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Astra Tech single-tooth implants: an audit of patient satisfaction and soft tissue form

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Abstract

Aim: To investigate patient centred outcomes, soft tissue morphology, and bone levels.

Material and Methods: Sixty-six subjects, who had completed treatment for a single implant restoration at least l year previously. Appearance was recorded photographically and bone levels and interdental contact points measured from intra-oral radiographs using a ×7 scale loupe. Subjects completed a satisfaction questionnaire.

Results: Subjects were highly satisfied with all aspects of the restoration including the appearance of the soft tissue (median shape/colour score 6 on scale 1–6). Twenty-eight sites in 20 subjects had no contact point between implant crown and adjacent tooth. A normal height papilla was judged to be present in 19 of these sites. These were excluded from the subsequent analysis. In the remaining 46 subjects with contact points the presence (JEMT score 3) or deficiency (score 1/2) of the papilla was significantly related to the distance to the bone level on the adjacent tooth and implant head. Differences were observed between the mesial and distal aspects of the implant restoration.

Conclusions: Examining clinicians were more critical of the restorations than the patients. The presence of a complete papilla was associated with a slightly greater distance from contact point to bone level than previously reported.

Traditionally most reports on single-tooth implant restorations have focused on implant success, complications, soft tissue aesthetics and to a lesser extent patient-based outcomes. There has however been an increasing tendency to scientifically evaluate patient's opinions of various types of implant-supported prosthesis (Belser et al. 2004), especially when placed in the aesthetic zone.

A study by Chang et al. (1999a) on 20 subjects compared single-tooth Branemark implant restorations and the contra-lateral tooth in terms of crown form and surrounding soft tissue dimensions. The implants were all restored with crowns that had been in place for at least 6 months. Results revealed longer implant crowns with a smaller facio-lingual width compared with natural teeth. The soft tissue margin at both facial and proximal sites was more apically located at implant sites compared with the teeth, and papilla dimensions were lower on the distal aspect of implants compared with corresponding teeth. However patient satisfaction measured on a visual analogue scale (VAS) had a median value of 96% indicating

that the observed differences may have been of little concern to the patients themselves. In another paper by the same authors (Chang et al. 1999b), it was shown that clinician's assessment of the aesthetic outcome was lower than that of the patient.

Vermylen et al. (2003) carried out a retrospective study to evaluate patient opinion regarding implant treatment outcome. Forty-eight patients with single-tooth Branemark implants placed by periodontists and restored by general dental practitioners replied to a postal questionnaire. The responses based on a six-grade ordinal scale indicated that overall patient satisfaction was high regarding aesthetics, phonetics, eating ability and overall satisfaction. Forty

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of the patients were examined clinically and radiographically and the professional rating reported that 17 cases were ''perfect'' and 25 cases were ''acceptable''.

Pjetursson et al. (2004), in a study of 104 patients treated with ITI implants, reported that over 90% of the patients were satisfied with their implants when asked questions about function and chewing comfort, phonetics, aesthetics and cleansability. The majority of patients reported no difference between implants and their natural teeth, in fact some preferred the implants to their natural teeth.

The soft tissues around teeth and implants are governed by similar factors in relationship to the biologic width (Berglundh & Lindhe 1996), and this has been mostly applied to the mid-labial or lingual surfaces. However, the presence and form of the inter-dental papilla is a key feature in the determination of soft tissue aesthetics. The presence of a papilla has been related to the distance between the crestal bone and the inter-dental contact point. In an early study by Tarnow et al. (1992), it was suggested that the papilla was always present (no space below contact point) if this distance was 5 mm or less. However, when this distance was 6 mm the papilla was only present 56% of the time. This widely quoted paper was based on clinical bone sounding measures from the contact point to the bone crest in the anterior, premolar and molar teeth of 30 subjects who had undergone non-surgical periodontal treatment (scaling and root planing to reduce inflammation). Their site-based descriptions were not statistically analysed. In 2001, Choquet et al. described similar findings in relation to single-tooth implant restorations. The study included 26 subjects with 27 restorations in the anterior maxilla (second bicuspid to second bicuspid) and used both clinical and radiographic assessment. In the radiographic assessment it was not clear how the contact point or the soft tissue level were identified, and the bone crest was recorded at the tooth surface and not at the implant. They concluded that 5 mm was the critical measure for the presence of a papilla (Jemt scores 2, 3) but the data were not statistically analysed.

Kan et al. (2003) in a study of 45 anterior maxilla implants (cuspid to cuspid) in 45 subjects proposed that the level of the papilla at single-tooth

implants was related to the bone level at the adjacent tooth. They reported bone-sounding measurements from the soft tissue surface with a periodontal probe under local anaesthesia at the implant and adjacent tooth surface. The bone-sounding measures were lower on the tooth (mesial 4.2 ± 0.77 mm, distal 4.2 ± 0.64 mm) than on the implants (mesial 6.17 ± 1.27 mm, distal 5.93 ± 1.21 mm). They did not relate these measures to the contact point or papilla form but did observe more favourable soft tissue form in those subjects with a thick gingival biotype.

Gastaldo et al. (2004) also used clinical probing measures from the contact point under local anaesthesia in a sub-group of subjects with single-tooth implant restorations. A complete papilla was defined when soft tissue filled the entire proximal space or part of the space with a triangular shape, and was always present when the distance was 3 or 4 mm but this reduced to being present 80% of the time when the distance was 5 mm. In addition they measured the horizontal distance between implant and tooth with a clinical probe and reported that the papilla was absent if this distance was 2.5 mm or less.

The aims of the present study were to evaluate patient satisfaction with single-tooth implant restorations and to compare this to clinician's ratings of the restorations, soft tissue profile and radiographic data. The audit criteria for patient and clinician satisfaction were based on previously published studies. Specifically, 90% of patients should rate the outcomes of implant treatment at the top two scores, the clinicians should rate over 50% of cases at this level and no cases should be rated lower than a score of 3 on a scale of 1–6.

Material and Methods

The subjects of this report were part of a clinical audit comparing patient satisfaction with single-tooth implant treatment in a hospital clinic ($n = 26$, 13 males and 13 females age range 21–56 years) at the Department of Periodontology, Guy's and St Thomas' Hospitals Trust, London SE1 9RT, UK and a private practice ($n = 40$, 20 males and 20 females, age range 18–74 years). All patients had a single-tooth implant restoration (Astra Tech AB, Molndal, Sweden) in the anterior maxilla that had been in function for at least 12 months. The clinical and radiographic examina-

tion was part of a normal recall programme.

Each subject was asked to fill out a satisfaction questionnaire regarding crown shape and colour, gum shape and colour, ability to eat and talk, comfort, ease of care and any additional problems they may have had giving a ranking between 1 and 6 (extremely dissatisfied to extremely satisfied) for each of these parameters.

A clinical examination was undertaken to assess soft tissue health and record probing depths at four sites around the implant restoration (mesial, distal, labial, palatal) and at the proximal surfaces of the adjacent teeth. Clinical photographs were taken of each implant restoration using a Nikon D100 or Canon EOS 300D digital camera with macro lens and ring flash at a magnification of between 1:1 and 1:1.2. Three photographs were taken of the implant restoration with images revealing the mesial papilla, mid labial and distal papilla. Care was taken to record images as close as possible to perpendicular to the area under examination.

Photographs were evaluated by two examiners to assess the presence and form of the papilla and to give a score in terms of gingival colour/contour and crown shade/contour of the implant restoration using the same scale used by the patient in the questionnaire. The mesial and distal papillae were assessed using the Jemt index (Jemt 1997) as follows:

- score 0 – no papilla was present, and there was no indication of a curvature of the soft tissue contour adjacent to the single-tooth implant restoration.
- score 1 – <half of the height of the papilla was present. A convex curvature of the soft tissue contour adjacent to the single-tooth implant crown and the adjacent tooth was observed.
- score 2 – half or more of the height of the papilla was present, but did not extend all the way up to the contact point between the teeth. The papilla was not completely in harmony with the adjacent papillae between the permanent teeth.
- score 3 – the papilla filled up the entire proximal space and was in good harmony with the adjacent papilla. Optimal soft tissue contour.
- score 4 – the papilla was hyperplastic and covered too much of the single-tooth implant restoration
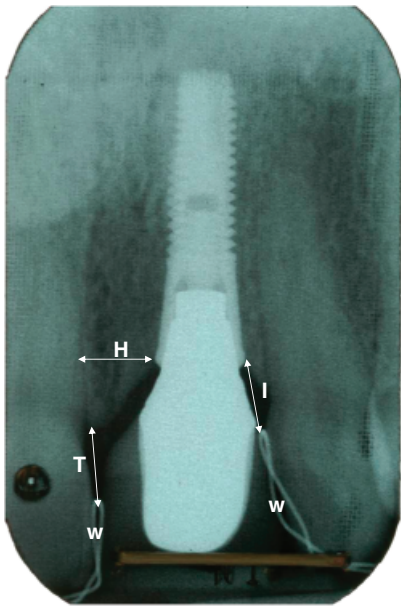
Fig. 1. Radiograph of a single-tooth implant replacing a maxillary left central incisor showing the wire (W) encircling contact point. The arrow on the mesial aspect depicts a measurement from the wire to the tooth associated bone crest (T). The arrow on the distal aspect depicts a measurement to the bone level on the implant (I). The horizontal arrow (H) depicts a measure from the shoulder of the implant to the adjacent tooth.

and/or adjacent tooth. The soft tissue contour was more or less irregular.

Periapical radiographs were taken using standardized paralleling technique with anterior Rinn holders using size 3, F speed film at 65/70 KV. Films were developed using an automated processor. Before the radiographic exposure a 0.25 mm orthodontic wire was placed apical to each contact point (when present) and tightened to demarcate the position of the contact point on the radiograph (Fig. 1). The radiographs were examined with a $\times 7$ magnification using a Peak Scale Lupe (Palmer et al. 2000) to measure the distance from the contact point (coronal margin of the orthodontic wire) to the bone crest on the implant and adjacent tooth at both mesial and distal sides. The bone crest was identified as the most coronal point of bone in contact with the implant or at the point where a normal periodontal ligament width existed at the tooth surface. The vertical level of the bone in relation to the head of the implant and the horizontal measurements from the shoulder of the implant to the adjacent

tooth were also taken. All measurements were taken to the nearest 0.1 mm.

Data were analysed using Stata 8 software (Stata Co. Austin, TX, USA). The main clinical variables were normally distributed, described using a mean and standard deviation and differences analyzed using parametric methods. Horizontal distance between the implant and tooth and the distance between the implant shoulder and the bone level and all patient and clinician scores were described using a median and inter-quartile range and analyzed using non-parametric methods. Within-subject comparisons were performed using either a paired t test or the Wilcoxon matched-pairs, signed ranks test. Between subject comparisons were performed using a two-group t test or a Mann–Whitney-U test. Statistical significance was inferred where $p < 0.05$.

Results

Sixty-six subjects with 66 single-tooth Astra Tech implant restorations (4.0 and 4.5 mm diameter implants and corresponding titanium or cast gold abutments) completed questionnaires and were assessed clinically and radiographically. All implant restorations were functional and free of complications. The median scores for the appearance (shape and colour) of the crown restoration and soft tissues assessed by the patient were a universally maximum six (interquartile range: 6–6). The combined clinicians' median assessments were lower, ranging from 5 for gum shape (4–5.5) to 5.5 for crown shape and crown and gum colour (4.5–5.5). The patients' scores were significantly greater than those judged by the clinicians in all cases ($p < 0.001$). Patient's assessments of the effect on their ability to eat and talk, general comfort and ease of care all showed median scores of the maximum 6 (6–6).

Twenty subjects had no contact point between implant crown and adjacent tooth on the mesial ($n = 6$), distal ($n = 6$) or both sites ($n = 16$ mesial and distal sites) (Fig. 2a and b). However, a normal height papilla was judged to be present in 19 out of 28 sites by the clinician observers. These subjects were excluded from the subsequent radiographic analysis because of the absence of the contact point landmark. In the remaining 46 subjects, there were no papillae that were judged to be Jemt score 0 or 4. 6 papillae were judged to
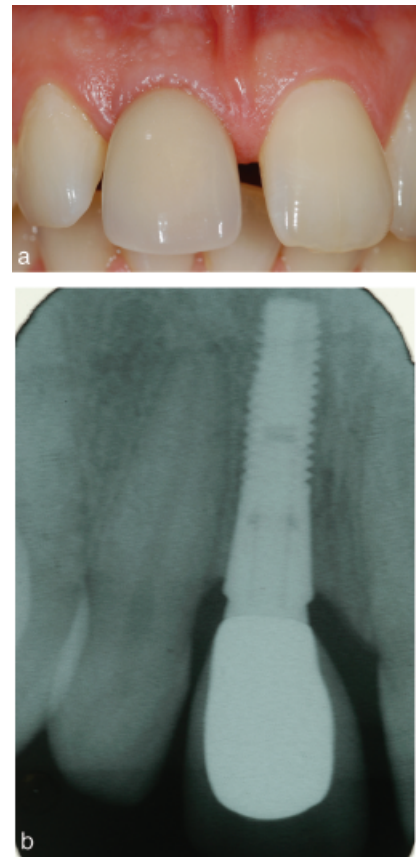

Fig. 2. (a) Clinical photograph of a single-tooth implant restoration replacing a maxillary right central incisor with mesial and distal diastemata. (b) Radiograph of the clinical case shown in Fig. 2a.

be Jemt 1, 41 were Jemt 2 and 45 were Jemt 3 (Figs 3 and 4). As the mesial and distal sites are not independent the results for these surfaces were analysed separately. In addition as there were only six surfaces with a Jemt score of 1, they were combined with Jemt 2 scores to represent deficient papillae (Jemt1/2) and allow comparison with complete intact papillae scoring Jemt 3.

The soft tissue health was good with shallow probing depths. Probing depths were significantly higher at implants (2.63 ± 0.92 mm) compared with adjacent teeth (2.09 ± 0.81 mm, $p < 0.001$). There was no difference in probing depths when comparing sites with Jemt papilla scores of 1/2 and those with Jemt 3. Tables 1 and 2 present the radiographic measures of contact point to bone level at the tooth and implant together with distance between implant and tooth and between implant shoulder and bone level. It should be noted that the distance between the contact point and the head of the implant was less on
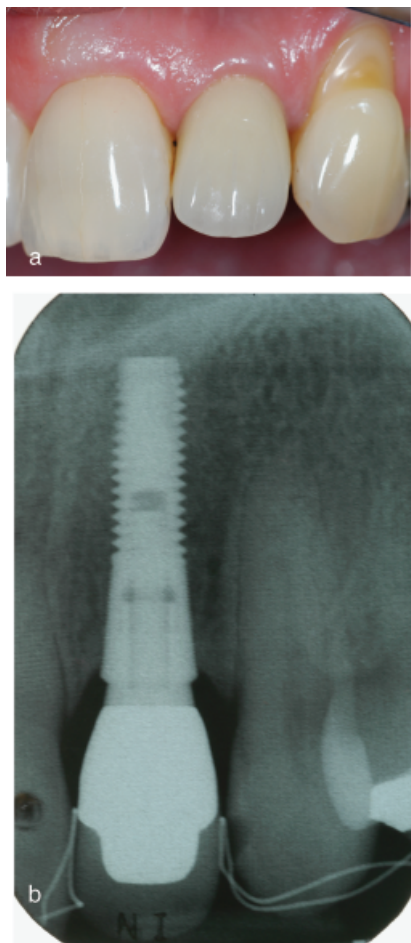
Fig. 3. (a) Clinical photograph of a single-tooth implant restoration replacing a maxillary left lateral incisor with good tissue form and papillae scored as Jemt 2 on mesial and distal aspects. (b) Radiograph of the clinical case shown in Fig. 3a.

Fig. 4. (a) Clinical photograph of a single-tooth implant restoration replacing a maxillary right central incisor with good tissue form and papillae scored as Jemt 3 on mesial and distal aspects. (b) Radiograph of the clinical case shown in Fig. 4a.

the distal surface (7.69 ± 0.32 mm) than on the mesial surface (9.18 ± 0.37 mm, $p < 0.001$). Consequently, all measures from the contact point landmark on the distal surface were less. Comparison of the Jemt groups 1/2 and 3 for the distance between the contact point and the bone level on mesial surfaces showed a statistically significant greater measurement for Jemt 1/2 at both implant and tooth ($p < 0.01$). The differences were less on the distal surfaces, but were statistically significant at the implant ($p = 0.023$) but not significant at the tooth ($p = 0.084$). The horizontal distance between the implant and tooth was not significantly different between the Jemt scores. The radiographic bone levels on the implant surfaces were close to the head of the implant and did not differ with Jemt score.
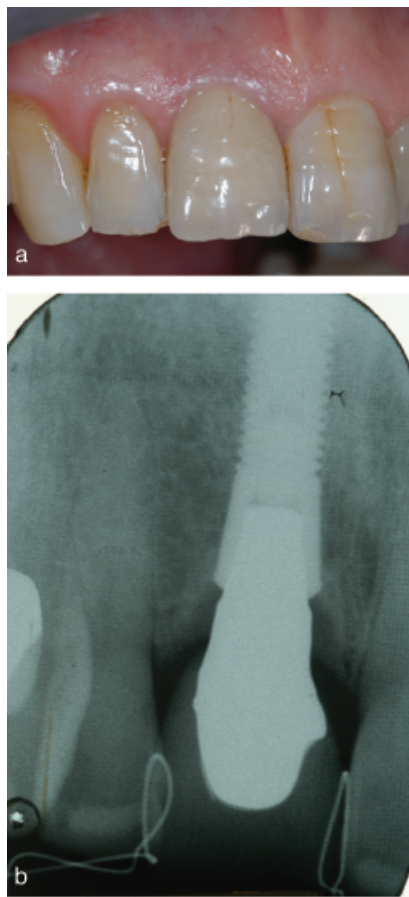
Discussion

The results of the patient satisfaction survey were very good and reached the level set by our audit target of 90% of subjects with the highest score, with patients rarely scoring as low as 5 in the range 1–6. Clinician's scores were lower but still fulfilled the audit criteria of 50% at this level set in the aim of the study. This is in agreement with other published studies on various implant systems (Chang et al. 1999a, b, Gotfredsen 2004) and it also confirms that clinician's ratings are generally lower. Therefore it confirms that single-tooth implant restorations have a high chance of fulfilling patient's aesthetic and functional expectations. The clinician's ratings are often critical of the crown characteristics, which may be due to technical difficulties, and the soft tissue aesthetics, which may be affected by the quantity and quality of tissue

before treatment, the periodontal health or bone level of the adjacent teeth (Kan et al. 2003), the surgical techniques used (Choquet et al. 2001), the crown morphology and emergence profile and the time elapsed following completion of the prosthodontic treatment (Jemt 1999). In particular, improvements in the fill of the embrasure space with the interproximal papilla have been described by several groups, especially during the first year (Jemt 1997, Gotfredsen 2004, Cardaropoli et al. 2006). Therefore it is preferable that patients should have been treated at least 12 months before assessment, as was the case for all subjects in the present study. Previous studies have related the presence of the papilla to the distance between the contact point and the bone crest. However, many of these studies have relied upon bone-sounding measurements with a periodontal probe to the nearest 0.5/1.0 mm, and the location of the bone crest that was probed was generally poorly defined. In many cases there was a lack of definition of anatomical landmarks and inadequately described methodology including what constituted a complete or deficient papilla. Despite these potential problems it was possible in this study to verify and extend previous observations on the vertical distance between the bone crest and contact point and the presence of the papillae using the Jemt index. The present study has some advantages over previous studies by combining clinical and radiographic data with clearer definition and imaging of the contact point. If we combine the data for mesial and distal papillae where a contact point was present to allow direct comparison with previous studies, our data indicates that the critical value for a complete papilla is 6 mm from the tooth-associated bone crest to the contact point [complete papilla 95% confidence interval (CI) 4.93–5.94 mm, Deficient papilla 95% CI 5.94–6.94 mm]. The corresponding critical value when measured from the implant-associated bone crest was 8.5 mm (complete papilla 95% CI 7.20–8.57 mm, deficient papilla 8.55–9.77 mm). These measures are greater than those originally described by Tarnow et al. (1992) and Choquet et al. (2001). The horizontal distance between implant and teeth had no impact on the papillae, in contrast to the paper by Gastaldo et al. (2004). The favourable results in the present study

Table 1. Mesial radiographic measures of contact point to bone level at the tooth and implant (mean, standard deviation, 95% confidence intervals) together with distance between implant and tooth and implant shoulder and bone level (median, interquartile range)

Measurement	Papilla JEMT score		p value[‡]
	1/2*	3[†]	
Contact point to bone level			
Tooth	6.92 (2.11)	5.17 (1.19)	<0.001
	6.05–7.79	4.63–5.71	
Implant	10.10 (2.22)	8.30 (2.00)	0.002
	9.18–11.02	7.39–9.21	
Horizontal distance implant–tooth	2.9 (2.1–3.7)	2.0 (1.5–2.2)	(0.084)
	$n = 24$		
Distance implant shoulder–bone level	0.2 (0.0–0.7)	0.0 (−0.2–0.5)	(0.777)
	$n = 24$		

*$N = 25$, unless stated.
[†]$N = 21$.
[‡]t test, unless in brackets, when Mann–Whitney U test.

Table 2. Distal radiographic measures of contact point to bone level at the tooth and implant (mean, standard deviation, 95% confidence intervals) together with distance between implant and tooth and implant shoulder and bone level (median, interquartile range)

Measurement	Papilla JEMT score		p value[‡]
	1/2*	3[†]	
Contact point to bone level			
Tooth	6.24 (1.70)	5.35 (1.29)	0.084
	5.50–6.97	4.79–5.90	
Implant	8.50 (2.11)	7.15 (1.68)	0.023
	7.59–9.42	6.42–7.87	
Horizontal distance implant–tooth	2.20 (1.5–2.9)	1.7 (1.0–2.1)	(0.143)
	$n = 21$	$n = 20$	
Distance implant shoulder–bone level	0.0 (−0.2–0.6)	0.0 (0.0–0.3)	(0.782)
	$n = 22$	$n = 22$	

*$N = 23$, unless stated.
[†]$N = 23$, unless stated.
[‡]t test, unless in brackets, when Mann–Whitney U test.

may be due to the very good bone levels at the implant head (as described for this implant system in previous studies by Palmer et al. 2000, Puchades-Roman et al. 2000, De Kok et al. 2006), the stable seal of the abutment/implant junction in this implant system, or the good periodontal status of the adjacent teeth. Although previous workers have placed emphasis on the bone level at the adjacent tooth surface, we suggest that the clinical attachment level (and connective tissue attachment) is very important and this was good in the present study as indicated by the shallow probing depths at the tooth surfaces. As in previous studies, the probing depths were greater at the implant surfaces.

This study is however the first to indicate that there are differences between mesial and distal papillae at single-tooth implant restorations, although there was a suggestion of this in the results of Chang et al. (1999a, b) where distal papillae at implant surfaces had lower Jemt scores than those at tooth surfaces (which was not the case for mesial papillae). It is known that there are anatomical differences in the embrasure spaces and that the distal contact point has been described to be always more apically located than the mesial contact point (Woelfel & Scheid 2002). It was possible to confirm this observation by comparing contact point distances from the fixed landmark of the implant head (see Fig. 1). This showed that the contact point was located approximately 1.5 mm more apically on the distal aspect compared with the mesial aspect of the single-tooth restoration, and that this anatomical difference could have an impact on the papilla form. Therefore the present study was able to demonstrate that the contact point to bone crest was significantly related to the presence of a complete papilla on the mesial aspect but this was only significant for the measure to the bone crest on the implant and not the tooth on the distal aspect. It should be noted that there was no difference in the frequency of complete papillae on the mesial and distal aspects, but that the critical measures may differ due to the anatomical differences in embrasure morphology. This complex three-dimensional analysis is beyond the scope of this paper. However, it was also evident that even where a diastema existed between a single-tooth implant and the adjacent natural tooth, in many cases a normal aesthetic gingival papilla was observed.

In conclusion, this study has shown that patients are satisfied with their single-tooth restorations, that the clinicians judge them slightly more critically and the presence of optimum soft tissue form could be related to embrasure morphology and the critical distances between contact point and bone crest may be greater than previously described. This may be due to greater accuracy in assessing this measure, larger numbers of subjects with favourable periodontal conditions on adjacent teeth or more favourable implant-supported restorations. It is conceded that these results are likely to be superior to those that would be observed between adjacent implant restorations (Tarnow et al. 2003).

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Clinical Relevance

Scientific rationale for the study: More detailed assessment of the outcome of single-tooth implant treatment is required, particularly patient satisfaction and factors that are important in achieving optimum soft tissue form and health.

Principal findings: Clinicians are more critical of the outcome than the patient. A large number of subjects had complete papillae, including some who had restorations that had no contact point.

Practical implications: Most patients are happy with their single-tooth restorations, including the appearance of the soft tissues. Preservation of periodontal health on the adjacent teeth is one of the most significant factors in achieving complete papillae.