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# Immediate and conventional single implant treatment in the anterior maxilla: 1-year results of a case series on hard and soft tissue response and aesthetics

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***Abstract***

**Aim:** The main objective of this clinical study was to document midfacial soft tissue dynamics following single immediate implant treatment (IIT) and conventional implant treatment (CIT) in the anterior maxilla when performed by experienced clinicians in well-selected patients.

**Material and Methods:** Appropriate bone volume and ideal soft tissue levels were considered requirements for implant therapy. Additional prerequisites for IIT were intact socket walls and a thick gingival biotype. CIT included standard flap elevation whereas IIT was either performed with a flap or flapless procedure. All implants were provisionally restored using cemented acrylic crowns. Bone levels, papillae and midfacial soft tissue levels were monitored at regular intervals. The aesthetic outcome was assessed after 1 year using the pink aesthetic score (PES) and white aesthetic score (WES).

**Results:** Sixteen patients (10 men, six women; mean age 45) received an immediate implant and 23 patients (12 men, 11 women; mean age 40) had conventional implant surgery. One immediate implant failed in the early healing phase. The mean bone level from the implant–abutment interface was 0.85 mm for IIT and 0.65 mm for CIT after 1 year ($p = 0.144$). Mesial papillae remained stable over time. Minute loss of distal papillae occurred following IIT (− 0.38 mm) and a tendency for re-growth was found following CIT (0.60 mm). Midfacial soft tissues remained stable over time following IIT with only 7% showing advanced recession (> 1 mm). Flapless surgery induced less midfacial recession than flap surgery ($p = 0.023$). Significant midfacial recession occurred following CIT (− 1 mm). Overall, 24% were aesthetic failures (PES < 8 and/or WES < 6) and 8% showed an (almost) perfect outcome (PES ⩾ 12 and WES ⩾ 9). The remainder (68%) demonstrated acceptable aesthetics.

**Conclusions:** Immediate implants demonstrated fairly stable midfacial soft tissue levels with only a minority of cases showing advanced recession. Irrespective of the timing of implant placement, aesthetic failures seem to be rather common and only a strict minority may show perfection.

Key words: conventional; dental implant; immediate; pink aesthetic score; single tooth; soft tissues

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**Conflict of interest and source of funding statement**

The authors declare that they have no conflict of interests.
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Single implant treatment has been found to be highly predictable in terms of implant survival and hard tissue remodelling (Creugers et al. 2000, Berglundh et al. 2002, den Hartog et al. 2008, Jung et al. 2008). These classical parameters seem hardly affected by the moment of implant placement relative to tooth extraction (Lindeboom et al. 2006, Palattella et al. 2008, Block et al. 2009, Eghbali et al. 2010) and variations in the surgical (De Bruyn et al. 2009) and restorative procedure (Jemt 1999, Ryser et al. 2005, Hall et al. 2007, De Rouck et al. 2009a). However, the impact of the treatment strategy on the soft tissues surrounding single implant restorations remains controversial. The presence of papillae is believed to be primarily related to the bone level at the adjacent tooth (Jemt 1997, Choquet et al. 2001, Kan et al. 2003b, Henriksson & Jemt 2004, Cardaropoli et al. 2006). Consequently, more papilla preservation would be expected following papilla preservation flaps or flapless surgery, although the scientific support for this is limited (Gomez-Roman 2001, Block et al. 2009). In addition, the management of the midfacial soft tissue level is considered problematic, in particular, when immediate implant placement is pursued (Chen & Buser 2009). Animal experiments as well as human studies showed that post-extraction bone remodelling is unaffected by immediate implant placement, possibly resulting in additional midfacial recession (Araújo et al. 2005, Botticelli et al. 2004). This view is confirmed by a case series on immediate implant treatment (IIT) showing advanced midfacial recession exceeding 1 mm or 10% of the crown length in 18–35% of the cases (Chen et al. 2007, Juodzbalys & Wang 2007, Kan et al. 2007, Evans & Chen 2008, Chen et al. 2009). In contrast, limited recession has been found following IIT in other case series (Wöhrle 1998, Groisman et al. 2003, Kan et al. 2003a, Cornelini et al. 2005, De Rouck et al. 2008, Redemagni et al. 2009), which is in line with what has been described for conventional implant treatment (CIT) in healed sites (Bengazi et al. 1996, Jemt 1999, Small & Tarnow 2000, Ryser et al. 2005, Cardaropoli et al. 2006, Zarone et al. 2006, Hall et al. 2007). Given this controversy, the primary goal of this clinical study was to document midfacial soft tissue dynamics following IIT and CIT when performed by experienced clinicians in well-selected patients.

Besides papillae and midfacial soft tissue level, the aesthetic outcome of single implant treatment is influenced by a number of factors related to the soft tissues as well as the implant crown. The Implant Crown Aesthetic Index by Meijer et al. (2005), the pink aesthetic score (PES) by Fürhauser et al. (2005) and the white aesthetic score (WES) by Belser et al. (2009) include an ordinal scoring index for these parameters and have been used to assess aesthetics. Still, the available literature on the aesthetic outcome of single implant treatment using such objective criteria is scarce. To our knowledge, only two case series relating to IIT (Juodzbalys & Wang 2007, Chen et al. 2009) and two relating to CIT (Lai et al. 2008, Cosyn et al. 2010) have been published. Hence, a secondary objective of this study was to document the aesthetic outcome of IIT and CIT using objective criteria.

## Material and Methods

### Patient selection

The present study included patients that were consecutively treated with a single chemically modified titanium implant (Astra Tech AB, Osseospeed™, Mölndal, Sweden) in the University Hospital in Ghent between May 2005 and December 2006 by one experienced periodontist (F. R.) and one prosthodontist (P. C.). The inclusion criteria were as follows:

1. At least 18 years old.
2. Minimum 20 teeth present.
3. Good oral hygiene defined as a full-mouth plaque score $\leqslant 25\%$ (O'Leary et al. 1972).
4. Presence of a single failing tooth or a single tooth gap in the anterior maxilla (15–25) with both neighbouring teeth present.
5. Ideal soft tissue level and contour at the facial aspect of the failing tooth or the single tooth gap, implying no visible disparity between the latter and the contra-lateral tooth and the adjacent teeth.
6. Appropriate bone volume as assessed by standard radiographs or CT scans to ensure primary implant stability.
7. Signed informed consent.

Exclusion criteria were as follows:

1. Pregnancy at the time of inclusion.
2. Diabetes mellitus.
3. Smokers.
4. Non-treated periodontal diseases and/or caries.
5. Immediate implantation in high-risk patients with a thin-scalloped gingival biotype as determined by the transparency of the periodontal probe through the gingival margin while probing the buccal sulcus of the upper central incisor (De Rouck et al. 2009b).
6. Tooth extraction at the site of interest within 3 months before inclusion.
7. Sites treated by guided bone regeneration or bone grafts before implant placement.

The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000 and the protocol was approved by the ethical committee of the University Hospital in Ghent (UZ Ghent, no. 2004/439).

### Treatment strategies

The present study was based on a convenience sample including data on IIT if the failing tooth was still in situ, and CIT if the tooth had already been lost at the time of inclusion. Upon surgical evaluation of either the extraction socket or the healed alveolar ridge, clinical decisions were made whether or not an implant could be placed. An important criterion in this respect included the dimension of available alveolar bone, and for sockets, the presence of an intact buccal bone wall. If implant placement was not possible at that time, guided bone regeneration was performed as described earlier (Cosyn & De Rouck 2009). These patients received an implant 4–5 months thereafter and were not considered in this study. If implant placement was possible at that time, however, without reaching a minimum insertion torque of 25 N cm, the case was also excluded because it was deemed inappropriate to install an immediate provisional crown under these conditions.

### Surgical procedures

When considered appropriate by the implant surgeon (F. R.), flapless surgery was performed in extraction sockets. In all other cases, minimal mucoperiosteal flaps were elevated including crevicular incisions extending to the midfacial aspect of both neighbouring teeth, hereby fully reflecting papillae (Fig. 1b). A midcrestal incision was performed in healed ridges. In extraction sockets, the palatal wall and bone apical to the extraction socket were engaged in the osteotomy avoiding contact with the intact buccal wall at all times. A correct three-dimensional implant positioning was considered of pivotal importance in all cases. Surgical guides were never used to facilitate this. As described by Buser et al. (2004), the neighbouring teeth essentially served as a reference for correct implant positioning. In the mesiodistal dimension, a minimum distance of 2 mm between the implant shoulder and neighbouring tooth was pursued. In the orofacial dimension, the implant shoulder was positioned palatal to the point of emergence at the adjacent teeth. In the apicocoronal dimension, the implant shoulder was located at the level of the buccal bone crest usually corresponding to a 1–2 mm apical position from the cement–enamel junction of the neighbouring teeth (Fig. 1b). In none of the cases, bone grafting materials were used. This implied for CIT that the alveolus was allowed to heal for at least 3 months without any hard tissue conditioning before or at the time of implant placement. The bone gap that was present between the alveolar crest and the implant shoulder following IIT was registered (width at the buccal aspect $<2$ mm or $\geqslant 2$ mm), yet never filled. Also, soft tissue conditioning using connective tissue grafts was never performed in any of the cases.

## Restorative Procedures

### Provisional restoration

All implants included in this study were immediately provisionalized by means of a titanium Direct Abutment (Astra Tech AB) (Fig. 1c) and an acrylic crown installed by the implant surgeon (F. R.). Abutment dimensions were selected on the basis of implant angulation and depth of the implant shoulder in reference to the midfacial soft tissue margin. A distance of the latter to the abutment–crown interface of about 1 mm was pursued to avoid deep cementation. The acrylic crown was fabricated chairside and adapted onto an abutment replica (Fig. 1d). The restoration was highly polished and cleared of all contact in centric occlusion and during eccentric movements before cementation with a temporary cement (TempBond® NE, Scafati, Kerr, Italy) (Fig. 1e). Following provisionalization, post-operative instructions were given focusing on the avoidance of the surgical site. In addition, oral hygiene was reinforced and medication was prescribed. The latter included analgesics (paracetamol 1000 mg), antibiotic therapy (amoxicillin 500 mg three times per day for 5 days) and chlorhexidine rinsing (0.2% chlorhexidine digluconate mouthwash two times per day for 1 week).

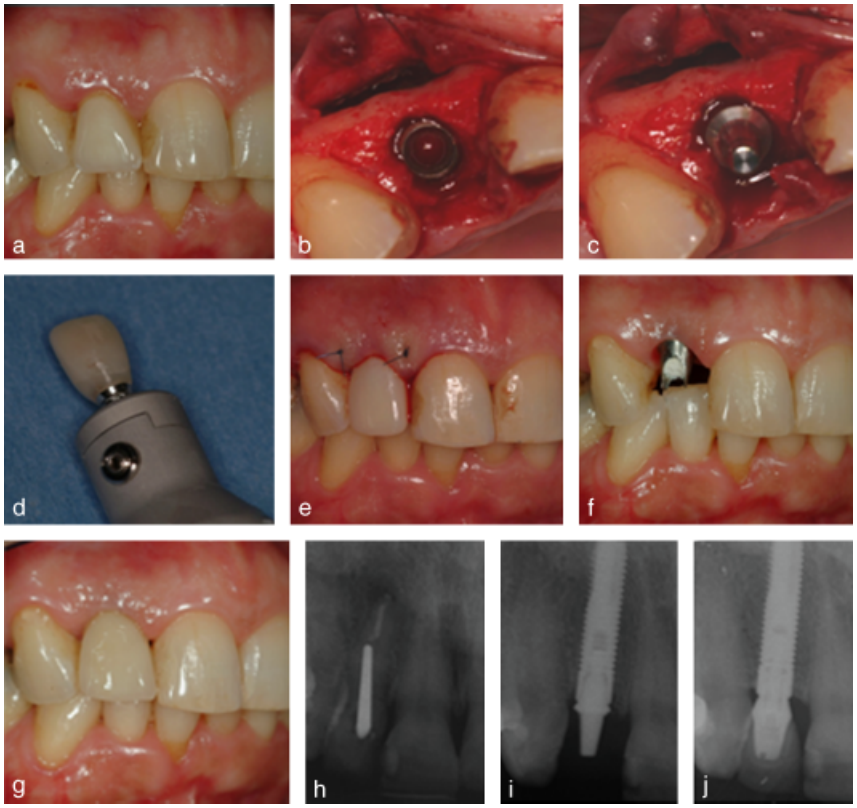


*Fig. 1.* Immediate implant case. (a) Preoperative condition of a patient with an endodontic problem on the maxillary right lateral incisor, (b) implant placement after tooth extraction, (c) Direct Abutment™ on top of the implant secured with 15 Ncm, (d) chairside adapted temporary crown on replica connected to handle, (e) cemented temporary crown and sutures, (f) TiDesign abutment™ connection before final crown placement, (g) result after one year of function, (h, i, and j) radiographic evaluation of the marginal bone level at intake, time of implant placement (Direct Abutment™) and 1-year follow-up (TiDesign Abutment™).

### Permanent restoration

Eight weeks following implant surgery, the patient was referred to the prosthodontist. If the Direct Abutment provided adequate retention, it was secured at 25 N cm with a torque wrench. If more retention for the final restoration was deemed necessary, the Direct Abutment would be replaced by a titanium TiDesign™ (Astra Tech AB) abutment (Fig. 1f). In this case, the Direct Abutment was removed and a torque test was performed with the implant driver and torque wrench, again at 25 N cm. The absence of implant mobility and pain was considered indicative of adequate osseointegration. An impression was made of the Direct Abutment or implant platform when a TiDesign™ abutment was chosen, using polyether impression material (Impregum Penta®, 3M Espe, Seefeld, Germany). All implants included in this study were restored by means of a titanium abutment and full-ceramic crown (Procera®, Nobel Biocare, Göteborg, Sweden). The latter was fabricated by the same dental technician (Themodent, Wemmel, Belgium) and all clinical steps relating to the permanent restoration were performed by the same prosthodontist (P. C.). Approximately 2 weeks following impression, the full-ceramic crown was

cemented using glasionomer cement (Ketac™ Cem, 3M Espe, Zoeterwoude, the Netherlands) (Fig. 1g). Finally, oral hygiene was reinforced.

## Outcome Variables

### Implant survival and hard tissue response

At each reassessment, namely after 4, 12, 26 and 52 weeks of follow-up, the presence or absence of the implant was registered. Immediately following the connection of the provisional restoration (baseline) and after 4, 12, 26 and 52 weeks a peri-apical radiograph was taken using the long-cone paralleling technique (Fig. 1h–j). An X-ray holder (XCP Bite Block, Dentsply Rinn, Elgin, IL) with an occlusal jig (Tempron, GC, Aichi, Japan) was used to standardize the angulation and position of the film in relation to the implant and the X-ray beam. An independent radiologist not affiliated with the study centre and blinded for the treatment strategy, evaluated all radiographs. Marginal bone level defined as the distance from the first bone-to-implant contact to the implant–abutment interface was determined at the mesial and distal aspect of the implant with measurements to the nearest 0.1 mm under seven times magnification. Per time point, mesial and distal levels were averaged to have a single value per implant.

### Soft tissue response

Immediately following the connection of the provisional restoration (baseline) and after 4, 12, 26 and 52 weeks soft tissue dimensions were calculated using standardized digital slides and computer software (Gingival Status 2009 1.0.0.2. by Inspector BV, Baarn, the Netherlands). Figure 2 illustrates the procedure. At each time point, the patient was positioned in front of the camera in a reproducible manner by biting into an individualized bite fork (Futar D®, Kettenbach, Eschenburg, Germany; Artex®, Amann Girbach, Pforzheim, Germany). The camera had a fixed position, while the angle could be adjusted by rotating the patient. As such, the photograph could be taken perpendicular to the implant crown. The angle on the protractor was registered for each patient in order to have the patient in the same position at each reassessment. With the computer program a yellow line was drawn connecting the incisal lines on both adjacent teeth. The three yellow lines perpendicular to this reference line were used to measure mesial and distal papillae and midfacial level. The latter was considered the primary outcome variable in this study. All slides were analysed by the same blinded clinician (E. C.). Calibration was performed by measuring the width of the mesial neighbouring natural tooth on a study cast with a slide ruler to the nearest 0.1 mm. This was transferred to the digital slide by means of a blue line. The study cast was made after final crown delivery. The changes from baseline were calculated for each reassessment interval. As such, recession was defined as soft tissue loss resulting in a negative value. Similarly, overgrowth or soft tissue gain resulted in a positive value. Intra- and inter-examiner reliability on study cast measurements were assessed on the basis of duplicate recordings relating to 17 study casts. The results indicated good to excellent agreement [agreement within 0.2 mm deviation: 17/17; Pearson's correlation coefficient $\geqslant 0.997$ ($p < 0.001$); Wilcoxon's signed-ranks test: $p \geqslant 0.668$). Intra- and inter-examiner reliability on digital analyses were assessed on the basis of duplicate recordings relating to 50 digital slides. Again, the results indicated good to excellent agreement [agreement within 0.2 mm deviation: $\geqslant 49/50$; Pearson's correlation coefficient $\geqslant 0.998$ ($p < 0.001$); Wilcoxon's signed-ranks test: $p \geqslant 0.058$).

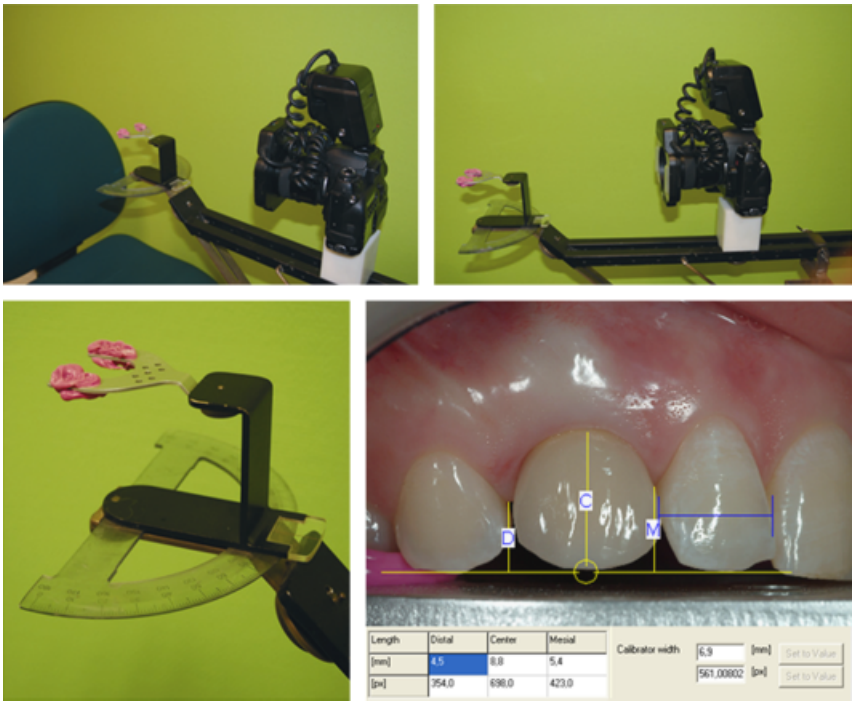


*Fig. 2.* Set-up and digital analysis for monitoring soft tissue remodelling (for details see text).

### Aesthetics

The PES was used to evaluate the aesthetic outcome of the peri-implant soft tissues after 52 weeks (Fürhauser et al. 2005). Each parameter is assessed with a 0–1–2 score with 2 being the best and 0 being the worst score. Papillae are evaluated for completeness; the other variables are assessed by comparison with a reference tooth, which is the contra-lateral tooth for incisor and cuspid replacements and the neighbouring premolar for premolar replacements. The WES was used to evaluate the aesthetic outcome of the visible part of the implant restoration after 52 weeks (Belser et al. 2009). Again, each parameter is assessed with a 0–1–2 score. All variables are assessed by comparison with a reference tooth, which is the contra-lateral tooth for incisor and cuspid replacements and the neighbouring premolar for premolar replacements.

All PES and WES scores were recorded by a blinded clinician who had not been involved in any treatment (J. C.) and were based on frontal and

occlusal colour slides. Because study casts corresponding to the 1-year follow-up were also available, these were used in addition to the occlusal slides in order to assess alveolar process deficiency. The recording clinician was calibrated before the study on the basis of 20 single implant cases. Per case a frontal and occlusal colour slide was available and all were scored twice with an interval of 1 week. The 20 cases were also scored by another clinician who performed all the scores for another study (Cosyn et al. 2010). The results indicated fair to perfect agreement as defined by Landis and Koch (1977) [$\kappa \geqslant 0.360$ ($p \leqslant 0.022$)] and all dissimilarities concerned one unit disparities.

#### Statistical analysis

Data analysis was performed using the patient as the experimental unit. Bone-level and soft tissue changes over time within each group were examined using the Friedman test. If a significant time effect was found, Wilcoxon's signed-ranks tests were performed comparing the different time points two by two. The impact of the surgical technique (flapless *versus* flap approach) and the width of the bone gap ($<2$ mm *versus* $\geqslant 2$ mm) on soft tissue changes for immediately installed implants was examined using the Mann–Whitney test. The latter was also adopted to evaluate the influence of the gingival biotype (thin *versus* thick) on soft tissue changes for conventionally installed implants. The level of significance was set at 0.05 for each test with no correction for multiple testing.

## Results

Of the 25 patients scheduled for IIT, 16 patients (10 men, six women; mean age 45; age range 22–68) received an immediate single implant as planned. Nine were excluded during surgery because of buccal bone dehiscency and/or fenestration. Twenty-three patients (12 men, 11 women; mean age 40; age range 19–75) had conventional implant surgery in healed bone. There were no exclusions in any of the groups because of insufficient insertion torque.

The reasons for tooth loss are shown in Table 1. Caries/endodontic lesions and tooth fractures were the most prevalent reasons for tooth failure in both groups.

*Table 1*. Reasons for tooth loss sorted per treatment strategy

| Treatment strategy | Reasons for tooth loss | | | | | Total |
|---|---|---|---|---|---|---|
| | Agenesis | Fracture | Caries/endodontic | Periodontal | Root resorption | |
| IIT | N/A | 5 | 7 | 1 | 3 | 16 |
| CIT | 8 | 5 | 6 | 3 | 1 | 23 |
| Total | 8 | 10 | 13 | 4 | 4 | 39 |

IIT, immediate implant treatment; CIT, conventional implant treatment.

*Table 2*. Implant positions sorted per treatment strategy

| Treatment strategy | Implant positions | | | | Total |
|---|---|---|---|---|---|
| | Central incisor | Lateral incisor | Cuspid | Premolar | |
| IIT | 3 | 5 | 2 | 6 | 16 |
| CIT | 3 | 10 | 1 | 9 | 23 |
| Total | 6 | 15 | 3 | 15 | 39 |

IIT, immediate implant treatment; CIT, conventional implant treatment.

*Table 3*. Implant length and diameter sorted per treatment strategy

| Treatment strategy | Diameter | Length | | | | Total |
|---|---|---|---|---|---|---|
| | | 11 | 13 | 15 | 17 | |
| IIT | 3.5 | 0 | 0 | 0 | 0 | 0 |
| | 4 | 0 | 0 | 2 | 3 | 5 |
| | 4.5 | 0 | 1 | 4 | 1 | 6 |
| | 5 | 0 | 0 | 2 | 3 | 5 |
| CIT | 3.5 | 0 | 4 | 5 | 1 | 10 |
| | 4 | 1 | 3 | 3 | 5 | 12 |
| | 4.5 | 1 | 0 | 0 | 0 | 1 |
| | 5 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 8 | 16 | 13 | 39 |

IIT, immediate implant treatment; CIT, conventional implant treatment.

Implant positions are depicted in Table 2. Overall, lateral incisors and premolars had to be replaced most often.

Table 3 cross-classifies implant length and diameter per treatment strategy.

Only patients with a thick gingival biotype could be treated with an immediate implant according to the selection criteria. Nine out of 23 patients treated by means of conventional implant surgery showed a thin-scalloped gingival biotype.

#### Implant survival and hard tissue response

One immediately installed implant in a lateral incisor position failed, pointing to an implant survival rate of 93.8% for IIT. The failure case presented with a fistula at 12 weeks and the implant was found to be mobile. In the CIT group, all implants survived.

Figure 3 shows the mean bone level over time per treatment strategy and suggests some bone fill in the IIT; however, this could not be statistically confirmed ($p = 0.459$). At 52 weeks, immediate implants showed a mean bone level of 0.85 mm (SD 0.64; range 0.00–0.30). Also in the CIT group, the time effect was not significant ($p = 0.074$). At 52 weeks, these implants showed a mean bone level of 0.65 mm (SD 0.79; range 0.00–3.15).

#### Soft tissue response

The changes relative to baseline in mesial and distal papilla height and midfacial level are illustrated in Table 4.

Mesial papillae remained stable over time in both groups.

A significant time effect was found for distal papillae in the IIT group ($p = 0.021$). However, at the end of the study period, distal papilla height was not significantly different from baseline. Distal papillae in the CIT group remained stable over time.

Midfacial soft tissue levels in the IIT remained stable over time. A significant time effect was found for midfacial levels in the CIT group ($p = 0.007$) showing significant recession relative to baseline at each reassessment. This resulted in a loss of 1 mm after 52 weeks ($p = 0.001$). At the final reassessment, advanced midfacial recession exceeding 1 mm was found in 7% of immediately installed implants and 43% of conventionally installed implants, respectively. Midfacial soft tissue gain exceeding 1 mm was found in 13% of immediately

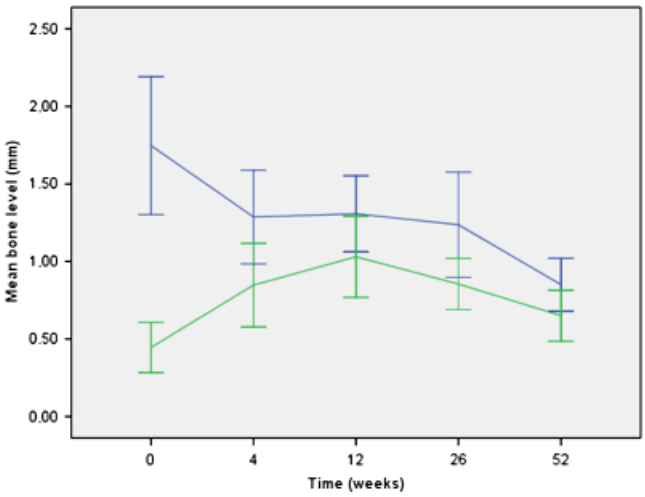


*Fig. 3*. Hard tissue response sorted per treatment strategy. IIT, blue line; CIT, green line. Error bars represent standard errors.

*Table 4*. Soft tissue response sorted per treatment strategy

| | Treatment strategy | 4 weeks | 12 weeks | 26 weeks | 52 weeks |
|---|---|---|---|---|---|
| Mesial papillae | IIT | − 0.63 (0.78) | − 0.45 (0.92) | 0.11 (0.84) | 0.07 (0.99) |
| | CIT | − 0.18 (1.12) | − 0.34 (1.23) | − 0.24 (1.33) | 0.30 (1.38) |
| Distal papillae | IIT[a] | − 0.58 (1.04) | − 0.82 (1.64) | − 0.04 (0.95) | − 0.38 (1.21) |
| | CIT | 0.07 (0.77) | − 0.08 (0.64) | 0.26 (0.85) | 0.60 (0.87) |
| Midfacial level | IIT | − 0.65 (0.65) | − 0.35 (0.64) | − 0.21 (0.62) | − 0.12 (0.78) |
| | CIT[b] | − 0.48 (0.50) | − 0.92 (0.95) | − 0.99 (1.31) | − 1.00 (1.15) |

[a]Significant within group difference between 4 and 26 weeks, 4 and 52 weeks, 12 and 26 weeks.
[b]Significant within group difference between baseline – all re-assessments, 12–52 weeks.
Negative value, soft tissue loss relative to baseline (provisional crown installation); positive value, soft tissue gain relative to baseline; IIT, immediate implant treatment; CIT, conventional implant treatment.

installed implants and 0% of conventionally installed implants, respectively.

Because immediately installed implants were either treated with a flapless (11/16) or flap approach (5/16), the impact of the surgical technique on soft tissue dynamics was explored. Papillae were not influenced by the surgical technique ($p \geqslant 0.124$). However, immediate implants installed with a flapless approach showed significantly less midfacial recession when compared with a flap procedure at 26 weeks (mean difference 0.74 mm; $p = 0.022$) and 52 weeks (mean difference 0.89 mm; $p = 0.023$).

In 9/16 immediate implant cases, the bone gap between the implant shoulder and the buccal bone wall was smaller than 2 mm and in the 7/16 cases it was 2 mm or more. The association of a wide bone gap with midfacial recession was of borderline significance at 52 weeks ($p = 0.053$).

Because patients with a thick (14/23) as well as a thin-scalloped (9/23) gingival biotype were treated by means of conventional implant surgery, the impact of the gingival biotype on soft tissue dynamics was explored. The gingival biotype was associated neither with papilla loss ($p \geqslant 0.082$) nor with midfacial recession ($p \geqslant 0.280$).

### Aesthetics

Table 5 shows the results of all criteria of the PES per treatment strategy. The mean PES was 10.33 (SD 2.29; range 6–14) and 10.35 (SD 1.58; range 7–13) for IIT CIT, respectively. Figure 4 shows the cumulative per cent of the PES per treatment strategy. Dotted lines indicate the upper limit for an unacceptable result (PES = 7) as arbitrarily chosen by the authors. The upper limit for a favourable, yet imperfect result (PES = 11) is indicated likewise. About 1/10 cases showed unfavourable soft tissues. The vast majority showed an acceptable outcome and about one in four cases showed an (almost) perfect result.

As shown in Table 5, the mean WES was 7.20 (SD 2.04; range 3–10) and 7.00 (SD 2.37; range 2–10) for IIT CIT, respectively. Figure 5 shows the cumulative per cent of the WES per treatment strategy. Again, dotted lines indicate arbitrarily chosen thresholds. About one in five cases showed an unfavourable implant crown. Approximately 40% showed an acceptable outcome and another 40% an (almost) perfect result.

The overall aesthetic treatment outcome was assessed by combining the results of the PES and WES. 3/38 (8%) single implant treatments showed an (almost) perfect result (PES $\geqslant$ 12 and WES $\geqslant$ 9). An acceptable result was found for 26/38 (68%) single implant cases. The aesthetic outcome was unfavourable for 9/38 (24%) and 1/38 (3%) was considered unfavourable because of a PES < 8, another five (13%) because of a WES < 6. Three single implant treatments (8%) showed a PES < 8 and WES < 6 and could be regarded as complete aesthetic failures.

## Discussion

Of the 39 implants included in the present study, only one immediate implant failed. This corresponds to the high survival rates ranging from 94% to 100% for single Astra Tech implants as described previously (Palmer et al. 2000, Wennström et al. 2005, Cooper et al. 2007). In addition, our data confirm that implant survival is not significantly affected by the moment of implant surgery relative to tooth extraction (Lindeboom et al. 2006, Palattella et al. 2008, Block et al. 2009, Eghbali et al. 2010).

Long-term clinical studies have shown that the Astra Tech™ implant system yields limited bone remodelling (Palmer et al. 2000, Wennström et al. 2005, Cooper et al. 2007). This study confirms this with mean bone levels well below 1 mm after 1 year of function and irrespective of the treatment strategy.

In order to accurately document soft tissue dynamics, fixed reference points are mandatory. For this purpose, we analysed colour slides calibrated by model casts. The intra- and inter-examiner agreement on this technique was good to excellent. Mesial papillae remained stable over time following either strategy with complete embrasure fill in about 60% of the cases at 1-year

*Table 5*. Aesthetic outcome at 52 weeks sorted per treatment strategy

| | IIT ($n = 15$) | | | CIT ($n = 23$) | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 0 | 1 | 2 |
| Mesial papilla | 0 | 6 | 9 | 0 | 10 | 13 |
| Distal papilla | 2 | 6 | 7 | 2 | 7 | 14 |
| Midfacial level | 2 | 5 | 8 | 2 | 7 | 14 |
| Midfacial contour | 0 | 7 | 8 | 0 | 7 | 16 |
| Alveolar process | 1 | 5 | 9 | 1 | 10 | 12 |
| Soft tissue colour | 1 | 5 | 9 | 1 | 12 | 10 |
| Soft tissue texture | 1 | 7 | 7 | 3 | 13 | 7 |
| Pink esthetic score mean (SD) | | 10.33 (2.29) | | | 10.35 (1.58) | |
| Tooth form | 1 | 6 | 8 | 4 | 9 | 10 |
| Tooth volume | 1 | 5 | 9 | 2 | 4 | 17 |
| Tooth colour | 3 | 7 | 5 | 8 | 7 | 8 |
| Tooth texture | 0 | 7 | 8 | 2 | 6 | 15 |
| Translucency | 2 | 3 | 10 | 0 | 11 | 12 |
| White esthetic score mean (SD) | | 7.20 (2.04) | | | 7.00 (2.37) | |

IIT, immediate implant treatment; CIT, conventional implant treatment.

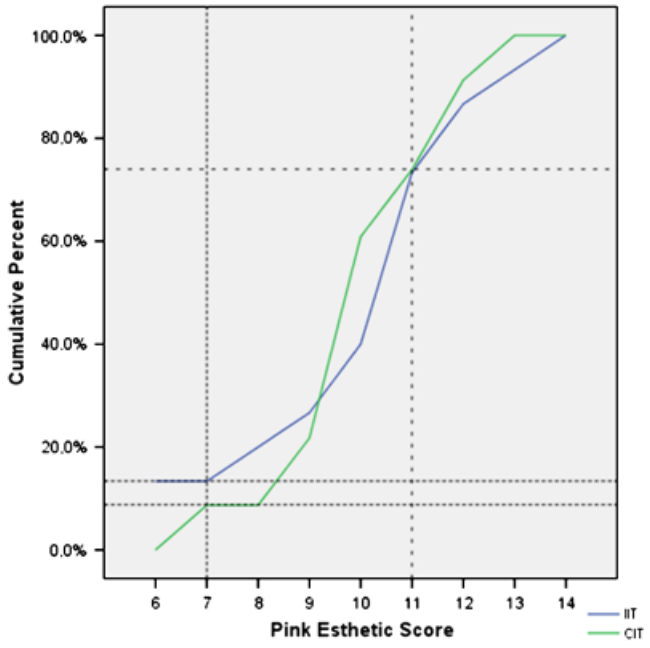


*Fig. 4*. Cumulative percent of the PES sorted per treatment strategy.

follow-up. Distal papilla levels seemed more delicate to maintain as more variation was seen over time especially for immediately installed implants. At 1-year follow-up, significant distal papilla loss was observed following IIT. Because it is believed that the papilla height is mainly related to the bone peak at the adjacent tooth, some papillary regrowth is to be expected following CIT (Jemt 1997, Choquet et al. 2001, Kan et al. 2003b, Henriksson & Jemt 2004, Cardaropoli et al. 2006) whereas minute loss could occur following IIT (Kan et al. 2003a, De Rouck et al. 2008).

Our data showed that midfacial soft tissue levels remained fairly stable over time following IIT with only 7% of the cases showing advanced recession. Earlier studies showed limited, yet significant recession of about 0.5 mm following this treatment concept using Nobelreplace TiUnite® implants (Nobel Biocare) (Kan et al. 2003a, De Rouck et al. 2008). The fact that Astra Tech Osseospeed™ implants yield minimal bone loss could be an explanation for the tissue preservation we observed, albeit recent animal studies could not confirm a relevant impact of the implant system either on bone healing or on soft tissue healing following IIT (de Sanctis et al. 2009, 2010).

In recent pre-clinical studies, it was concluded that implants placed in fresh extraction sockets demonstrate a longer epithelial interface when compared with implants placed in a healed ridge (Vignoletti et al. 2009, de Sanctis et al. 2010). Given the lack of comparative histomorphometric data in humans on these treatment concepts, it is difficult to assess how these findings relate to our clinical results. What is clear on the basis of this study, however, is that a significant time effect for midfacial soft tissue level is to be expected following implant treatment in a healed ridge. This time effect resulted in a significant midfacial recession that mainly developed during the early healing phase and pointed to a mean loss of 1 mm after 1 year of function, which is somewhat higher than what has been described for CIT (Cardaropoli et al. 2006, Zarone et al. 2006, Hall et al. 2007). Given the fact that this time effect was not observed following IIT, the present study suggests a higher risk for midfacial recession following CIT. However, this statement should be interpreted with caution given the results on the PES and the limitations of the study design. With respect to the PES, midfacial soft tissue level in relation to the corresponding natural tooth was comparable for CIT and IIT. In this respect, one should realize that a crestal incision in a healed site creates some excess of midfacial soft tissues following suturing around a provisional restoration. As a result of biologic width development, part of this tissue will inevitably recede explaining excessive midfacial shrinkage following CIT. In contrast, no such excess exists when IIT is performed resulting in more stable levels over time. With respect to the limitations of the study design, we wish to emphasize that this was not a randomized-controlled trial making any comparison possibly biased. A randomized-controlled trial is by definition characterized by random allocation of patients to a control or test strategy and a comparable starting situation for all patients. Because the failing tooth had already been lost at the time of inclusion for CIT, important morphometric information was not available on these cases.

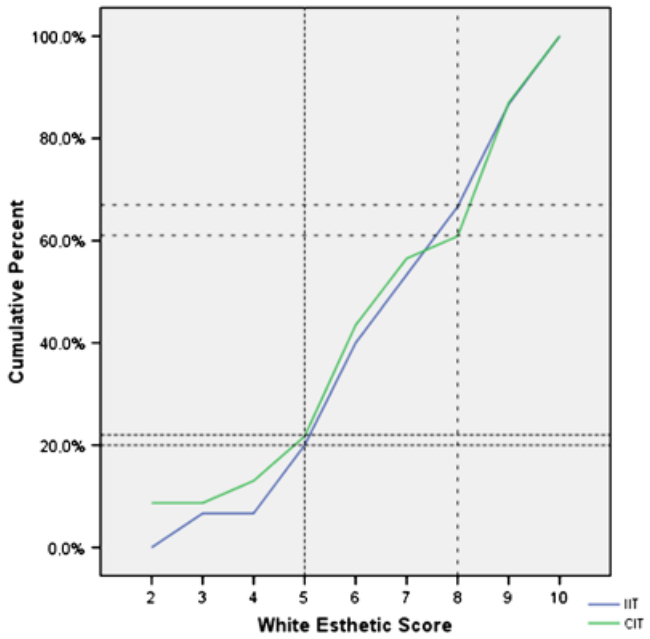


*Fig. 5.* Cumulative percent of the WES sorted per treatment strategy.

Hence, it is unclear to what extent pre-existing disparities among the groups could have influenced our results on soft tissue dynamics. Even though we included consecutively treated cases, we must also acknowledge that the selection criteria for IIT and CIT were not identical. We excluded patients with a thin-scalloped biotype for IIT, which created a significant distortion between the groups and another possible source of bias. A final source of variability, which further diluted the impact of the treatment strategy on soft tissue dynamics was the inclusion of two different surgical approaches (flap and flapless surgery) for IIT. For all these reasons, we believe that one should focus on the within-group effects, rather than on the between-group effects in this study.

Hitherto, at least three randomized-controlled trials have been published comparing IIT with CIT (Lindeboom et al. 2006, Palattella et al. 2008, Block et al. 2009). These may provide more accurate information on possible disparities in terms of soft tissue dynamics. Palattella et al. (2008) and Block et al. (2009) showed comparable or even less midfacial soft tissue recession following IIT when compared with CIT. In another randomized-controlled study by Lindeboom et al. (2006) comparing IIT with CIT in infected sites, a trend towards more midfacial recession was seen following IIT, which seems to contrast the aforementioned studies and ours. A difference in restorative procedures could explain this disparity because a removable partial denture served as provisional restoration in the study by Lindeboom et al. (2006), whereas an implant-retained fixed restoration was installed in the study by Palattella et al. (2008) and Block et al. (2009). As shown in a randomized-controlled study on IIT by De Rouck et al. (2009a), usage of a removable partial denture resulted in 0.75 mm extra midfacial recession on average after 1 year when compared with a fixed provisional crown. As such, the lack of a provisional crown in some case series on IIT (Chen et al. 2007, Juodzbalys & Wang 2007, Evans & Chen 2008, Chen et al. 2009) could partly explain the aforementioned inconsistency with other case series using an implant-supported fixed restoration during healing (Wöhrle 1998, Groisman et al. 2003, Kan et al. 2003a, Cornelini et al. 2005, De Rouck et al. 2008, Redemagni et al. 2009).

To our knowledge, this is the first clinical report showing a significant impact of the surgical technique on midfacial soft tissue dynamics following IIT. Even though this study was not designed to compare a flapless with a flap procedure, immediate implants installed with a flapless approach showed 0.89 mm less midfacial recession on average after 1 year. This finding may be in line with a recent preclinical study showing a trend towards less soft tissue recession and smaller biological width dimensions following the latter (Blanco et al. 2008). Hence, in contrast to earlier beliefs and findings by others (De Rouck et al. 2008, Block et al. 2009), disrupting the blood supply of the fragile buccal bone wall could have an impact on soft tissue levels. Evidently, this issue needs to be scrutinized in controlled clinical studies.

The available literature documenting the aesthetic outcome of IIT and CIT using objective criteria is scarce and comparative studies are lacking. This investigation showed similar aesthetic results for both treatment strategies after 1 year. Hitherto, four case series have been published on IIT or CIT using the PES (Juodzbalys & Wang 2007, Lai et al. 2008, Chen et al. 2009, Cosyn et al. 2010). In these studies, an (almost) perfect soft tissue outcome (PES $\geqslant$ 12) was found in 19–39% of the cases, which resembles quite well with our findings (26%). Unfavourable soft tissue outcome (PES $\leqslant$ 7) was found in 11% of our cases, which is again in line with the available literature (0–22%).

To our knowledge, three case series have been published documenting the aesthetic characteristics of single implant crowns (Belser et al. 2009, Buser et al. 2009, Cosyn et al. 2010). In these studies, an (almost) perfect implant crown (WES $\geqslant$ 9) was found in 18–50% of the cases, which corresponds with our findings (37%). However, 21% of our implant crowns were considered unsuitable from an aesthetic viewpoint (WES $\leqslant$ 5), which is quite high when compared with the available literature (0–20%). The criterion that showed most discrepancy with the corresponding natural tooth was the colour of the crown, which is in agreement with Cosyn et al. (2010).

When assessing the overall aesthetic treatment outcome by combining the results of the PES and WES 8% of our cases showed perfection (PES $\geqslant$ 12 and WES $\geqslant$ 9) and 24% could be considered aesthetic failures (PES $<$ 8 and/or WES $<$ 6). This may be surprising because our results related to well-selected patients treated by experienced clinicians. Clearly, optimal aesthetics may be rare and failures quite prevalent following single implant treatment even under these conditions, which is in agreement with Cosyn et al. (2010).

An important limitation of the present study is that our results may not fully reflect daily practice any more. Indeed, today most clinicians would probably fill the bone gap between the alveolar crest and the implant shoulder following IIT using a grafting material. Similarly, surgeons would probably use more connective tissue grafts in order to condition the soft tissues following either treatment strategy. Needless to say, improvements to the protocols under investigation in this study should be encouraged given the relatively high occurrence of aesthetic failures. On the other hand, the impact on aesthetics of such hard and/or soft tissue grafting still needs to be elucidated in future studies.

In conclusion, this clinical study showed that immediate implants restored at the day of surgery demonstrated stable midfacial soft tissue levels with only a minority of cases showing advanced recession. Clinical experience and careful case selection only considering low-risk patients with a thick gingival biotype are deemed mandatory for IIT. Significant midfacial recession was observed following CIT, which could be explained by flap management. Irrespective of the timing of implant placement, aesthetic failures seem to be rather common and only a strict minority may show perfection.

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**Clinical Relevance**

*Scientific rationale for the study*: Conflicting results have been published concerning the risk for midfacial soft tissue recession following IIT. The goal was to document midfacial soft tissue dynamics following single IIT and CIT.

*Principal findings*: IIT showed stable midfacial levels and CIT demonstrated significant recession.

*Practical implications*: Immediate implants restored at the day of surgery may not show an increased risk for midfacial recession when treatment is performed by experienced clinicians in well-selected cases.