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A 10-year prospective study on single immediate implants

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ABSTRACT

Purpose: To evaluate the clinical, aesthetic and radiographical outcome of single immediate implant placement (IIP) after 10 years (1); to identify putative risk factors for advanced midfacial recession (2).

Material and methods: Periodontally healthy patients with a thick gingival biotype and intact buccal bone wall were consecutively treated with a single immediate implant and crown in the aesthetic zone (15–25). Flapless surgery and socket grafting with deproteinized bovine bone mineral was performed. Seven patients received a connective tissue graft (CTG) at 3 months due to obvious alveolar process deficiency ($n = 5$) or advanced midfacial recession ($n = 2$). Clinical, aesthetic and radiographical outcomes at 10 years were compared to those at 5 years and CBCTs were taken at 10 years.

Results: Twenty-two patients (10 women; mean age 50) were consecutively treated and 18 could be re-examined. Two implants failed and 2 patients died. None of the parameters differed between the 5- and 10-year re-assessment (marginal bone loss: 0.31 mm; plaque score: 15 %; probing depth: 3.4 mm; bleeding on probing: 32 %; pink esthetic score: 10.61; mesial papillary recession: -0.03 mm; distal papillary recession: 0.22 mm; midfacial recession: 0.58 mm). Six implants (33 %) demonstrated ≥ 1 mm midfacial recession. Putative risk factors were merely based on descriptive statistics and included buccal shoulder position, no CTG, convex emergence profile and central incisor position. Three implants (17 %) had no visible buccal bone on CBCT. One of these was too buccally positioned, another yielded peri-implant mucositis and another demonstrated peri-implantitis.

Conclusions: Advanced midfacial recession is common in the long term following IIP. Therefore, caution is required for IIP in the aesthetic zone.

CLINICAL RELEVANCE

Scientific rationale for the study: The long-term documentation of immediate implant placement (IIP) is scarce.

Principal findings: Although mean changes in clinical, aesthetic and radiographical outcomes appear insignificant between 5 and 10 years following IIP in well-selected patients, 33 % of the cases showed advanced midfacial recession.

Practical implications: Caution is required for IIP in the aesthetic zone.

INTRODUCTION

Immediate implant placement (IIP), also known as Type I placement (Hammerle et al., 2004), has always been an attractive treatment protocol for patients in need of tooth replacement. Especially when combined with immediate provisionalization, instant functionality and aesthetics can be achieved. Notwithstanding the reduction of surgical interventions and treatment time, this protocol also has its drawbacks. From a surgical standpoint, IIP is a very challenging procedure. In order to achieve sufficient primary stability only the apical and palatal bone can be engaged. As a result, early implant failures due to lack of osseointegration may be more frequent with IIP as compared to delayed implant placement (Cosyn et al., 2019). Furthermore, IIP in the aesthetic zone has been associated with unpredictable aesthetic results and a significant risk for advanced midfacial recession, especially when only limited inclusion criteria are applied (Chen and Buser, 2014). This may be explained by the fact that installing an implant in a fresh extraction socket does not prevent post-extractive bone remodelling (Botticelli et al., 2004, Araujo et al., 2005, Covani et al., 2007, Vignoletti et al., 2009). Given that these hard tissue alterations mainly occur at the buccal aspect (Tan et al., 2012), long-term stability of the facial bone wall around immediate single implants in the premaxilla seems questionable. In addition, many immediate implants seem to end up in a buccal shoulder position when placed free-handedly (Chen and Buser, 2009, 2014).

Ample systematic reviews (Cosyn et al., 2012, Slagter et al., 2014, Khzam et al., 2015, Kinaia et al., 2017) have highlighted the importance of pre-operative diagnosis by means of 3D-imaging and strict case selection. Indeed, favorable anatomical factors such as a thick gingival biotype (Chen et al., 2009, Kan et al., 2011, Bittner et al., 2019) and a thick (> 1 mm), intact buccal bone wall (Kan et al., 2007, Chappuis et al., 2013) seem of major importance to prevent hard and soft tissue collapse. However, even with strict case selection and protective interventions such as connective tissue grafting (van Nimwegen et al., 2018, Zuiderveld et al., 2018) and immediate restoration (De Rouck et al., 2009a) aesthetic complications may develop over time despite satisfactory initial results (Kan et al., 2011, Cosyn et al., 2016).

To the best of our knowledge, three clinical studies have been published with long-term data on both buccal bone wall dimensions and soft tissue alterations around immediate implants (Benic et al., 2012, Kuchler et al., 2016, Raes et al., 2018). Relevant dimensional changes may be expected, yet conflicting statements were made on the risk for complete resorption of the buccal bone wall and midfacial recession. In addition, post-op evaluation of the orofacial implant position is lacking

in these studies, which is of critical importance since a buccal shoulder position has been associated with relevant tissue alterations (Chen and Buser, 2009, 2014).

The primary objective of this prospective study was to compare the clinical, aesthetic and radiographical outcome of single IIP in the aesthetic zone of low-risk patients between 5 and 10 years of function. The secondary objective was to identify putative risk factors for advanced midfacial recession.

MATERIAL AND METHODS

Patient selection

Patients were enrolled in a private periodontal practice in Belgium between January 2009 and April 2010 to participate in this prospective case series. All patients were treated with an immediate single implant in the aesthetic zone. The 1- and 5-year results of this patient cohort have been published previously (Cosyn et al., 2013a, 2016).

Inclusion criteria were as follows:

- At least 18 years old
- Good oral hygiene (full mouth plaque score $\leq 25\%$ (O'Leary et al., 1972))
- Good general health
- Presence of a single failing tooth in the anterior maxilla (15 – 25) with both neighboring teeth present
- Ideal soft tissue level and contour at the buccal aspect of the failing tooth in perfect harmony with the surrounding teeth
- Thick gingival biotype determined on the lack of transparency of a periodontal probe through the gingival margin when probing the buccal sulcus of the failing tooth (De Rouck et al., 2009b)
- Adequate bone height apical to the alveolus of the failing tooth (≥ 5 mm) to ensure a primary implant stability of at least 35 Ncm
- Signed informed consent

Exclusion criteria were as follows:

- Smoking
- Visible signs suggestive of bruxism (attrition and abrasion)

- Lack of posterior occlusion
- (History of) periodontal disease
- Presence of active infection (pus, fistula) around the failing tooth
- Incomplete buccal bone wall after extraction of the failing tooth

The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000.

The University Hospital ethically approved a clinical and radiographical examination of patients at 10 years follow-up, including a CBCT (B.U.N. B670201942450).

Implant surgery and provisional restoration

Implant surgery was preceded by antibiotic therapy (amoxicillin 1000 mg twice a day for 4 days and started the day before) and oral disinfection (Corsodyl®, GlaxoSmithKline, Genval, Belgium). Teeth were removed without flap elevation using periotomes. In case of an intact buccal bone wall, a bone condensing implant with variable-thread design (NobelActive®, Nobel Biocare, Göteborg, Sweden) was placed at the palatal aspect of the alveolar socket without the use of a surgical guide. Upon confirmation of at least 35 Ncm primary stability, a conventional impression was made for a screw-retained provisional crown with concave buccal emergence profile (De Rouck et al., 2008). Deproteinized bovine bone mineral (DBBM) particles (Bio-Oss® 0.25–1 mm, Geistlich Biomaterials, Wolhusen, Switzerland) soaked in saline and blood were used to graft the space between the implant surface and the inner bone walls (Cornelini et al., 2004). The provisional restoration was installed approximately 3 h following surgery, tightened at 15 Ncm and adjusted to clear centric and excentric contacts. Details on the surgical procedure can be found in an earlier paper (Cosyn et al., 2013a, 2016).

Connective tissue grafting

Three months following implant surgery, patients were invited for a clinical reassessment. In case of advanced midfacial recession (≥ 1 mm) and/or obvious alveolar process deficiency a CTG was applied at the buccal aspect. Alveolar process deficiency was assessed on the basis of clinical judgement from an occlusal aspect with 0 corresponding to obvious alveolar process deficiency, 1 to slight alveolar process deficiency and 2 to no alveolar process deficiency as described by Fürhauser et al. (2005).

An appropriately sized CTG was harvested from the palate through a single incision approach. Then, the CTG was pulled inside the buccal peri-implant mucosa following a pouch procedure and

fixed using single 6/0 sutures (Seralon®, Serag Wiessner, Nail, Germany). Details on buccal connective tissue grafting can be found in an earlier paper (De Bruyckere et al., 2015).

Replication of emergence profile and permanent restoration

Between 3 and 6 months the emergence profile of the provisional restoration was slightly adjusted when deemed necessary using flowable composite (Charisma® Flow, Heraeus Kulzer GmbH, Hanau, Germany). It was intended to achieve a slightly concave profile in proximity to the bone, while a convex profile was created in proximity to the mucosal margin. After six months, the permanent restoration was fabricated replicating the emergence profile that had been created by the provisional restoration. Details on the replication of the emergence profile can be found in an earlier paper (Cosyn et al., 2013a, 2016). All surgical procedures were performed by the same surgeon (JC) and all restorative procedures were performed by the same prosthodontist (RC).

Clinical and aesthetic outcome

The following clinical and aesthetic parameters were registered at 5- and 10-year follow-up:

- *Implant survival and complications.* The proportion of implants demonstrating peri-implant health, peri-implant mucositis and peri-implantitis was calculated. Case definitions were adopted from the 2017 World Workshop on the classification of periodontal and peri-implant diseases and conditions (Renvert et al., 2018). Technical complications (loosening of the abutment screw, loss of retention of the crown and fracture of components) and aesthetic complications (obvious alveolar process deficiency and metal exposure as a result of advanced mid-facial recession) were also recorded.
- *Marginal bone loss from baseline* was calculated as the change in marginal bone level between the time of implant installation (baseline) and follow-up. Marginal bone level was defined as the distance from the implant-abutment interface to the first bone-to-implant contact registered at the mesial and distal aspect of each implant using digital peri-apical radiographs (long-cone paralleling technique). A mean value was calculated per implant. All bone measurements were performed to the nearest 0.01 mm using designated software (DBSWIN, Dürr Dental AG, Bietigheim-Bissingen, Germany).
- *Plaque* was recorded at four sites per implant (mesial, distal, buccal, palatal) using a dichotomous score (0: no visible plaque at the soft tissue margin; 1: visible plaque at the

soft tissue margin). These values were averaged and expressed as a percentage on implant level.

- *Probing depth* was measured at four sites per implant (mesial, distal, buccal, palatal) using a periodontal probe (CP 15 UNC, Hu-Friedy®, Chicago, IL, USA) to the nearest 0.5 mm. A mean value was calculated per implant.
- *Bleeding on probing* was registered 15 seconds following pocket probing at four sites per implant (mesial, distal, buccal, palatal) using a dichotomous score (0: no bleeding; 1: bleeding). These values were averaged and expressed as a percentage on implant level.
- *Pink esthetic score* (PES) was registered (Furhauser et al., 2005).
- *Papillary recession from baseline* was calculated as the change in papillary level between pre-op (baseline) and follow-up. Papillary level was defined as the distance from an acrylic stent to the top of the papilla at the mesial and distal aspect of each implant using a periodontal probe, as described by De Rouck et al. (2008). A mean value was calculated per implant (fig. 1).
- *Midfacial recession from baseline* was calculated as the change in midfacial level between pre-op (baseline) and follow-up. Midfacial level was defined as the distance from an acrylic stent to the free mucosal margin at the center of the implant using a periodontal probe, as described by De Rouck et al. (2008) (fig. 1).

(HERE APPROXIMATELY FIGURE 1 PLEASE)

CBCT analysis

Cone Beam Computed Tomographies (Planmeca, ProMax® 3D, Helsinki, Finland) were captured after 10-year follow-up. For each patient the same settings were used (90kV, 6.3mA, 12s, voxel size 200 μ m) with a FOV of 50 mm x 50 mm. In addition, a cotton roll was placed in the vestibule, lifting the lip from the alveolar process hereby visualizing hard and soft tissues on every cross-sectional slide. CBCT images were imported in DICOM format in planning software (Romexis 4.6.0.R, Helsinki, Finland) for data registration.

The orofacial implant position was evaluated on axial CBCT slides at the level of the implant shoulder (fig. 2). A reference line was drawn connecting the buccal outline of both adjacent teeth. A second line was constructed perpendicular to the reference line crossing the center of the implant. The distance of the second line between the implant surface to the reference line was

registered in mm. When this distance was ≤ 0.5 mm it was considered a buccal shoulder position. An implant was considered properly placed in the orofacial dimension when this distance was > 0.5 mm.

Cross-sectional slides were produced in the center of the implant and contra-lateral tooth (fig. 2). Therefore, a panoramic curve was constructed at the level of the implant shoulder crossing the center of both adjacent teeth. Cross-sections perpendicular to the panoramic curve were produced. A line visualized the level of the implant shoulder in the implant cross-section as well as in the tooth cross-section. Thereupon, 3 lines were drawn parallel to the implant shoulder line at 1, 3 and 5 mm apical to the implant shoulder. The width of the alveolar process was measured in mm at the 3 levels on the implant as well as on the tooth cross-section. Buccal bone thickness on the tooth cross-section was determined by subtracting the alveolar process width from the distance between the inner surface of the buccal bone wall to the outer surface of the palatal bone wall. This was performed at the 3 levels. To correct for artifacts as a result of beam hardening when measuring buccal bone thickness on the implant cross-section, an implant template corresponding to the actual implant in terms of diameter and length was inserted and aligned in the software. Thereupon, buccal bone thickness on the implant cross-section was determined by subtracting the alveolar process width from the distance between the buccal surface of the implant template to the outer surface of the palatal bone wall. This was performed at the 3 levels.

(HERE APPROXIMATELY FIGURE 2 PLEASE)

Statistical analysis

Descriptive statistics included mean, standard deviation, median and interquartile (IQ) range for continuous variables and frequency distributions for categorical variables. Changes in clinical and aesthetic parameters between 5 and 10 years were evaluated using the Wilcoxon signed ranks test. The level of significance was set at 0.05.

RESULTS

Twenty-two patients (12 men, 10 women; mean age 50 with a range from 27 to 74) were consecutively treated with a single immediate implant and 7 received a CTG. One implant was

removed 2 weeks after implant placement because of pain and mobility. In 9 patients a screw-retained permanent restoration was placed. Of those, three were full-ceramic crowns. In twelve patients a cement-retained permanent restoration was placed with a non-eugenol temporary cement (TempBond NE, Kerr, Bioggio, Switzerland). Of those, eight were placed onto a titanium stock abutment, two onto a customized titanium abutment and two onto a customized zirconia abutment. One patient died in the first year. At 5 years, 17 out of 20 patients could be re-examined. Another patient died at 7 years follow-up and an implant was lost after 8 years because of peri-implantitis. This resulted in a final sample of 18 patients at 10 years. Following multiple attempts, all were willing to return for re-assessment. During the 10-year period, patients received maintenance care on a yearly basis by the general dentist.

Clinical and aesthetic outcome

Table 1 shows the clinical outcome of single immediate implants at 5- and 10-year follow-up. Marginal bone loss from baseline did not differ significantly between the two time points and amounted to 0.31 mm at the final re-assessment. The same applied to plaque score, probing depth and bleeding on probing finally pointing to 15 %, 3.4 mm and 32 %, respectively.

Based on case definitions as described by Renvert et al. (2018), peri-implant health was found for nine out of 17 implants at 5-year follow-up. Eight implants demonstrated peri-implant mucositis. At 10-year follow-up, peri-implant health was found for 11 out of 18 implants. Six implants showed peri-implant mucositis. These patients received oral hygiene reinforcement and polishing. One patient developed peri-implantitis and was scheduled for regenerative peri-implant surgery.

With regard to technical complications that occurred between 5 and 10 years, one crown had porcelain chipping and one was re-cemented after 7 years. Another cemented crown was lost after 9 years and was renewed. With regard to aesthetic complications, midfacial recession resulted in metal exposure in one patient.

Aesthetic outcome and vertical soft tissue changes are also shown in table 1. PES remained stable between the 5- (11.18) and 10-year (10.61) re-assessment ($p = 0.164$). From all PES criteria, alveolar process scored worst. Only 5 implants (28 %) showed perfect buccal soft tissue convexity at study termination. Three of these received a CTG, 2 did not. Slight and obvious alveolar process deficiency was observed in 10 (55 %) and 3 (17 %) patients, respectively.

Mesial papillae fully recovered and stayed stable between 5- and 10-years ($p = 0.564$). Distal papillae yielded limited shrinkage, yet also remained stable between these time points ($p = 0.317$).

Midfacial recession was 0.53 mm after 5 years and 0.58 mm after 10 years. There was no significant difference between these time points ($p = 0.655$). A clinical case is shown in fig. 3.

(HERE APPROXIMATELY TABLE 1 AND FIGURE 3 PLEASE)

CBCT analysis

The distance between the implant shoulder and the line of emergence at adjacent teeth was 1.2 mm (SD 0.8). Three implants were too buccally positioned given a distance ≤ 0.5 mm.

Table 2 shows the width of the alveolar process and buccal bone thickness at tooth sites and implant sites after 10 years. Although merely based on descriptive statistics, the alveolar process was wider at tooth sites when compared to implant sites. At level -1 mm, buccal bone thickness at implant sites was 1.1 mm (SD 0.8). Two implants demonstrated ≥ 2 mm buccal bone thickness, yet 3 implants yielded no visible buccal bone at level -1 mm. These implants had no visible buccal bone at all levels. At level -3 mm and -5 mm, 5 and 7 implants failed to show visible buccal bone, respectively.

(HERE APPROXIMATELY TABLE 2 PLEASE)

Sub-analysis of cases with at least 1 mm midfacial recession

Six out of eighteen (33 %) implants demonstrated ≥ 1 mm midfacial recession at 10 years. Given the low number of implants, putative risk factors were merely assessed on the basis of descriptive statistics (table 3). Three out of six implants with ≥ 1 mm midfacial recession had a *buccal shoulder position* (fig. 4). In contrast, none of the 12 implants with < 1 mm midfacial recession showed a buccal shoulder position. All 6 implants demonstrating ≥ 1 mm midfacial recession were treated *without a CTG*. In contrast, 6 out of 12 implants with < 1 mm midfacial recession were treated with a CTG. Two out of six implants with ≥ 1 mm midfacial recession were restored with a permanent crown yielding a *convex buccal emergence profile*. Permanent crowns onto the 12 implants with < 1 mm midfacial recession showed a straight or concave buccal emergence profile. Four out of 6 implants with ≥ 1 mm midfacial recession were in a *central incisor position*. Only 4 out of 12 implants showing < 1 mm midfacial recession were in such a position. Five out of six implants with ≥ 1 mm midfacial recession had at least 2 putative risk factors. In contrast, all 12 implants with < 1 mm midfacial recession had no or only one putative risk factor.

Four out of 6 implants with \geq 1 mm midfacial recession were restored with a cement-retained restoration. Six out of 12 implants with < 1 mm midfacial recession were also restored with a cement-retained restoration. Therefore, the prosthetic connection did not seem to have an impact on the development of midfacial recession.

(HERE APPROXIMATELY TABLE 3 AND FIGURE 4 PLEASE)

Sub-analysis of cases with missing buccal bone

Three out of eighteen (17 %) implants failed to demonstrate visible buccal bone on CBCT at the final re-assessment. One of these 3 implants was too buccally positioned and showed 1 mm midfacial recession. Another yielded peri-implant mucositis and the third implant showed peri-implantitis.

DISCUSSION

The primary objective of this study was to evaluate the clinical, aesthetic and radiographical outcome of single immediate implants in the aesthetic zone after a follow-up period of 10 years. According to recent systematic reviews, IIP may present a higher risk for early failures as compared to implant placement in healed (Cosyn et al., 2019) as well as preserved (Zhou et al., 2019) alveolar ridges. This might be attributed to a lower bone-to-implant contact possibly hampering primary implant stability. Therefore, a bone condensing implant with variable-thread design was selected for this study. In the current sample, one implant was removed during the early healing phase and one late failure occurred due to peri-implantitis amounting to a 10-year survival rate of 90.9%. Marginal bone loss was low and stable between 5 and 10 years, resulting in a mean loss of 0.31 mm at study termination. This is comparable to the results of a study by Cristalli et al. using the same implant type (Cristalli et al., 2015). In contrast, mean marginal bone loss of 0.81 mm may be expected following IIP according to Slagter et al. (2014). In this respect, data on marginal bone loss around immediate implants should be interpreted with caution. Without socket grafting, significant bone growth occurs within a socket and along the implant surface resulting in bone gain or negative data on marginal bone loss. With socket grafting, data on

marginal bone loss may also be biased since one basically assesses the level of the grafting material.

Limited long-term data have been published on soft tissue alterations and aesthetic outcomes following IIP (Benic et al., 2012, Cooper et al., 2014, Cosyn et al., 2016, Furhauser et al., 2017, Raes et al., 2018). Although a mean PES of 10.61 over time seems acceptable and quite similar to the results of Raes et al. (2018), it should be pointed out that only low-risk patients with ideal hard and soft tissue levels had been selected. Nevertheless, 17 % of the implants displayed obvious alveolar process deficiency.

In the present study, midfacial recession was stable between 5 and 10 years amounting to 0.58 mm. More important is that 6 out of 18 (33 %) implants demonstrated ≥ 1 mm midfacial recession at the final re-assessment. This is substantially higher than 11 % as described in a systematic review by Khzam et al. (2015). Possibly, the difference in observation period may explain this and points to the fact that mucosal changes may still occur after the first year of implant function. The successive reporting on the present study sample after 1, 5 and 10 years may also corroborate this (Cosyn et al., 2013a, 2016).

Given the limited sample size, only putative risk factors for ≥ 1 mm midfacial recession could be identified. Buccal shoulder position, no CTG, convex emergence profile and central incisor position were more frequently observed for cases with ≥ 1 mm midfacial recession. Whether these are true risk factors remains to be investigated in large studies on the basis of regression analyses. Interestingly, also Chen and Buser (Chen and Buser, 2009, 2014) observed an association between a buccal shoulder position and advanced midfacial recession following IIP. They advised to install implants palatal to the imaginary line of emergence between the two adjacent teeth to ensure mucosal stability (Buser et al., 2004). It should be noted that our study was initiated more than a decade ago, before the implementation of pre-operative CBCT planning and computer-assisted surgery. The fact that all of the implants with a buccal shoulder position ($n = 3$) presented ≥ 1 mm midfacial recession shows benefit of these recent innovations. Given that guided implant surgery is most accurate (Younes et al., 2018) and has a favorable cost-benefit ratio (Younes et al., 2019), clinicians should at the very least consider guided implant surgery for IIP in order to avoid midfacial recession. Besides a buccal shoulder position, descriptive statistics also identified the lack of a CTG as putative risk factor for ≥ 1 mm midfacial recession. The application of a CTG as an adjunct to IIP was recommended in a recent RCT as it stabilized midfacial soft tissue levels in the short term (Zuiderveld et al., 2018). A convex buccal emergence profile was also associated

with ≥ 1 mm midfacial recession in this study. This observation was most interesting since a slightly concave emergence profile in proximity to the bone was intended and attention was paid to replication of this emergence profile for fabrication of the permanent crown. Clearly, this goal was not achieved in two cases demonstrating a convex buccal emergence profile. In this respect, perfect replication of the emergence profile may be difficult when opting for a cement-retained restoration and stock abutment. In this study, ten out of 18 implants that could be re-assessed after 10 years had a cement-retained permanent restoration. Six of those were cemented onto a titanium stock abutment. CAD-CAM abutments (Long et al., 2017) and the one-abutment one-time concept (Molina et al., 2017) have shown promising results in terms of soft tissue preservation, yet more studies are needed to elucidate their clinical relevance. Finally, descriptive statistics showed that implants with ≥ 1 mm midfacial recession were more frequently found in a central incisor position than implants with < 1 mm midfacial recession. This was also observed at 5 years follow-up and could be explained by the wider mesio-distal gap increasing the risk for resorption of the buccal bone wall and associated soft tissue margin. Altogether, it is important to realize that this tentative analysis does not allow robust conclusions.

Even though ≥ 1 mm midfacial recession was a common finding in this long-term study, the judgement of patients was unfortunately not assessed. However, this information is important since only soft tissue alterations noticed by patients are clearly clinically relevant. In this context, studies have indicated that clinicians are usually more critical than patients in judging aesthetics (Chang et al., 1999, Meijndert et al., 2007, Esposito et al., 2009, Cosyn et al., 2013a, Cosyn et al., 2013b).

It is assumed that the presence of an intact facial bone wall is an important parameter to attain a stable peri-implant mucosa (Chen and Buser, 2009). Benic et al. (2012) found that 7 years after IIP the mucosal margin was 1 mm more apically located in cases without a visible facial bone wall on CBCT. They used DBBM particles to graft the bone-to-implant gap. According to a recent RCT, bone grafting may significantly reduce resorptive changes of the facial bone wall (Sanz et al., 2017). Mean buccal bone thickness amounted to 1.1 mm, which has also been reported by Raes et al. (2018). More importantly, three out of 18 implants (17 %) failed to demonstrate buccal bone. Benic et al. (2012) and Kuchler et al. (2016) both reported thinner facial bone walls (0.4 mm and 0.9 mm, respectively) and a higher frequency of missing facial bone walls (24% and 35.7%, respectively). However, both these authors performed IIP with bone grafting using DBBM particles and a collagen membrane. For this procedure, a buccal full thickness flap was elevated

which may induce more facial bone wall resorption (Clementini et al., 2015). On the other hand, Raes et al. (2018) never found a deficient facial bone wall 8 to 10 years following flapless IIP without bone grafting. A possible explanation for this finding may be substantial differences in baseline buccal bone thickness between our study (0.8) and the study of Raes et al. (2018) (1.29). Finally, when discussing buccal bone at implants it is important to address some methodological aspects. The phenomenon of “implant blooming” on CBCT can be overcome by aligning an implant template corresponding to the actual implant dimensions, which was done in this study. Even then, very thin buccal bone walls remain difficult to assess. In this regard one should realize that any buccal bone measurement related to bone visible on CBCT. Consequently, having no visible buccal bone on CBCT does not necessarily imply that there is no bony layer.

When interpreting the outcomes of this study, the following limitations should be taken into consideration. First, this study did not involve a control group and therefore any comparison to an alternative protocol may be biased. Second, although patients could be prospectively followed for 10 years, a study sample of 18 patients is small to draw robust conclusions. For that reason, putative risk factors for advanced midfacial recession were identified. These should be confirmed in appropriately powered clinical studies.

CONCLUSIONS

This prospective study on IIP demonstrated stable clinical, aesthetic and radiographical outcomes between 5 and 10 years of follow-up. However, advanced midfacial recession was common after 10 years. Therefore, caution is required for IIP in the aesthetic zone.

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Table 1. Clinical and aesthetic outcome of single immediate implants

Parameter	5 years (n=17)	10 years (n=18)	p-value*
Marginal bone loss from baseline (mm)†	0.19 (0.30) 0.09 (-0.03; 0.38)	0.31 (0.64) 0.03 (0.00; 0.33)	0.944
Plaque score (%)	15 (15) 25 (0; 25)	15 (21) 0 (0; 25)	0.557
Probing depth (mm)	3.1 (0.4) 3.0 (2.8; 3.5)	3.4 (1.5) 3.0 (2.8; 3.8)	0.825
Bleeding on probing (%)	32 (19) 25 (25; 50)	32 (27) 25 (19; 50)	0.935
Pink Esthetic Score (/14)	11.18 (1.38) 11 (10.5; 12)	10.61 (1.75) 10 (9.75; 12)	0.164
Mesial papillary recession from baseline (mm)‡	-0.09 (0.33) 0 (0; 0)	-0.03 (0.36) 0 (0; 0)	0.564
Distal papillary recession from baseline (mm)‡	0.25 (0.45) 0 (0; 0.5)	0.22 (0.31) 0 (0; 0.5)	0.317
Midfacial recession from baseline (mm)‡	0.53 (0.53) 0.5 (0.25; 1)	0.58 (0.60) 0.5 (0; 1)	0.655

Values in bold: Mean (SD); italics: Median (IQ range)

Negative value indicates bone gain (parameter: marginal bone loss) or vertical soft tissue growth (parameter: mesial papillary recession)

*Comparison between 5- and 10-year data using Wilcoxon signed ranks test

†Baseline: implant installation

‡Baseline: pre-operative status

Table 2. Bone dimensions at tooth and implant sites at 10 years follow-up						
	Tooth sites			Implant sites		
	Level -1 mm†	Level -3 mm†	Level -5 mm†	Level -1 mm†	Level -3 mm†	Level -5 mm†
Alveolar process width (mm)	8.9 (0.8) 8.9 (8.3; 9.4)	9.1 (1.0) 9.3 (8.3; 10.1)	9.1 (1.4) 9.3 (8.3; 9.9)	7.3 (1.2) 7.4 (6.7; 8.2)	7.8 (1.1) 7.9 (7.2; 8.7)	8.3 (1.1) 8.4 (7.5; 9.4)
Buccal bone thickness (mm)	0.8 (0.4) 0.8 (0.6; 1.0)	0.8 (0.4) 0.8 (0.5; 1.0)	0.7 (0.4) 0.8 (0.3; 0.9)	1.1 (0.8) 1.1 (0.7; 1.6)	0.9 (0.9) 0.9 (0.0; 1.4)	0.7 (0.8) 0.7 (0.0; 1.0)

Values in bold: Mean (SD); italics: Median (IQ range)

†Distance apical to the implant shoulder

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Table 3. Putative risk factors for ≥ 1 mm midfacial recession at 10 years follow-up

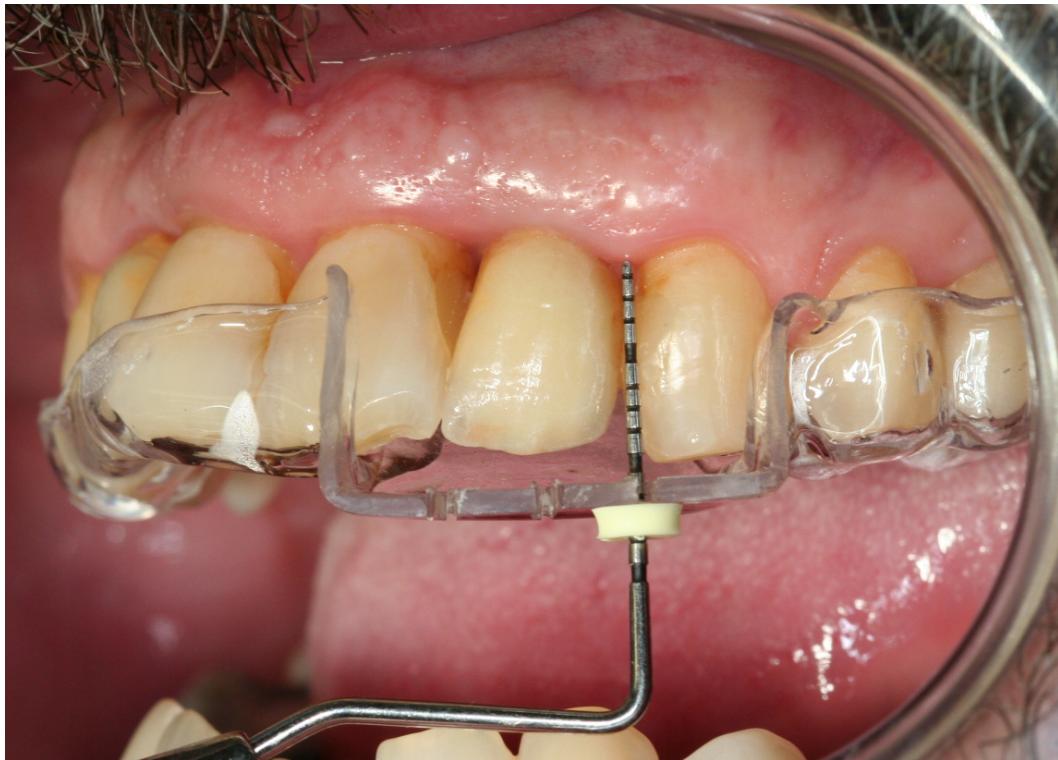
	Buccal shoulder position	No CTG	Convex emergence profile	Central incisor position
Implants with ≥ 1 mm midfacial recession (n = 6)	Red	Red	Red	Red
	Green	Red	Green	Red
	Red	Red	Green	Red
	Green	Red	Red	Red
	Red	Red	Green	Green
	Green	Red	Green	Green
Implants with < 1 mm midfacial recession (n = 12)	Green	Red	Green	Green
	Green	Red	Green	Green
	Green	Red	Green	Green
	Green	Red	Green	Green
	Green	Green	Green	Red
	Green	Green	Green	Red
	Green	Green	Green	Red
	Green	Green	Green	Green

CTG: connective tissue graft

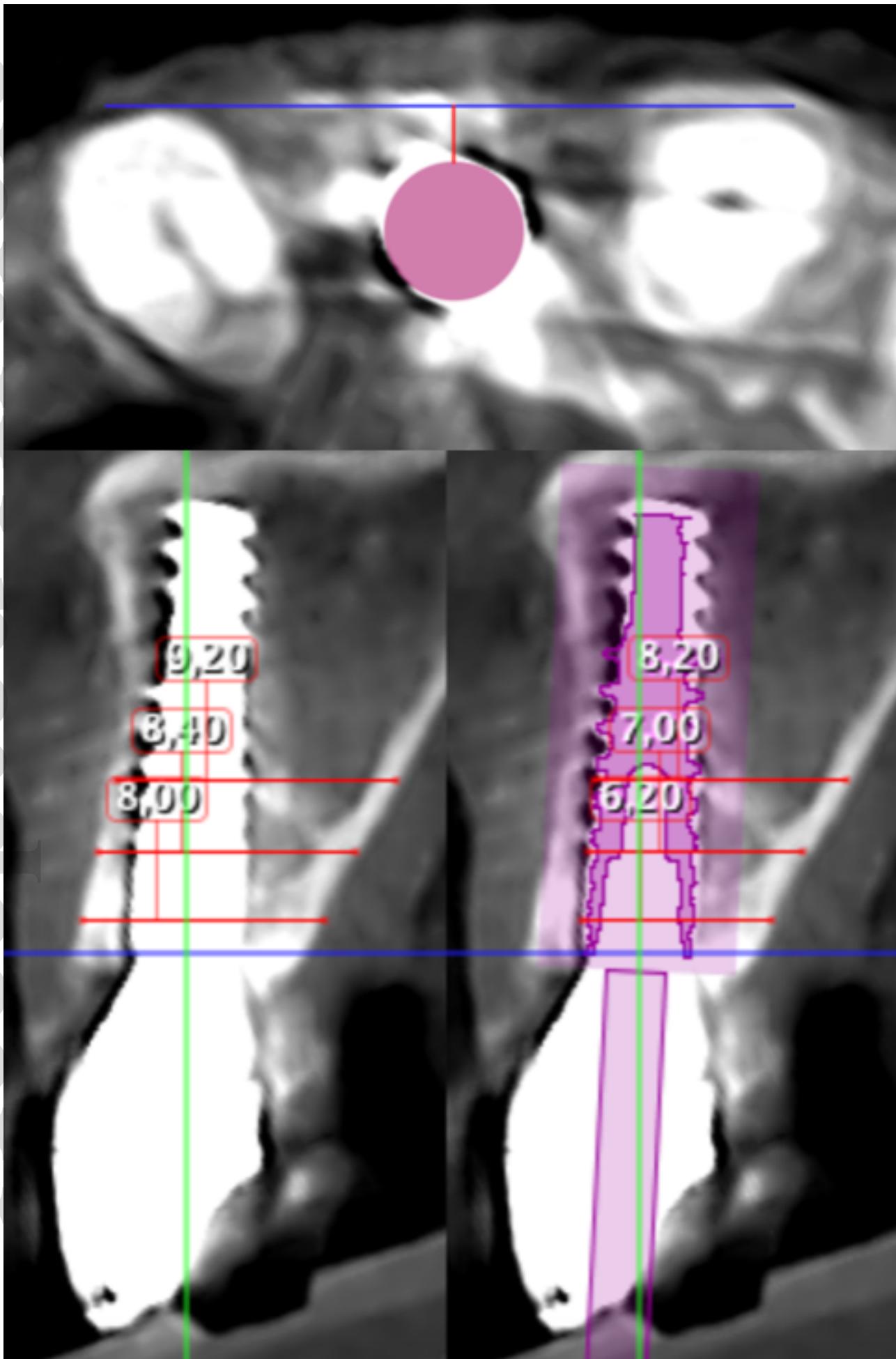
Red: patient positive for putative risk factor

Green: patient negative for putative risk factor

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