

Paul Weigl, Antonio Strangio

# The impact of immediately placed and restored single-tooth implants on hard and soft tissues in the anterior maxilla



**Paul Weigl, DDS**

Department of Postgraduate Education, Faculty of Oral and Dental Medicine at J.W. Goethe-University, Frankfurt, Germany

**Antonio Strangio, MSc**

Oral Implantology, Joondalup, Australia

**Correspondence to:**

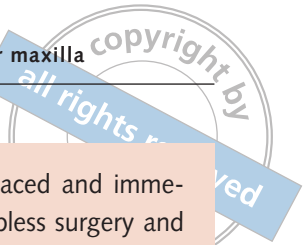
Paul Weigl  
Department of Postgraduate Education, Faculty of Oral and Dental Medicine at J.W. Goethe-University, Frankfurt, Germany.  
Tel: +49-69-6301-4738  
Email: weigl@em.uni-frankfurt.de

**Key words** *immediate implant placement, immediate implant restoration, peri-implant tissue remodelling, single-tooth replacement*

**Aim:** The purpose of this literature review is to systematically evaluate the impact of immediate implant placement and restoration (IIPR) on hard and soft tissues and to identify clinical parameters which influence the outcome.

**Materials and methods:** An electronic search of the PubMed database was performed from January 2000 to September 2015. A further hand search was conducted in selected journals and only abstracts published in English were considered for review. Human clinical trials with at least 10 participants and which reported hard and soft tissue outcomes were assessed. Randomised controlled trials (RCT), prospective, prospective comparative and retrospective studies were considered. The effects of the following clinical parameters on hard and soft tissue outcomes were analysed: type of implant, primary stability, gingival biotype, flapless surgery, tooth extraction, spatial arrangement of the implant, socket grafting, the gap between implant surface and alveolar wall and the loading protocol.

**Results:** 17 studies (four RCT, six prospective, two comparative prospective, three controlled cohort and two retrospective studies) were included with 626 censored IIPR in 609 patients. A total of 411 (65.56 %) implants were placed flapless vs 215 implants after raising a mucoperiosteal flap. Five studies defined raising a mucoperiosteal flap as a mandatory part of the surgical protocol. The mean of the remaining gap in between the implant surface and the alveolar wall, the so-called "jump space", was reported for 170 implants ranging from 1.38 mm to 2.25 mm. Two hundred and one implant sites were not grafted, 405 were grafted, mostly with bone substitutes; for 20 no information was available. For 419 implants, a minimum insertion torque of  $\geq 32$  Ncm or an ISQ value of  $\geq 60$  was reached; for 53 implants an insertion torque of 25 Ncm was accepted. The implants were mostly placed palatally of the jaw bone. The vertical position of the platform was reported either to be 0.5 to 1.0 mm below the vestibular bone crest or 3 to 4 mm apical to the adjacent cemento-enamel junction of the neighbouring tooth. Post-insertion healing with a non-functional occlusion occurred for 97.8% of the implants. The final single crowns were inserted 3 to 6 months after implant placement. The IIPR resulted in a high success (97.96 %) and survival rate (98.25%) after a mean follow-up period of 31.2 months. The soft-tissue biotype was evaluated in 379 (60.5%) sites as thick. The mean crestal bone and the mean interproximal mucosa level changes were less than 1 mm compared to the baseline. The midfacial periimplant mucosal level change was less than 0.95 mm. This level was reached for both thin and thick soft-tissue biotypes, without a significant difference. Only in one study did the thin biotypes show a significantly higher recession.



**Conclusion:** The systematic review revealed promising results for immediately placed and immediately restored implants (IIPR) in the anterior maxilla. The possible options of flapless surgery and absence of grafting of the socket allows a minimal surgical intervention. However, a strict patient selection seemed mandatory for all included clinical trials.

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## ■ Introduction

The use of single-tooth implants for the treatment of single tooth loss is steadily increasing. With a few exceptions in the molar region, only one implant is inserted for anchoring a single crown. The conventional loading protocol consists of several months of healing after implant insertion, without any load application. It aims to avoid micromovements between the implant and the bone, enabling a predictable osseointegration. However, this delayed loading protocol implies additional surgery for exposing the implant. During healing the crown may either be out of occlusion or in functional occlusion and contributes at the day of implant placement to a satisfactory aesthetic result. Additionally, immediately implant-anchored temporary single crowns provide a satisfactory aesthetic result. The undisputed increased patient comfort by minimal invasiveness, shortened treatment time and cost reduction render the IIPR approach popular among clinicians.

To keep the micromovements at the implant-bone interface sufficiently low during healing, a high primary stability of the implant is imperative. An immediate rigid connection between multiple implants to ensure immobilisation is not available at a single-tooth gap. The primary stability of an implant is known to depend on many factors, which include the anatomical site, the protocol of the osteotomy, the implant dimensions (length and diameter) and the macro- and micro-design of the endosseous implant surface.

A special feature of immediately restored implants is the immediate correct shaping of the peri-implant soft tissue at the already healed alveolar ridge, by the correctly shaped morphology of the abutment and/or the cervical portion of the temporary single crown. In the case of a fresh extraction wound, this

temporary crown supports the existing dentogingival complex and seals the wound. The aesthetic outcomes are mainly dependent on the stability or the remodelling of soft and hard peri-implant tissue. The impact of immediate placement and loading of single implants on surrounding hard and soft tissues is especially relevant in the aesthetic zone of the maxilla. The search strategy of available literature was therefore focused on immediately placed and restored single implants.

Following tooth extraction in the anterior maxilla, the clinician is often faced with the dilemma of whether to place the implant immediately or at varying post-extraction time intervals.

Immediate implant placement in the aesthetic zone was first advocated with advantages including preserving the alveolar bone, decreasing treatment time and providing superior aesthetics<sup>1</sup>. This concept developed from a two-stage submerged protocol into immediate implant placement and restoration therapy (IIPR)<sup>2</sup>. The rationale for this one-stage therapy was to preserve the original hard and soft tissue architecture with a suitably fabricated provisional abutment and crown. This technique was also thought to be of particular relevance in the thin highly scalloped gingival biotype, where hard and soft tissue recession are more likely<sup>3</sup>. This approach offers social and psychological (shorter treatment time), functional (correct placement permitting axial loads) and aesthetic (tissue preservation) advantages<sup>4</sup>.

The literature appears to be inconclusive regarding the best method to preserve crestal tissues following the loss of a single tooth in the aesthetic zone.

Following tooth removal the extraction socket is subject to physiological remodelling. Clinical studies involving subtraction radiography, study casts and linear radiographs have demonstrated major alveolar bone loss over 1 year, with up to 50% reduction



in the orofacial dimension, following tooth extraction<sup>5</sup>. Two thirds of this change occur during the first 3 months. This is also in agreement with an animal study which showed vertical bone loss on the buccal and lingual crest, with greater changes on the buccal crest, translating into a net loss of bucco-palatal bone after 8 weeks<sup>6</sup>.

Due to marked post-extraction reductions in alveolar dimensions, ridge preservation techniques have emerged, however they provide limited capacity to prevent remodelling of the original alveolar bone<sup>7</sup>. Fickl et al<sup>7</sup> evaluated four such preservation techniques in a dog model. All treatment groups suffered from vertical and horizontal bone loss. Furthermore, it was demonstrated that overbuilding of the buccal plate failed to prevent resorption or a more effective preservation technique. Hence ridge preservation techniques were unable to halt the physiological changes which take place post-extraction.

Both human<sup>8</sup> and animal studies<sup>9</sup> have demonstrated that the sole placement of an implant in an extraction socket is insufficient to prevent bone. These experiments concluded that hard tissue alterations still occur despite the placement of an implant, although to a lesser extent when a low-turnover bone substitute is used in the peri-implant defect<sup>10</sup>.

Immediate implant placement and restoration procedures require careful selection of patients, with appropriate assessment of hard and soft tissues and accurate implant positioning in all three dimensions<sup>3,11</sup>. Since the placement of the implant is more challenging in post-extraction sockets, clinicians may decide to insert the implant 4 to 8 weeks later<sup>12</sup>, with possible tissue loss, which may compromise the final aesthetic result or dictate additional hard and soft tissue augmentation techniques. The main purpose of the present review is to explore the impact of immediate single implant placement and restoration on surrounding hard and soft tissue.

## ■ **Materials and methods**

### ■ **Participants**

Patients requiring an immediate single tooth implant and restoration in the anterior aesthetic zone.

### ■ **Intervention**

Immediate implant placement and immediate restoration with a single crown.

### ■ **Outcome**

Implant survival/success, soft and hard tissue behaviour. For the purpose of this review, the anterior maxilla was chosen as the incisor, canine and premolar areas. Immediate implant placement is defined as placement of an implant immediately post-extraction, and immediate restoration is defined as placement of a dental restoration within 48 h after implant placement. The loading protocol was further defined as immediate occlusal and non-occlusal depending on whether or not the restoration was in contact with the antagonistic teeth.

### ■ **Search strategy**

An electronic search of MEDLINE (PubMed) was conducted from January 2000 until September 2015 using the following search terms: 'immediate' AND 'implant' AND 'placement' AND 'single' AND 'maxilla' AND 'anterior'. In addition, a manual search of the following journals was performed from 2000 to 2015: International Journal of Oral and Maxillofacial Implants, Clinical Oral Implant Research, Clinical Implant Dentistry and Related Research, International Journal of Periodontics and Restorative Dentistry, European Journal of Oral Implantology, Journal of Prosthetic Dentistry, Journal of Periodontology and Journal of Clinical Periodontology.

### ■ **Study selection**

Only clinical studies which met the following inclusion criteria were permissible in this review:

1. prospective RCT's, prospective cohort studies, retrospective studies, comparative studies and case series with a minimum of 10 participants;
2. follow-up of at least 12 months;
3. immediate single tooth replacement in the anterior maxilla including incisors, canines and premolar regions;
4. co-reporting of objective soft and hard tissue outcomes;



5. clearly stated restorative protocol and material selection;
6. reports describing the three-dimensional positioning of the implant;
7. restorations delivered within 48 h of implant placement;
8. defined success criteria e.g. according to Smith and Zarb<sup>13</sup> or Adell et al<sup>14</sup>;
9. publication is in English.

Studies which included multiple interventions like ridge splitting, sinus grafting, soft and hard tissue grafting, other than filling the horizontal defect distance with bone or bone substitute, were omitted.

Of the 95 articles, 59 were selected for review of abstracts. Of the 37 articles determined for further review, only 17 articles were included for final analysis. Figure 1 describes the workflow in achieving the final choice of articles for analysis. The main reasons for omission include:

- failure to report on hard and/or soft tissue outcomes;
- mean follow up of less than 1 year;
- implants placed in healed sites;
- multiple interventions;
- multiple surgical protocols without linked differentiation of results;
- splinted implants;
- implants placed in partially dentate regions;
- case presentation;
- less than 10 patients;
- no immediate restoration.

### ■ Data extraction

Data were extracted independently of the 17 studies which were included for final analysis.

Survival of implants was defined as the number of implants still in situ at the follow-up period and was expressed as a cumulative survival rate.

The mucosal biotype was described as thin or thick according to the translucency of the periodontal probe through the free gingival margin or by direct measurement.

The papillary morphology was recorded in either a millimetre scale, percentage fill or scored according to the papilla index<sup>15</sup>. The papilla index proposed by Jemt<sup>15</sup> allowed for assessment of the interproximal

papilla adjacent to single tooth restorations. The following values were used to describe the degree of papillary fill:

- Index 0 = complete absence of papilla;
- Index 1 = less than half of the papilla is present;
- Index 2 = greater than half but still not to the level of the contact point;
- Index 3 = the papilla fills the entire proximal space and represents the ideal contour;
- Index 4 = the papilla is hyperplastic.

The horizontal defect distance which arises from the placement of an implant immediately into an extraction socket is the distance measured from the outer surface of a defined point of the implant to the inner wall of the cortical plate. In addition to recording this distance, the eventual use of a graft material and the type of graft material was also noted.

### ■ Assessment of study quality

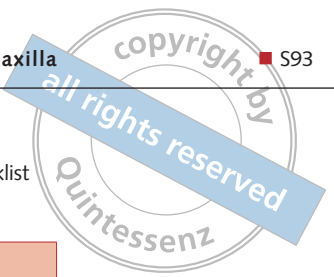
Following the selection of eligible papers for review, a quality checklist devised by the Dutch Cochrane Collaboration was utilised to assess study design. The checklist was modified to include a quality assessment process for retrospective studies. This quality checklist in Table 1 describes the quality assessment for randomised case series and retrospective studies. The areas of assessment included randomisation (if appropriate), patient and site characteristics, patient selection, intervention, evaluation method, outcome and follow-up. The study was considered appropriate for inclusion if the randomised studies scored at least 8 pluses and the case series and retrospective studies scored at least 7 pluses.

### ■ Statistical analysis

Given the huge heterogeneity amongst the articles, in terms of the variables which affect hard and soft tissue outcomes, the results were analysed with descriptive statistics since no meta-analysis was possible.

### ■ Results

A total of 17 studies<sup>4, 16-31</sup> reporting hard and soft tissue outcomes of maxillary single tooth IIPR were



**Table 1** Modified quality assessment check list for randomised case series and retrospective studies (unmodified checklist devised by Dutch Cochrane Collaboration).

	Quality assessment of randomised controlled trials	Quality assessment of case series/ retrospective studies
<b>Randomisation</b>	Were adequate methods used for randomisation?	N/A
<b>Patient and site characteristics</b>	Were patient characteristics well described for both groups? Were site characteristics well described for both groups? Were there no disparities between patient and site characteristics between groups?	Were patient characteristics well described? Were site characteristics well described?
<b>Patient selection</b>	Were the inclusion and exclusion criteria well described and the same for both groups? Did the study report on consecutively treated patients?	Were the inclusion and exclusion criteria well described? Did the study report on consecutively treated patients?
<b>Intervention</b>	Were interventions for both groups clearly described? Were all patients of the same group treated according to the same interventions?	Was the intervention clearly described? Were all patients treated according to the same intervention?
<b>Evaluation method</b>	Was blinding used to assess the outcome? Were adequate methods used to assess the outcome? Were reproducibility data reported on the outcome variable(s)?	Was the outcome assessed by an investigator who had not been involved in the treatment? Were adequate methods used to assess the outcome? Were reproducibility data reported on the outcome variable(s)?
<b>Outcome and follow-up</b>	Was the outcome clearly described? Was an intention-to-treat analysis performed and was there a low risk of selective loss to follow-up?	Was the outcome clearly described? Was the response rate acceptable and was the number of patients lost to follow-up clearly described?

included in the present systematic review for final analysis. Of the 17 studies, four were RCTs, six were prospective, two were comparative prospective, three were controlled cohort and two were retrospective studies. A summary of these studies are included in Tables 2 to 4.

The four randomised controlled studies had test and control groups to compare i) implants placed in extraction sockets with matching abutments vs implants placed in the socket with mismatching abutments (platform-switched)<sup>4,22</sup>; ii) Implants placed in extraction sockets with final abutments vs implants placed in extraction sockets requiring several abutment changes<sup>20</sup>; iii) immediate implant placement and restoration vs immediate loading in a healed site<sup>31</sup>.

There was one prospective comparative study<sup>18</sup> which compared IIPR versus implants placed in post-extraction sockets, and implants which were

submerged with a delayed restorative protocol. A retrospective study<sup>21</sup> compared IIPR with grafting and non-grafting of the horizontal defect distance, defined as the space between the outer rim of the implant and the inner wall of the socket.

There were additional studies which did not satisfy the quality checklist. The reasons for exclusion are summarised below.

### ■ Reasons for exclusion

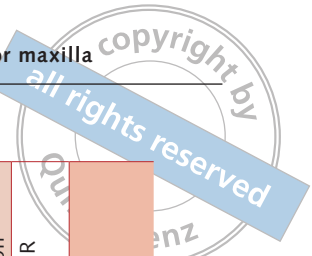
#### Cooper et al<sup>32</sup>

There was a 5-year follow-up study of Cooper et al<sup>25</sup> describing the same clinical trial at a later follow-up.

#### De Bruyn et al<sup>33</sup>

This was a 5-year follow-up study of the co-author of Cooper et al<sup>25</sup> and was not included for the reasons described above.

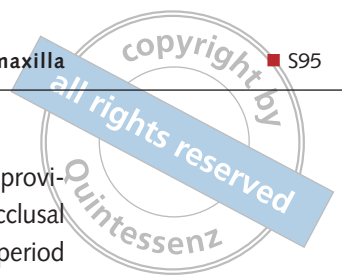




**Table 2** Enrollment and survival/success rate.

Author name	Year of publication	Journal	Follow-up period (months)	Mean follow-up (months)	Type of study	No. of patients with immediate placed and restored implants	Region	No. of total placed implants	No. of immediate placed and restored implants	Failures of implants	Survival rate (CSR %)	Success rate (%)	Used criteria for success
Kan et al <sup>16</sup>	2003	IJOMI	12	12	Prospective	35	Ant Max (13-23)	35	35	0	100	100	Smith/Zarb
Kan et al <sup>17</sup>	2011	IJOMI	96	48	Prospective	35	Ant Max (13-23)	35	35	0	100	100	Smith/Zarb
De Rouck et al <sup>18</sup>	2009	COIR	12	12	Prospective comparative	49 (24 IP / 25 DP)	Ant Max (15-25)	49	24	1	96	96	Smith/Zarb
De Rouck et al <sup>19</sup>	2008	JCP	12	12	Prospective	30	Ant Max (15-25)	30	30	1	97	97	Smith/Zarb
Canullo et al <sup>4</sup>	2009	COIR	NR	25	RCT	22	Ant Max (15-25)	22 (11 PS / 11 NS)	22	0	100	NR	NR
Degidi et al <sup>20</sup>	2013	CIDRR	24	24	RCT	68 (35 control / 33 test)	Ant Max (13-23)	68	53 (24 test / 29 control)	0	100	NR	NR
Spinato et al <sup>21</sup>	2012	ID	NR	32	Retrospective	41	Ant Max (15-25)	45	45	0	100	NR	NR
Pieri et al <sup>22</sup>	2011	IJOMI	12	12	RCT	38	Ant Max (pre-m)	40 (20 PS / 20 NS)	38 (19 PS / 19 NS)	1	94.7	94.7	Smith/Zarb
Cosyn et al <sup>23</sup>	2011	JCP	36	36	Prospective	25	Ant Max (15-25)	25	25	1	96	96	Smith/Zarb
Berberi et al <sup>24</sup>	2014	J Cont. D. Pract	36	NR	Prospective	20	Ant Max (14-24)	20	20	0	100	100	NR
Cooper et al <sup>25</sup>	2014	IJOMI	60	NR	Prospective comparative	104 (45 Ext / 49 HS)	Ant Max (15-25)	113 (55 Ext / 58 HS)	55	3 (Ext) 1 (HS)	94.55 (Ext) 98.28 (HS)	NR	Smith/Zarb
Ross et al <sup>26</sup>	2014	IJOMI	60	NR	Retrospective	47	Ant Max (12-22)	30 flap 17 flapless	47	0	100	NR	NR
Calvo-Guirado et al <sup>27</sup>	2015	COIR	36	NR	Controlled cohort study	53	Ant Max (15-25)	71	71	0	100	NR	NR
Bruno et al <sup>28</sup>	2014	J Prost Dent	12	NR	Controlled cohort study	23	Ant Max (15-25)	36	31 (17 one year follow up)	0	100	NR	NR
Grandi et al <sup>29</sup>	2013	EJOI	12	NR	Controlled cohort study	50 (25 IP / 25 DP)	Ant Max (15-25)	50	25	2 (8%)	92	NR	NR
Malchiodi et al <sup>30</sup>	2013	CIDRR	36	NR	Prospective	58	Ant Max (13-23)	64	64	0	100	100	Albrekts-son
Slagter et al <sup>31</sup>	2015	J Clin Period.	12	NR	RCT	40 (20 IP / 20 DP)	Ant Max (13-23)	40	20	0	100	NR	NR
			Mean: 31.2			Σ = 609		Σ = 790	Σ = 626 (Ext)	Σ = 9 (Ext)	Mean = 98.25 % (Ext)	Mean = 97.96	

NR: Not reported; PS: Platform switched; NS: Non platform switched; HS: placement healed site; Ext: placement fresh extraction socket; IP: immediate placement; DP: delayed placement.

**Block et al<sup>34</sup>**

This was a randomised controlled study comparing IIPR with placement of an implant in a healed socket 4 months later. A total of 76 patients were originally included in the study with 21 lost to follow-up. This represents a significant risk for selection bias. A fixed reference guide stent was fabricated for hard and soft tissue measurements prior to extraction and at varying time points after the definitive restoration. Despite this, the baseline was the time of definitive crown delivery and subsequently measured every 6 months up to 2 years. It was unclear whether any significant soft and hard tissue remodelling had occurred prior to this newly adopted baseline, which may have resulted in an underestimation of soft and hard tissue values. The papilla height values were not available for assessment. The outcome measurements were unclear and not adequately described. A mean follow-up time could not be deduced. A survival rate was neither documented nor clearly defined in the results.

**Mijiritsky et al<sup>35</sup>**

There was significant study design heterogeneity. Not all patients were treated according to the same surgical protocol and different implant designs were used (Xive, MIS and Frialit 2). Site characteristics were unclear as there was no mention of gingival biotype, horizontal defect dimension and placement of implant relative to the facial crest of bone. A non-standardised radiograph technique was used without clear explanation of reference points. The soft tissue outcomes were not measurable as data were not provided. Due to the inadequate evaluation method the outcomes remained unclear.

**Hui et al<sup>36</sup>**

This prospective study compared immediate restorations in healed sites versus in extraction sockets. The site characteristics were lacking with no documentation of biotype, horizontal defect dimensions and placement protocol relative to the facial osseous crest. All patients in the immediate placement group were not treated according to the same time interval to finalise the permanent restoration. The timing of definitive crown delivery varied from 2 weeks to 3 months after implant placement. These variables may have influenced the final hard and soft tissue

outcomes. It was also unclear whether the provisional crowns were placed in occlusal or non-occlusal loading. The response rate over a 12-month period was unacceptable, with half of the original participants lost to follow-up. No reason was given for dropouts and only seven belonged to the immediate group. This results in a risk of selection bias.

**Cornelini et al<sup>37</sup>**

This study analysed immediate implant placement and restoration in 22 patients in the maxillae and the mandible. While the number of implants placed in the premolar, incisor and canine sites were documented, the locations were not stated. Hence, the data for the mandible and maxillae were pooled, making it impossible to analyse results for the maxillae.

The article failed to document the type of permanent restoration or the mean delivery time of the definitive prosthesis. The site characteristics were not adequately described. There was no mention of the gingival biotype, the peri-implant defect dimensions and the presence or absence of facial bone defects following extraction was not clear. The study claimed that three-wall defects were included, provided the dehiscence defect did not exceed 3 mm. Not all patients were treated according to the same surgical protocol. Some patients underwent a full-thickness flap reflection via an intrasulcular incision, while others received a full-thickness flap with mesial and distal releasing incisions. It was unclear whether the provisional crown was subject to occlusal or non-occlusal loading. Bone remodelling was assessed by non-standardised radiographs and the soft tissue margin was recorded relative to a straight line, which joined the zenith points of the adjacent teeth. These recordings were performed at surgery and at 12-month follow-up. The open flap surgery could have caused recession of the adjacent tissues, affecting the reference line and actual midfacial gingival recession values.

**Canullo and Rasperini<sup>38</sup>**

The aim of the study was to assess the hard and soft tissue outcomes of IIPR in the anterior aesthetic zone, after a mean follow-up of 22 months. A further aim of the study was to assess the impact of utilising a platform switching implant and its effect on clinical parameters. Baseline measurements were



defined from placement of the final prosthesis which was 3 months after implant placement. The actual bone loss and soft tissue measurements may have been over-rated for this very reason, due to unaccounted potential tissue loss. This may have biased the results and is the reason why the soft tissue results showed an increase in both midfacial mucosal level and papilla heights for the mean follow-up of the study. Although the descriptions of patient and site characteristics were adequate, the methodology used to assess the gingival biotype was not described. It was unclear whether an objective assessment via the transparency of a periodontal probe through the gingiva or a subjective visual assessment was carried out. Only nine patients were included, while the inclusion criteria asked for 10.

#### **Brown and Payne<sup>39</sup>**

This study compared a novel implant design with an inbuilt 12 degree angulation for IIPR in the anterior maxillary zone. Not all patients were treated according to the same surgical intervention. A facial plate dehiscence of 3 mm was accepted, necessitating adjunctive augmentation therapy. It was not clear from the study how many received this therapy. Adjunctive augmentation techniques other than filling of the "jump space" were reasons for exclusion. The selected baseline was 8 weeks after implant placement and patients were followed for 52 weeks from the time of surgery. This resulted in a follow-up period of less than 1 year from baseline, which did not satisfy the defined inclusion criteria. The site characteristics lacked a description of the gingival biotype and it was impossible to deduce the actual three-dimensional positioning of the implants.

#### **Cabello et al<sup>40</sup>**

The aim of this study was to analyse a flapless IIPR relative to the gingival biotype in the anterior zone of the maxilla (limited to the intercanine area).

Not all patients were treated according to the same surgical technique, with some patients receiving bone level implants and others mucosal level implants. These implants were placed with different three-dimensional placement techniques. There were additional confounding variables and significant heterogeneity in the study design.

#### **Rieder et al<sup>41</sup>**

The follow-up period of 4 months does not meet the inclusion criteria.

#### **Berberi et al<sup>42</sup>**

The distribution of delayed or immediately loaded implants was not reported.

#### **Cecchinato et al<sup>43</sup>**

It concerned implants with delayed loading.

#### **Felice et al<sup>44</sup>**

The follow-up period of 4 months does not meet the inclusion criteria.

#### **Noelken et al<sup>45</sup>**

Thirteen patients received a single crown and three patients received a partial restoration. The results pooled both prosthetic restoration types.

#### **Covani et al<sup>46</sup>**

It concerned implants with delayed loading.

#### **den Hartog et al<sup>47</sup>**

All implants were placed in healed sites.

### ■ **Region**

All implants were placed in the anterior aesthetic zone (from tooth locations 15 to 25), with one study analysing the IIPP of an implant in the maxillary premolar region<sup>22</sup>.

### ■ **Survival and success rate**

The review included 626 censored IIPR in 609 patients, with a success rate of 97.96% and a survival rate of 98.25%, after a mean follow-up period of 31.2 months (Table 2).

### ■ **Types of implants**

A total of eight different implant systems were utilised in these studies (Table 3). The implants had a tapered and/or a straight body configuration, with a moderately roughened surface and an internal connection.





## ■ Gingival biotype

The gingival biotypes were assessed as thick or thin according to the visibility of the periodontal probe through the gingival tissues. Only one of the studies<sup>21</sup> measured the thickness of the gingiva directly with the aid of an endodontic file. The soft-tissue biotype was evaluated as thick in 379 (60.5%) sites (Table 3).

## ■ Socket grafting

Socket grafting consisted of the placement of graft material in the peri-implant space, between the outer surface of the implant and the inner wall of the facial socket wall.

Two hundred and one implants sites were not grafted, 405 were grafted mostly with bone substitutes and 20 were not reported (Table 3). The majority of the studies utilised deproteinized bovine bone material (DBBM) or a mixture with autogenous bone (Table 3). The size of that space, which was reported for 170 implants, ranged from 1.38 mm to 2.25 mm.

## ■ Loading protocol and time to definitive restoration

Nearly all of the implants (97.8 %) healed with non-functional occlusion; Bruno et al<sup>28</sup> fabricated temporary crowns with functional occlusion. The final single crowns were inserted between 3 and 6 months after implant placement.

## ■ Implant position

Only two studies<sup>18,25</sup> did not include specific three-dimensional placement parameters. All 15 residual studies placed the implant palatally, with an interproximal space between implants and teeth. The vertical position of the implant shoulders were reported as either 0.5 to 1.0 mm below the vestibular bone crest or 3 to 4 mm apical to the adjacent cemento-enamel junction.

## ■ Flapless vs flap raising

Flapless placement applied to 411 (65.56 %) implants, while 215 implants were placed after rais-

ing a mucoperiosteal flap. Five studies defined a mucoperiosteal flap as a mandatory part of the surgical protocol.

## ■ Antibiotics

Only one study<sup>18</sup> did not stipulate an antibiotic regimen, while the other 16 studies used preoperative and postoperative antibiotics. The documented choice of antibiotics was a broad-spectrum antibiotic such as amoxicillin, augmentin and clindamycin. The doses are listed in Table 3.

## ■ Insertion torque

For 419 implants, a minimum insertion torque of 32 Ncm or an ISQ value of 60 were mandatory, while for 53 implants, a minimum insertion torque of 25 Ncm was allowed.

## ■ Interproximal mucosa level

The mean reduction of interproximal mucosa level was less than 1 mm compared to the baseline (Table 4).

## ■ Midfacial peri-implant mucosal level

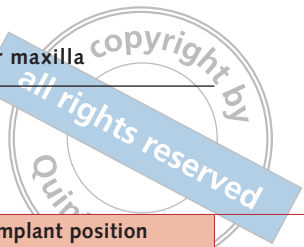
The midfacial peri-implant mucosal level change was less than 0.95 mm (Table 4). This level was for thin and thick soft-tissue biotype, without a significant difference, however in one study the thin biotype showed a significantly increased recession.

## ■ Crestal bone loss

The crestal bone loss was radiographically measured using a long-cone paralleling technique at various intervals relative to a baseline measurement. The mean crestal bone resorption was less than 1 mm compared to the baseline (Table 4).

## ■ Discussion

The main purpose of this review was to assess the impact of immediate single-tooth placement and restoration on hard and soft tissue outcomes, and to

**Table 3** Treatment protocol.

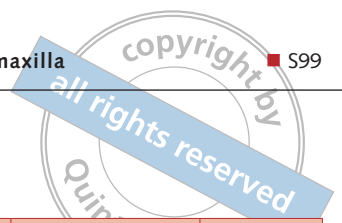
Author name	Year of publication	Journal	Type of implant	Implant shape (tapered/straight)	Type of implant connection	Antibiotics (pre/post)	Type of antibiotic	Implant position
Kan et al <sup>16</sup>	2003	IJOMI	Nobel Bio-care	Tapered	Internal	Post	Amoxicillin 500 mg	Palatal
Kan et al <sup>17</sup>	2011	IJOMI	Nobel Bio-care	Tapered	Internal	Post	Amoxicillin 500 mg	Palatal
De Rouck et al <sup>18</sup>	2009	COIR	Nobel Bio-care	Tapered	Internal	NR	NR	NR
De Rouck et al <sup>19</sup>	2008	JCP	Nobel Bio-care	Tapered	Internal	Pre/post	Amoxicillin	Palatal
Canullo et al <sup>4</sup>	2009	COIR	Global	Tapered	Internal	Pre/post	Amoxicillin	Palatal
Degidi et al <sup>20</sup>	2013	CIDRR	Ankylos	Tapered	Internal	Pre/post	Amoxicillin	Palatal
Spinato et al <sup>21</sup>	2012	ID	Screw Vent	Tapered	Internal	Pre/post	NR	Palatal
Pieri et al <sup>22</sup>	2011	IJOMI	Biospark	Tapered	Internal/morse taper	Pre/post	Augmentin	Palatal
Cosyn et al <sup>23</sup>	2011	JCP	Nobel Bio-care	Tapered	Internal	Pre/post	Amoxicillin	Palatal
Berberi et al <sup>24</sup>	2014	J Cont. D. Pract	Astra	Tapered	Internal	Pre/post	Amoxicillin	0.5 mm below crestal bone level
Cooper et al <sup>25</sup>	2014	IJOMI	Astra	Tapered	Internal	Pre/post	NR	NR
Ross et al <sup>26</sup>	2014	IJOMI	Nobel Bio-care	NR	NR	Pre/post	Amoxicillin / clindamycin	3 - 4 mm apical to the adjacent cemento-enamel junction
Calvo-Guirado et al <sup>27</sup>	2015	COIR	MIS Implants	NR	Internal	Post	Amoxicillin 875 mg	Bone crest level
Bruno et al <sup>28</sup>	2014	J Prost Dent	Nobel Bio-care	Tapered / straight	Internal	NR	Amoxicillin 1000 mg	0.5 - 1.0 mm below the interproximal bone crest
Grandi et al <sup>29</sup>	2013	EJOI	JDentalCare	tapered	Internal	Pre	Amoxicillin 1000 mg	0.5 - 1.0 mm below the vestibular bone crest
Malchiodi et al <sup>30</sup>	2013	CIDRR	NR	NR	NR	Pre/post	Amoxicillin 3000 mg	Most coronal part of the alveolar crest
Slagter et al <sup>31</sup>	2015	J Clin Period.	Nobel Bio-care	Tapered	Internal	Pre	Amoxicillin 500 mg	3 mm apical to most apical aspect of prosp. clinical crown

NR: Not reported; PS: platform switched, NS: non platform switched; PIS: Jemt Papilla Index Score; HS: placement healed site; Ext: placement fresh extraction socket; IT: insertion torque; IIPR: immediate implant placement and restoration; ILHS: immediate loading healed site.

identify critical clinical parameters which influence success. From a total of 95 articles, only 17 met the inclusion criteria. There was a scarcity of data involving both hard and soft tissue outcomes and many of the studies were underpowered, thus with a high risk of bias. In a recent Cochrane Database of Systematic Reviews<sup>48</sup>, a similar finding was observed and the authors concluded that there was insuffi-

cient evidence to recommend either an immediate or a delayed approach.

Randomised controlled trials assessing immediate implant placement versus delayed placement have found no statistical difference in the survival and success between these two treatment modalities<sup>49,50</sup>. This systematic review showed a mean survival rate of 98.40% over a mean follow-up



Insertion torque (Ncm)	Biotype thick	Biotype thin	Flap elevation vs flapless	Socket grafting	Grafting material	Jump space (mm)	Immed. rest. Therapy	Loading protocol non-functional / functional	Definitive restoration (months)
NR	14	21	Without flap reflection	No	--	NR	IIPR	Non-functional	5
NR	14	21	Without flap reflection	No	--	NR	IIPR	Non-functional	5
IT > 35	Normal to thick-flat	0	Minimal mucoperiosteal flap	Yes	DBBM	NR	IIPR	Non-functional	6
IT > 35	Normal to thick-flat	0	Minimal mucoperiosteal flap	Yes	DBBM	(0-4) mean 1.38	IIPR	Non-functional	6
IT 32 - 45	11	11	Without raising a flap	Yes > 1mm	Bioss Collagen	NR	IIPR	Non-functional	2
IT > 25 Ncm / ISQ > 60	30	23	Flapless	No	--	1.97	IIPR	Non-functional	6
IT > 35	45	0	Flapless	Yes (22), no (23)	DBBM (D)	2.25 (G) 2.03 (NG)	IIPR	Non-functional	6
IT > 40	Thick	0	Flapless	Yes	Mixture A & D	NR	IIPR	Non-functional	4
IT > 35	Normal-thick	0	Minimal mucoperiosteal flap	Yes	DBBM	1.38	IIPR	Non-functional	6
IT > 32	NR	NR	Limited flap design	NR	NR	NR	IIPR	Non-functional	NR
IT < 55	NR	NR	15 flap (Ext), 40 flapless (Ext)	No	--	NR	IIPR & ILHS	Non-functional	3
IT > 35 Ncm	36	11	30 flap, 17 flapless	Yes	Cortical allograft (Puros)	NR	IIPP	Non-functional	3
ISQ > 60	32	21	Flap	NR	NR	NR	IIPP	Non-functional	NR
IT > 35 Ncm / ISQ > 65	NR	NR	Flapless	Yes	DBBM (D)	1.5	IIPP	Functional	6
IT 72.2 Ncm (average)	NR	NR	Flapless	Yes	DBBM	NR	IIPR & ILHS	Non-functional	4
NR	64	Excluded	Flapless	Yes	Autol. bonechips	NR	IIPP	Non-functional	6
NR	16	4	Flapless	Yes	Autol. Bonechips & DBBM	NR	IIPR & ILHS	Non-functional	3
<b>Number of implants</b>	<b>Σ = 379</b>	<b>Σ = 112</b>	<b>Σ = 411 flapless / Σ = 215 flapless (65.56 % flapless)</b>	<b>Σ = 201 non grafted (= 32.11 %)</b>		<b>Σ = 170</b>		<b>Σ = 609 non-func. / Σ = 17 func. (97.28 % non-func.)</b>	

period of 23.7 months. These results were identical to a recent systematic review<sup>51</sup> which found the survival of immediate implants to be 98.4% over 2 years.

The success rate was not reported in nine studies (Table 2). In a review<sup>52</sup>, the authors concluded that there is a scarcity of data and there were limitations in aesthetically relevant and reproducible param-

eters. Some studies have also relied on patient-based satisfaction criteria, which have been shown to result in high levels of satisfaction, despite obvious discrepancies in crown height, owing to increased recession and incomplete papilla formation<sup>53</sup>. In an attempt to address this limitation in reporting, indices have been developed to score the papilla level<sup>15</sup>, and the so-called pink esthetic score (PES)<sup>54</sup>.



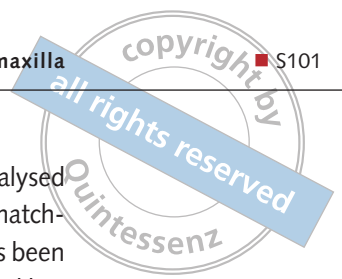
Table 4 Hard and soft tissue behaviour.

Author name	Year of publication	Inter-proximal mucosa level mesial (mean/mm)	Inter-proximal IML distal (mean/mm)	Midfacial peri-implant mucosal level (mean/mm)	Midfacial periimplant mucosal level MML thin biotype (mean/mm)	Midfacial periimplant mucosal level MML thick biotype (mean/mm)	Midfacial periimplant mucosal level (MML range / mm)	Crestal bone loss / gain (mean / mm)	Crestal bone loss / gain mesial (mean/ mm)	Crestal bone loss / gain distal (mean/ mm)
Kan et al <sup>16</sup>	2003	-0.53	-0.39	-0.55	NR	NR	NR	-0.24	-0.26	-0.22
Kan et al <sup>17</sup>	2011	-0.22	-0.21	-1.13	-1.5	-0.56	0-3	-0.67	-0.72	-0.62
De Rouck et al <sup>18</sup>	2009	-0.44	-0.31	-0.41	NR	-0.41	NR	-0.82	-0.92	-0.72
De Rouck et al <sup>19</sup>	2008	-0.41	-0.31	-0.53	NR	-0.53	NR	-0.88	-0.98	-0.78
Canullo et al <sup>4</sup>	2009	0.0 (PS), -0.94 (NS)	+0.14(PS), -1.0 (NS)	+0.18 (PS), -0.45 (NS)	+0.4 (PS), -0.5 (NS)	0.0 (PS), -0.4 (NS)	NR	-0.1 (PS), -0.21 (NS)	NR	NR
Degidi et al <sup>20</sup>	2014	-0.08 (test), -0.01 (control)	-0.1 (test), 0.03 (control)	-0.35 (test), -0.59 (control)	-0.41 (test), -0.64 (control)	-0.31 (test), -0.56 (control)	0-0.95	-0.96 (test), -0.97 (control)	-0.65 (test), -0.62 (control)	-0.77 (test), -0.68 (control)
Spinato et al <sup>21</sup>	2012	NR	NR	-0.4mm (G), -0.35 (NG)	NR	-0.4 (G), -0.35 (NG)	NR	-0.94 (G), -0.9(NG)	NR	NR
Pieri et al <sup>22</sup>	2011	-0.24 (PS), (NS)	-0.33 (PS), -0.28 (NS)	-0.61 (PS), -0.73 (NS)	NR	-0.61 (PS), -0.73 (NS)	NR	-0.19 (PS), -0.49 (NS)	NR	NR
Cosyn et al <sup>23</sup>	2011	-0.05	-0.08	-0.34	NR	-0.34	NR	-1.0	-1.13	-0.86
Berberi et al <sup>24</sup>	2014	NR	NR	NR	NR	NR	NR	-0.265	-0.24	-0.29
Cooper et al <sup>25</sup>	2014	*-0.13 (Ext), (HS)	*-0.21 (Ext), 0.50 (HS)	*0.06 (Ext), 0.42 (HS)	NR	NR	*-2.0-+2.0	+0.43 (Ext), +0.38 (HS)	NR	NR
Ross et al <sup>26</sup>	2014	NR	NR	0.30	> 2.0	0.30	0.08-0.82	NR	NR	NR
Calvo-Guirado et al <sup>27</sup>	2015	NR	NR	NR	NR	NR	NR	**ICBL -0.86	-0.09	-0.11
Bruno et al <sup>28</sup>	2014	17.6%, PIS score 3	23.5 %, PIS score 3	NR	NR	NR	NR	0	NR	NR
Grandi et al <sup>29</sup>	2013	82.6 % (mesial and distal), PIS score 3	82.6 % (mesial and distal) PIS score 3	52.1 % ideal (no recession)	NR	NR	0.0-2.0	-0.71	NR	NR
Malchiodi et al <sup>30</sup>	2013	-0.6	-0.8	46.9% no recession	NR	NR	0.0-2.5	-0.8, **ICBL +0.2	-0.7	-0.9
Slagter et al <sup>31</sup>	2015	-0.89, PIS 2.35	-1.00, PIS 2.45	-0.95	NR	NR	- 0.95 ± 0.62	NR	-0.75	- 0.70

\* Baseline: time of definitive crown placement.

\*\* ICBL: distance between the interproximal crestal apex and the contact point with adjacent teeth at the moment of tooth extraction.

NR: Not reported; PS: platform switched; NS: non platform switched; PIS: Jemt Papilla Index Score; HS: placement healed site; Ext: placement fresh extraction socket.



In order to obtain a predictable and a very good aesthetic result, careful patient selection and treatment planning seems to be needed, with assessment of key diagnostic indicators<sup>18,55</sup>. The proper placement of the implant in the three dimensions of space is considered to be a key clinical parameter for achieving good aesthetics<sup>56</sup>. Buser et al<sup>11</sup> described these spatial relationships relative to comfort and danger zones. It was considered safe if an implant was placed 1 mm palatal to the cervical emergence profile of the adjacent teeth, with a mesiodistal clearance of 1.5 mm and an apico-coronal position 1 mm apical to the CEJ of the adjacent teeth. Grunder et al<sup>56</sup> also considered it to be of particular relevance if there was at least 2 mm of bone buccal to the implant. This was to compensate for the possible re-establishment in the biological width, which was approximately 1.5 mm in both the vertical and horizontal position. Funato et al<sup>57</sup> has further illustrated the placement requirements of an implant, with importance given to the implant being prosthetically driven, ensuring it engages the palatal socket wall, and is ideally placed just lingual to the incisal plane.

### ■ Type of implant

The implants used in the included studies were broadly defined according to their shape, surface characteristics and interface connection. All of the implants had a solid tapered or straight and threaded design, with a moderately roughened surface and internal connection. There are arguments in favour of the use of a tapered implant design in extraction sockets, owing to the shape of this implant design better matching socket anatomy and facilitating placement<sup>58</sup>. The benefit of a tapered design to achieve high primary and secondary stability has been demonstrated<sup>59</sup>. All of the studies in the present review used a standard tapered and threaded design with two studies adopting a progressive thread pattern<sup>20,31</sup>.

One of the features which was constant throughout the reviewed literature, was the use of a moderately rough surface. The advantage of a roughened surface vs a machined one is the ability to achieve more rapid osseointegration and secondary stability<sup>60</sup>.

The implant interfaces utilised in the analysed studies consisted of internal connections with matching and mismatching abutments. The latter has been commonly referred to as platform switching and has recently gained popularity through claims of superior postoperative crestal bone preservation. The beneficial effects of limiting crestal bone loss with platform switching implants has been confirmed in a recent systematic review and meta-analysis<sup>61</sup>.

The studies by Canullo et al<sup>4</sup> and Pieriet al<sup>22</sup> represented randomised controlled studies comparing matching and mismatching abutments. In both of these studies the bone level preservation tended to be improved in the platform switching group compared with the non-switching groups. However, the peri-implant soft tissue levels had different outcomes with the two studies. Pieri et al<sup>22</sup> demonstrated no statistical difference in the recession of the midfacial gingiva and papillae, with almost identical results at the 12-month follow up. This may have been influenced by the placement of implants in patients with thick gingival biotypes only. In contrast, the study by Canullo et al<sup>4</sup> included 11 participants with thin biotypes and 11 with thick biotypes. In the thin biotype group, the platform switching groups mean midfacial recession value was almost 1 mm better. When we analyse the thick biotype subgroup, the difference in recession is 0.4 mm. Hence, it appears that the platform switching concept may be of particular relevance in the thin gingival biotype groups.

### ■ Gingival biotype

Recent studies have considered the presence of a thick gingival biotype to be crucial for immediate implant placement procedures<sup>55</sup>. In three of the included studies, only patients with thick gingival biotypes were enrolled, as thin gingival biotypes were considered to carry high aesthetic risks with IIPR<sup>19,21,23</sup>.

While the mucosal biotype had a negative influence on midfacial gingival levels, it failed to influence crestal bone loss and regeneration of papillae. In both thick and thin gingival biotypes, the amounts of crestal bone loss and papilla regeneration were about the same and independent of biotype. The papillae were the only soft tissue parameters which improved with time, despite continued crestal bone loss. In two



studies<sup>21,23</sup>, a continuous trend for papilla regeneration occurred even after more than 12 months, while two other studies<sup>4,20</sup> demonstrated stable papillae after 2 and 6 months, respectively. This was independent of the choice of a matching or mismatching abutment, although the platform switching concept resulted in greater papilla regeneration. This finding is also in contrast to other published data which have demonstrated that the papilla will only reach a stable state after 1.5 years<sup>15,62</sup>. In a study by Romeo et al<sup>63</sup>, it was shown that the presence of a papilla statistically correlated with thick gingival biotypes over a follow-up period of 12 months. In contrast, Canullo et al<sup>4</sup> found no relationship between biotype and papilla, and Kan et al<sup>17</sup> demonstrated progressive regeneration of the papilla, irrespective of biotype. The failure to establish a relationship between papilla level and biotype also corresponded with the findings of a recent study by Cordaro et al<sup>64</sup>. However, they did conclude that thin gingival biotypes resulted in statistically increased levels of midfacial recession when compared to thick gingival biotypes. These findings were also confirmed by results of a 4-year follow-up study by Kan et al<sup>17</sup>. In comparison, the studies by Canullo et al<sup>4</sup> and Degidi et al<sup>20</sup> did not demonstrate a relationship between thin gingival biotype and increased recession. In the study by Canullo et al<sup>4</sup>, the single most important influencing factor for improved peri-implant soft tissue profile was the use of a platform switching implant-abutment-joint. Although more recession occurred with thin gingival biotypes and in particular with the use of matching abutments, this was found to be statistically insignificant. The study by Degidi et al<sup>20</sup> also failed to provide a relationship between the midfacial recession and biotype. Degidi et al<sup>20</sup> found that the non-removal of abutments and the “one abutment at one time concept”, resulted in preservation of horizontal bone overlying the platform switching component of the implant. The removal of abutments (control) resulted in loss of the horizontal dimension of the bone and increased midfacial recession.

There is limited evidence to support or refute the stability of the midfacial gingival recession despite the recommendation for thick gingival biotypes with IIPP<sup>65</sup>. In particular, the present review failed to demonstrate a difference between thick and thin

biotypes. The stability of the midfacial gingiva and papilla has been attributed to the fabrication of an immediate anatomically contoured provisional<sup>16,18</sup>, and the presence of bone adjacent to the natural tooth<sup>66</sup>. The study by De Rouck et al<sup>18</sup> compared IIPR versus IIP and healing abutments, in patients with thick gingival biotypes. It was found that IIPR resulted in superior aesthetic results and that failure to instantly provisionalise caused a two to three times greater recession. The prosthetic therapy was shown to be the single most influencing factor favouring soft tissue stability. In the latter investigation, a relationship between biotype and marginal bone levels could not be shown, with both thick and thin biotypes behaving similarly. This was also reported by Cordaro et al<sup>64</sup>, although the technique for assessing bone loss utilised a non-standardised long cone paralleling technique, and therefore the results should be interpreted with caution. The greatest rate of marginal bone loss was shown to occur in the first 6 months and continued after 12 months, with a range between 0.7 mm and 1.0 mm, despite the difference in biotypes.

### ■ Spatial implant placement

The studies which described the three-dimensional placement of immediate post-extraction implants dictated palatal placement, engaging bone beyond the apex and ensuring an interproximal space of 1 to 2 mm. When placing implants into extraction sockets, it is important to control the axial inclination, to prevent contact with the thin facial plate of the bone. Implants which have been placed buccally have been associated with negative aesthetic outcomes<sup>67</sup>. In the same study, it was found that implants with a buccal shoulder position showed three times more recession than those that were placed with a palatal shoulder. Chen et al<sup>10</sup> investigated this in a prospective study, analysing the effects of axial implant placement and resultant peri-implant defects on aesthetic outcomes. The peri-implant defect was measured in a horizontal and vertical dimension at placement and at re-entry after 6 months of healing. The horizontal defect dimension (HDD) was measured from the outer bevel of the implant to the inner wall of the buccal plate. This distance was shown to significantly influence the aesthetic outcome when the

HDD measured  $1.1 \pm 0.3$  mm, and the implant was placed buccally. Ten implants (33%) were scored as aesthetic failures, with midfacial recessions ranging between 1 mm and 3 mm. Implants which were buccally placed represented 70% of the aesthetic failures and the remaining 30% belonged to the implants with a palatal placement of  $2.3 \pm 0.6$  mm. Interestingly, three out of four implants with initial dehiscence defects, also resulted in an unsatisfactory recession, 6 months after implant placement. This finding is also in agreement with a study by Kan et al<sup>68</sup>, who investigated the morphology of facial osseous defects and their effects on mucosal recessions with IIP. The morphology of the facial defects were characterised as V-, U- and ultra U (UU)-shaped, based on osseous probing. A V defect is one where the defect can only be probed on the buccal; a U defect is one which extends to the mesial and distal aspect of the failing tooth; a UU defect is one where the defect extends to the mesial and distal aspects of the neighbouring teeth. The incidence of the recession was found to occur in 100% of cases with UU morphology, 42.7% of cases with U morphology and 8.3% of cases with V-shaped defects. The study also found that there was no statistical relationship between biotype and the incidence of recession greater than 1.5 mm after 1 year.

The vertical or apico-coronal placement of the implant varied from 0.5 mm supracrestal, equicrestal and up to 2 mm subcrestal placement. The 2 mm subcrestal placement was recommended by Degidi et al<sup>20</sup>, together with the platform switching concept. De Rouck et al<sup>19</sup> recommended the placement of the implant 1 mm subcrestally and utilised matching abutments. This placement methodology resulted in the greatest amount of bone loss in studies with 12-month follow-up, but had no significant influence in midfacial recession outcomes. The equicrestal placement protocol was recommended by Canullo et al<sup>4</sup> and resulted in superior bone level outcomes compared to subcrestal placement methodologies. This study also analysed the difference in matching and mismatching abutments in thin and thick biotypes. In these groups, the midfacial recession and crestal bone loss was primarily influenced by the choice of prosthetic protocol and not by the biotype. The midfacial gingival position was superior with an equicrestal and platform switching concept,

compared to a subcrestal placement with platform switching. The only study which specified a supracrestal placement was by Pieri et al<sup>22</sup>. This study served to analyse the difference between switching and non-switching abutments in patients with thick gingival biotypes. The supracrestal placement with a platform-switching concept resulted in better marginal bone levels than for the subcrestal switching placement reported by Degidi et al<sup>20</sup>. Pieri et al<sup>22</sup> failed to establish such a relationship. It is important to note that they were dealing with single-tooth premolar sites which exhibited thick gingival biotypes.

It would appear from this systematic review that, where possible, an equicrestal placement should be maintained and if an implant needs to be placed further down to ensure stability, a platform switching implant should be considered. The use of equicrestal implants with platform switching also resulted in the best aesthetic and hard tissue outcome, irrespective of biotype.

#### ■ Antibiotics

In nearly all of the included studies, antibiotics were taken either, preoperatively and postoperatively or postoperatively only. The choice was always a broad-spectrum antibiotic.

#### ■ Socket grafting and gap size between implant and alveolar wall

When placing implants in extraction sockets, a space will usually remain between the implant and the inner wall of the facial plate of the bone. This defect can be managed with or without a graft and with a varying choice of filling materials. An experimental study by Araújo et al<sup>69</sup> demonstrated the benefits of grafting such 1 to 2 mm gaps, with immediate implant placement in the mandibles of dogs. The benefits of grafting were illustrated with the establishment of a thicker buccal bone, and maintaining the level of buccal bone close to baseline crestal positions. In contrast, the non-grafted sites resulted in a significantly apical and thinner buccal bone crest. The study by Caneva et al<sup>70</sup> failed to demonstrate the same beneficial effects in preserving vertical crestal bone level, since a similar magnitude of bone loss in grafted and non-grafted sites was observed. One of





the distinguishing features in this study was the very small baseline defect width, consisting of 0.5 mm. The merits of grafting a small site and in particular less than 1 mm has been questioned<sup>19</sup>.

A human 7-year prospective study served to analyse the relationship between baseline horizontal defect depths (HDD) grafted with DBBM and its effects on hard and soft tissue outcomes<sup>71</sup>. The bone levels were examined via CBCT and revealed that when the buccal bone was absent, 1 mm greater recession occurred. The mean HDD for this group without buccal bone was 1.3 mm, and when buccal bone was maintained, the mean HDD was 1.6 mm. This was not statistically significant and the study failed to establish a relationship between the morphology of the defects at baseline and bone dimensions at the 7-year follow up. It would appear from this study and that of Chen et al<sup>10</sup>, that grafting of the horizontal “jump space” alone is not adequate in preventing vertical soft and hard tissue loss.

The need for bone graft materials in the remaining gaps has been questioned<sup>8,72</sup>, and their ability to limit vertical crestal bone loss is unsubstantiated<sup>4,10,18,19,21,22,71,73,74</sup>. Although there may be some merits for increasing the horizontal dimension of bone<sup>10,67,69</sup> or providing a scaffold for hard and soft tissue development<sup>69,75</sup>, the current systematic review has failed to conclusively provide evidence in support of this method. Other factors such as the palatal placement of the implant and correct axial alignment<sup>4,10</sup> appear to be more important than just simply treating the HDD with bone substitute.

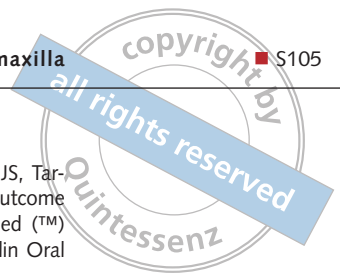
## ■ Conclusion

Within the limitations of this systematic review, it revealed excellent results for immediately placed and immediately restored single implants (IIPR) in the anterior maxilla. The possible choice for flapless surgery and a lack of grafting procedure of the socket enables minimally invasive surgery. However strict patient selection was used for all included clinical trials.

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