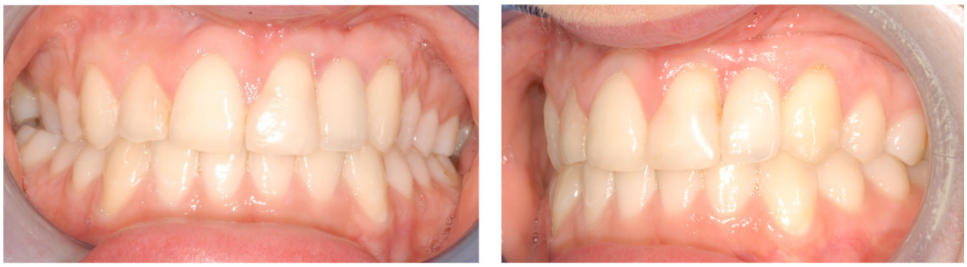

Fig. 2. Digital photographs of a cleft patient who received an implant at location 22.

Table 1. Characteristics of the patients in the two study groups.

	Cleft group ($n = 17$)	Control group ($n = 17$)
Implant site location		
Incisor	4	4
Lateral incisor	12	12
Cuspid	1	1
Sex		
Male	11	10
Female	6	7
Bone grafting during implant placement		
Yes	15	8
No	2	9
Age (years) at implant placement		
Mean ± SD	21.2 ± 5.2	36.4 ± 14.9
Range	(17–33)	(17–60)
Follow-up duration (months), median; IQR	69.0; 64.0	77.0; 75.0

SD, standard deviation; IQR, interquartile range.

the Mann–Whitney *U*-test. *P*-values less than 0.05 were considered statistically significant.

Results

The baseline characteristics of the patients in both study groups are depicted in Tables 1–3. In the cleft group, three patients received two implants. In these cases, one implant was chosen randomly to include in the patient-level analysis. All other patients received one implant. No signs of inflammation, wound dehiscence, sequestration, or loss of bone particles occurred in either group.

In the cleft group, a screw-retained restoration was placed in 16 patients and a cemented crown in one. The restorations in the control group were all screw-retained. The mean duration of follow-up for all patients was 72.4 ± 46.4 months. One implant was lost in the cleft group, at 9 months after insertion, resulting in an implant survival rate in the alveolar cleft group of 95%. No implants were lost in the control group.

Bleeding upon probing around the implant ($P = 0.02$) and the presence of plaque ($P < 0.001$) occurred significantly more often in cleft patients than in controls (Figs 3 and 4). Probing pocket depths and loss of marginal bone were comparable in the cleft patients and controls (Table 4). Patient satisfaction was also comparable in the cleft patients and controls (8.6 ± 0.9 versus 8.9 ± 1.1, $P = 0.331$). Overall, aesthetics tended to be less favourable in cleft patients than in controls (PES/WES total 12.9 ± 2.1 versus 14.1 ± 2.6; $P = 0.149$). This was mainly due to a significant difference in the appearance of the gingiva (PES total 5.0 ± 1.9 versus 6.5 ± 1.7; $P = 0.025$) (Table 4).

Tertiary grafting at 3 months before implant placement was performed in seven cleft patients. When the cleft patients without tertiary grafting were excluded and the seven cleft patients with tertiary grafting were compared to their matched controls, no significant difference in clinical outcomes was found. To assess the difference between the patients who received tertiary grafting (cleft group 1) and those who did not (cleft group 2), an additional analysis was conducted on these two subgroups. The results of this analysis are reported in Table 5. Aesthetics tended to be less favourable in the additionally augmented patients (PES/WES total 12.0 ± 2.6 versus 13.6 ± 1.5, $P = 0.092$).

Discussion

Dental implant therapy in cleft patients was associated with high implant survival, healthy peri-implant soft and hard tissues, and a satisfactory aesthetic appearance when compared to augmented non-cleft patients.

The implant survival rate in cleft patients was 95%, which is in line with the results of previous studies on cleft patients[7,10,11,13–15] and also comparable to studies on non-cleft groups[5]. Most studies have not reported on marginal bone loss and pocket depths around implants in cleft patients, but the marginal bone loss and probing pocket depths in the current study are comparable with data reported by Landes[23].

Table 2. Characteristics of each patient in the cleft group.

	Sex	Age at implant placement (years)	Implant site	Brand	Implant length (mm)	Implant diameter (mm)	Number of implants
1	Male	33	22	Straumann Bone Level	14	3.3	1
2	Female	18	22	Straumann Bone Level	8	3.3	1
3	Male	19	21	Nobel	13	4.3	1
4	Male	18	12	Nobel	13	3.5	1
5	Male	19	22	Straumann Bone Level	12	3.3	1
6	Male	20	12/22	Biomet 3i	13	3.25	2
7	Male	25	21/22	Brånemark	13	3.3	2
8	Male	17	23	Nobel	13	4.3	1
9	Female	18	22	Straumann Bone Level	10	3.3	1
10	Male	19	22	Straumann Bone Level	8	4.1	1
11	Female	24	12	Straumann Bone Level	10	3.3	1
12	Male	19	12	Straumann Bone Level	14	4.1	1
13	Female	18	22	Biomet 3i	13	4	1
14	Female	29	21	Brånemark	15	4.3	1
15	Female	17	22	Nobel	13	3.5	1
16	Male	18	12/22	Biomet 3i	13	3.25	2
17	Male	31	21	Straumann Bone Level	12	4.1	1

Table 3. Characteristics of each patient in the control group.

	Sex	Age at implant placement (years)	Implant site	Brand	Implant length (mm)	Implant diameter (mm)	Number of implants
1	Male	34	12	Straumann Bone Level	14	3.3	1
2	Female	60	22	Straumann Bone Level	14	3.3	1
3	Male	22	12	Straumann Bone Level	14	3.3	1
4	Male	60	22	Straumann Bone Level	14	4.1	1
5	Female	47	13	Straumann Bone Level	14	4.1	1
6	Female	19	22	Straumann Bone Level	14	3.3	1
7	Male	40	12	Straumann Bone Level	10	3.3	1
8	Female	48	12	Nobel	12	3.5	1
9	Male	51	12	Straumann Bone Level	14	3.3	1
10	Male	43	21	Straumann Bone Level	14	4.1	1
11	Male	20	21	Nobel	16	4.3	1
12	Female	17	12	Nobel	16	3.5	1
13	Female	52	22	Nobel	16	3.5	1
14	Male	25	21	Nobel	16	4.3	1
15	Female	31	21	Nobel	16	4.3	1
16	Male	32	22	Nobel	13	3.5	1
17	Male	18	12	Nobel	16	3.5	1

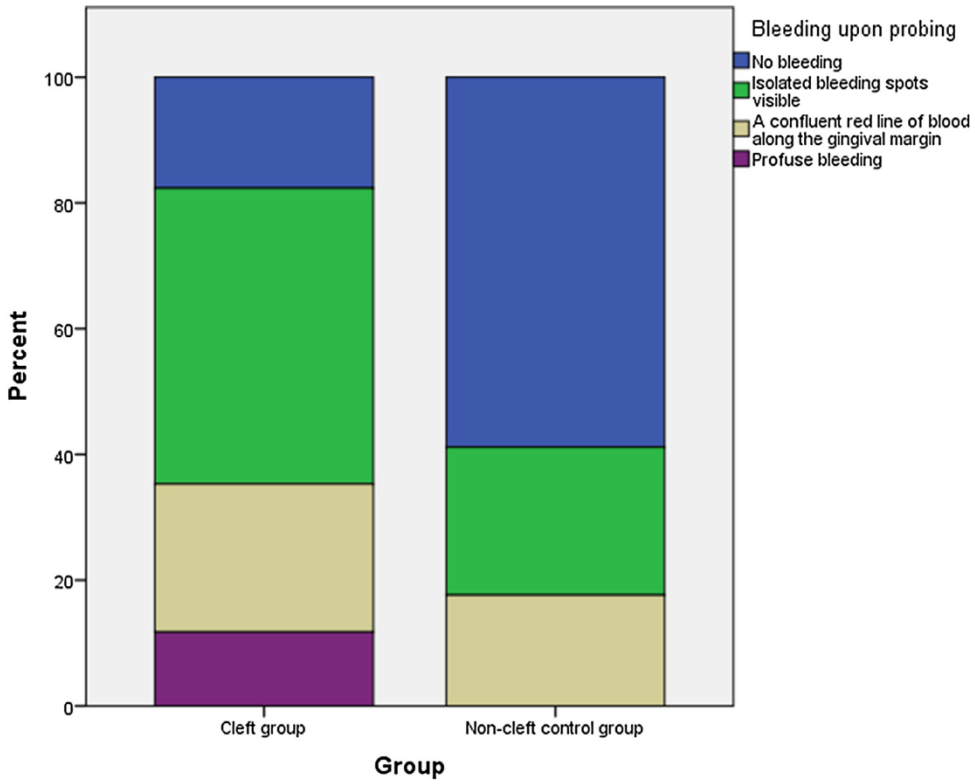

Fig. 3. Frequency distribution of bleeding index scores ($P = 0.02$).

While most parameters tested were comparable between cleft patients and non-cleft controls, the alveolar cleft group presented more plaque and more bleeding on probing. This suggests a lower level of oral hygiene in the cleft patients included in this study. These findings differ from those of previously published studies, in which plaque indices in cleft patients were similar to those found normally around teeth in well-motivated patients[24]. Impaired perioral soft tissue movements in cleft patients may contribute to these findings.

With respect to aesthetics, the PES were significantly lower in the cleft patients, as expected. This finding has also been reported in previous studies[8,12,25] and is related to the multiple surgical treatments and scar tissue in the alveolar cleft area. Although the soft tissues in the cleft group scored considerably lower on the aesthetic scale, the patients were still satisfied with their appearance. This discrepancy between the professional's and patient's perception has also been reported in non-cleft patients[26]. It might be that the patients in the cleft group tended to have more realistic expectations due to the comprised baseline situation, and were

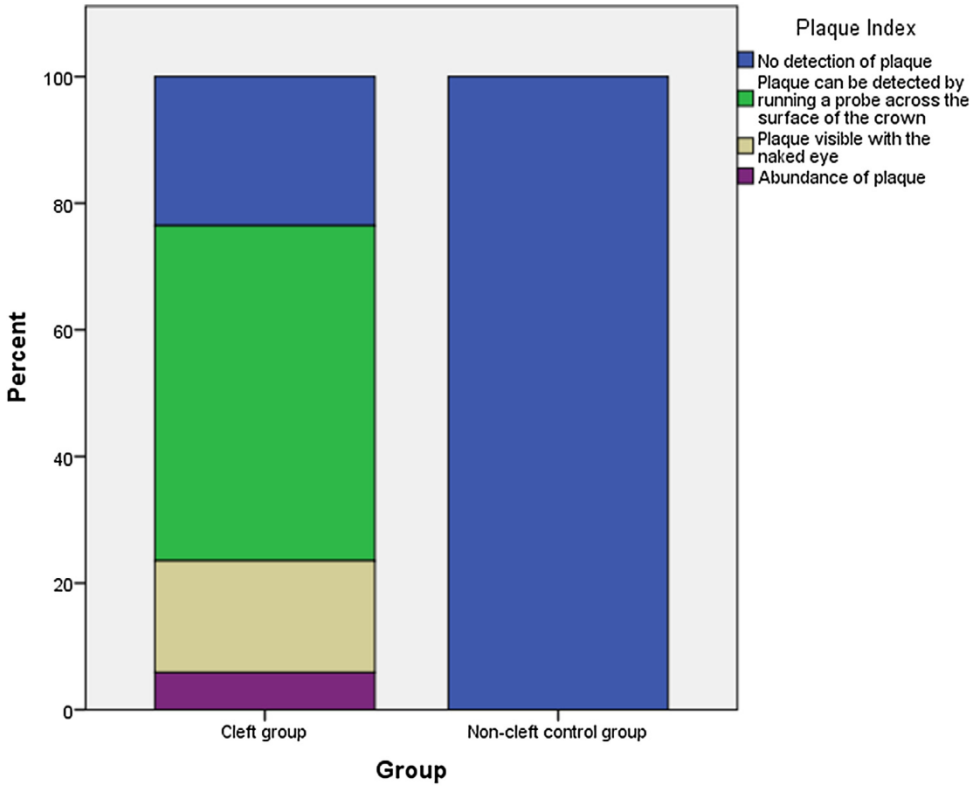

Fig. 4. Frequency distribution of plaque index scores ($P < 0.001$).

Table 4. Comparison of PES/WES, probing pocket depths, marginal bone level changes, and patient satisfaction scores between the study groups; mean ± standard deviation values.

Variable	Cleft group ($n = 17$)	Control group ($n = 17$)	*P*-value
PES total (max 10)	5.0 ± 1.9	6.5 ± 1.7	0.025
Mesial papilla	1.0 ± 0.8	1.5 ± 0.6	0.117
Distal papilla	0.9 ± 0.8	1.2 ± 0.7	0.363
Curvature of facial mucosa	1.2 ± 0.7	1.5 ± 0.5	0.241
Level of facial mucosa	0.9 ± 0.7	1.2 ± 0.8	0.256
Root convexity/soft tissue colour and texture	0.9 ± 0.8	1.2 ± 0.8	0.284
WES total (max 10)	7.9 ± 1.7	7.6 ± 1.3	0.358
Tooth form	1.3 ± 0.6	1.4 ± 0.5	0.677
Outline/volume	1.5 ± 0.5	1.5 ± 0.5	0.868
Colour (hue/value)	1.6 ± 0. 6	1.5 ± 0.7	0.525
Surface texture	1.8 ± 0.4	1.8 ± 0.4	0.741
Translucency/characterization	1.8 ± 0.4	1.5 ± 0.5	0.106
PES/WES total (max 20)	12.9 ± 2.1	14.1 ± 2.6	0.149
Probing pocket depth (mm)	3.1 ± 1.2	3.2 ± 0.8	0.066
Marginal bone level change (mm)	−0.4 ± 0.4	−0.2 ± 0.4	0.230
Patient satisfaction	8.6 ± 0.9	8.9 ± 1.1	0.331

PES, pink aesthetic score; WES, white aesthetic score.

therefore satisfied even when the aesthetic index scores were worse. Also, the limited elevation of the upper lip in cleft patients might make soft tissues less visible and therefore less disturbing.

In the present population, it was possible to place the implants in the original graft in 10 out of the 17 patients. The graft had generally been in situ for a mean period of 8 years and still provided just enough volume for implant placement. However, in seven cases, optimal three-dimensional positioning of the implant was not possible due to an insufficient bone volume, and tertiary bone augmentation was necessary 3 months before implant placement. In these seven patients, the mean period after closure of the alveolar cleft was longer than in the other 10 patients (10.7 versus 6.3 years). These findings suggest not waiting too long after closing the alveolar cleft before starting implant treatment. In those patients requiring an additional bone augmentation 3 months prior to implant placement, there appeared to be a tendency towards less favourable results regarding marginal bone level changes and aesthetics. The significantly deeper probing pocket depths in the additionally

Table 5. Comparison of probing pocket depths, marginal bone level changes, and PES/WES between cleft group 1 (additional bone augmentation at 3 months prior to implant placement) and cleft group 2 (no additional bone augmentation at 3 months prior to implant placement); mean ± standard deviation values.

Variable	Cleft group 1 ($n = 7$)	Cleft group 2 ($n = 10$)	*P*-value
Probing pocket depth (mm)	4.9 ± 0.7	3.3 ± 1.0	0.008
Marginal bone level change (mm)	−0.5 ± 0.3	−0.3 ± 0.4	0.106
Mean PES	4.4 ± 1.8	5.2 ± 1.7	0.460
PES/WES total (max 20)	12.0 ± 2.6	13.6 ± 1.5	0.092

PES, pink aesthetic score; WES, white aesthetic score.

augmented patients can be explained, at least in part, by scar tissue, which leads to thicker mucosa and thus the formation of pseudopockets.

An earlier study concluded that a one-stage procedure, whereby augmentation and implant placement are done in a single session, could result in wound dehiscence and or graft sequestration[27]. In the current study, these problems did not occur and we suggest that implants placed in a one- as well as a two-stage procedure can lead to good results, provided that an optimal prosthetic position and sufficient primary stability of the implant can be achieved.

Due to the small sample size, the results of this study should be interpreted with caution. A major drawback was that it was not possible to match all of the patients by age, as not many people need an implant in the anterior region at a young age. Another potential confounding factor in this study that has to be mentioned was the difference between the groups with regard to the need for a local augmentation procedure during implant placement: 15 in the cleft group versus eight in the control group. This reflects the on average longer period in cleft patients between closing the cleft (at a younger age) and the timing of implant placement (after cessation of growth) than in the control patients (time between loss of the tooth and implant placement). The preferred study design would be a randomized prospective clinical trial. Given the low incidence of cleft of the alveolus and the low incidence of patients needing implant placement in the anterior region at a young age, such a randomized controlled trial would probably be feasible only in a multi-centre study.

In conclusion, due to the comparable survival rates in the two patient groups, dental implant therapy in cleft patients can be considered a reliable and durable treatment option. Although the soft tissues are compromised, the appearance of the soft tissues does not, at least not with a clinically relevant impact, influence the patient satisfaction rate. Also, in cases where an additional bone graft is needed prior to implant placement, clinical parameters and aesthetics remain acceptable.

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Competing interests

The authors declare that they have no conflict of interest with regard to this work.

Ethical approval

After consulting the Medical Ethics Committee of the University Medical Centre Groningen, it was concluded that this retrospective case–control study was not subject to the Medical Research Involving Human Subjects Act (Number M18.242253).

Patient consent

Patient consent was obtained.

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