Dimensional changes in the supporting tissues following immediate placement and restoration of dental implants in the aesthetic zone: a retrospective study

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ABSTRACT

Aim: The objective of this retrospective study was to assess the survival rate and the hard and soft tissue response following immediate placement and provisional restoration of single-tooth implants in the aesthetic zone.

Materials and Methods: Thirty-four patients (13 male and 21 female) with 37 immediately placed and restored implants (Astra-Tech® AB, Mölndal, Sweden) were identified as eligible to participate in this retrospective study. Thirteen of these patients returned for the follow-up examination. All participating patients underwent the same treatment strategy which was removal of the failed tooth, flapless surgery, immediate implant placement and the connection of a screw-retained temporary restoration. Reasons for tooth loss included failed root canal treatment, trauma and tooth resorption. Three months following implant placement, the temporary crowns were replaced by the definitive restorations. Implant survival rates and hard and soft tissue changes were measured using photographs and periapical x-rays. The range of observation period was between 12 to 27 months with a mean period of 16 ± 5 months.

Results: At 16 ± 5 months, all implants were present at the time of follow-up with no complications, resulting in an implant survival rate of 100%. Radiographic evaluation revealed that there was no statistical difference in bone loss mesially and distally between baseline and follow-up. Clinical evaluation of the soft tissue revealed no statistically significant changes in mesial papilla, distal papilla and mid-facial tissue stability throughout the observation period.
**Conclusions:** Within the limitation of this retrospective study, immediate implant placement and provisional restoration in the aesthetic zone of the maxilla can result in acceptable treatment outcomes as well as stable peri-implant tissues after a follow up period of 16 ± 5 months using the Astra Tech implant system.
This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.
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1.0 Introduction

1.1 Overview

Dental implants are metal structures inserted into alveolar bone in order to facilitate the replacement of missing teeth. They are manufactured from titanium, which is highly biocompatible and has a unique ability to integrate with bone, forming an irreversible bond. This phenomenon is known as osseointegration. Following implant placement, a period of time is required for osseointegration and the implant is subsequently restored with a prosthesis which has a similar appearance and functionality to natural teeth. The use of dental prostheses supported by implants has become a widely utilised treatment option for tooth replacement. This treatment modality has demonstrated favourable outcomes in terms of long term prosthetic success as well as quality of life outcomes for patients.

Osseointegration was first described by Brånemark [1], who defined it as a direct connection between living bone and a load-carrying endosseous implant, as observed at the light microscopic level. Subsequently, osseointegration was defined as a direct structural and functional connection between living bone and the surface of a load-bearing implant [2].

The original implant placement protocol involved a load free period after implant placement of 3 and 6 months in the mandible and maxilla respectively [3]. It was postulated that a load free period would assist in minimizing micromotion, thus reducing the possibility of fibrous tissue formation or encapsulation and providing an environment conducive to osseointegration [4].
The original ‘Branemark protocol’ also involved placement of the implant following complete healing of the tooth extraction socket. The implant was then left to heal for six months prior to prosthesis attachment in order to allow for osseointegration to occur [2]. During this healing period, the implant was submerged under the oral mucosa, necessitating a second surgical procedure to expose it, which was followed by a period of soft tissue healing prior to construction of the prosthesis. Although this treatment protocol demonstrated good survival rates, it was also very lengthy.

With the increased popularity of dental implants, demand has grown for treatment completion in a shorter period of time compared with the original ‘Branemark protocol’. This has led to the introduction of new surgical and prosthetic protocols. One such technique involves the immediate insertion of the implant at the same time as tooth extraction (immediate implant placement) and subsequent restoration of the implant with a provisional prosthesis within 24 hours (immediate restoration). This treatment protocol is most likely to be utilised in the aesthetic zone of the patient’s dentition involving the anterior maxillary teeth [5].

1.2 Research question

The research questions are:

1) What is the survival rate associated with this clinical procedure?

2) What are the soft and hard tissues dimensional changes associated with immediately placed and restored implants in the aesthetic zone?

1.3 Significance of the current study
The assessment of clinical outcomes associated with immediately placed and restored implants in the aesthetic zone will provide vital information to the clinical practitioner regarding this increasingly popular treatment modality.

1.4 Objectives of the current study

The objectives of the current study were to retrospectively assess the survival rate, as well as soft and hard tissue dimensional changes associated with immediately placed and restored implants replacing single teeth in the aesthetic zone after a minimum follow up of 12 months.
2.0 LITERATURE REVIEW

2.1 Terminology

There has been inconsistency in the use of the key terms “immediate placement”, “immediate loading” and “immediate restoration” in the literature. Various authors have defined the terms differently leading to misinterpretation of results and miscommunication of outcomes. For instance, a number of authors [4] define “immediate loading” as any restoration that is visible in the oral cavity even if it does not have any occlusal contact with the opposite dentition. They argue that lip and cheek pressure, as well as tongue movement and food particles coming into contact with the implant will place a load on the implant, and hence the definition of immediate implant loading should apply. Furthermore, they consider that flexure stress and strain occurring in the jaw during opening and closing movement of the mouth generates functional loads on implants even when they are not in direct occlusal function [4]. Therefore, due to this discrepancy it is important to outline the terms and definitions which clearly differentiate between different clinical implant loading and placement protocols. Cochran et al [6] defined the various loading protocols as follows:

- Conventional loading: Defined as the restoration of implants after a healing period of 3 and 6 months in the mandible and maxilla respectively.
- Immediate restorations: Defined as any restoration placed within 48 hours of implant insertion but with no contact with the opposite dentition in both centric and eccentric occlusion. The rationale behind the 48 hour window is not based on any biological consideration but is purely related to the practicality and logistics associated with the ability to perform the restorative placement at the same setting as the surgical implant placement (which is not
always possible).

- Immediate loading: Defined as the placement of the restoration in direct contact with the occlusal plane of the opposing teeth within 48 hours of implant insertion.

- Early loading: Defined as the placement of a restoration in direct contact with the opposite dentition more than 48 hours, but less than three months, after implant insertion.

- Delayed loading: Defined as the delivery of the prosthesis some time after the conventional healing period of three and six months in the mandible and the maxilla respectively.

Recently, a modification of the above definitions [6] has been recommended [7]:

- Conventional loading of dental implants is defined as the restoration of the implant more than 2 months after implant placement.

- Early loading of dental implants is defined as loading between 1 week and 2 months following implant placement.

- Immediate loading is defined as being less than 1 week following implant placement.

- A separate definition for delayed loading was no longer considered necessary.

In terms of implant placement protocols, the following classification can be utilised [8]:

- Type 1 or “Immediate implant placement”: The implant is placed immediately following tooth extraction.
- Type 2: Implant placement 4 to 8 weeks after tooth extraction to allow complete soft tissue coverage of the tooth socket.
- Type 3: Implant placement 3 to 4 months after tooth extraction to allow substantial bone fill to occur within the tooth socket.
- Type 4: Implant placement more than 4 months after tooth extraction to allow complete healing of the tooth socket.

This retrospective study focuses on the clinical protocol of immediate implant placement (type 1) into fresh extraction sockets immediately following tooth extraction, and immediate provisional restoration of this implant. A follow up period of a minimum of 12 months was chosen as changes in soft and hard tissue dimensions can continue during the period of wound healing and maturation, thus affecting the aesthetic outcome and level of patient satisfaction.

2.2 Historical background of immediate implant placement and restoration

Several investigators have investigated the clinical outcomes resulting from immediate implant placement and/or restoration of dental implants. The concept of immediate implant placement (without restoration) was introduced by Lazzara [9] in 1989, with the rationale of reducing treatment time. Subsequently, Gomez et al [10] in 1997 reported a 98.84% five year success rate in eighty three implants placed immediately after tooth extraction without immediate restoration.

In terms of immediate restoration of implants, Tarnow et al [11] in 1997 reported a
97.1% success rate using a protocol that involved the placement of implants in healed sockets in both jaws and immediately restoring them without any contact in both centric and eccentric occlusion. In 1998, Wohrle [12] was the first clinician who used immediate implantation in fresh extraction sockets in the anterior area of the maxilla and placed a temporary crown immediately after surgery. The outcome of this study was a 100% success rate in fourteen patients and acceptable aesthetic outcome was reported.

2.3 Immediately placed and restored implant compared with delayed implant placement

The traditional implant placement protocol, where the implants are inserted into the completely healed socket, has shown a high clinical survival rate. However, efforts have now focused on improving the aesthetic outcome of implant therapy, especially in more demanding aesthetic circumstances. The immediate implant placement and immediate restoration treatment protocol has been developed based on the rationale that it preserves both soft and hard tissue architecture around the immediately installed implant. Hui at el [13] compared implants placed according to the conventional placement protocol with those placed into extraction sockets and immediately restored. His study concluded that both groups showed promising initial results in terms of patient satisfaction and aesthetic outcome. Another study carried out by Guirado at el [14] revealed that immediate implant placement in fresh single tooth extraction sites followed by immediate restoration with provisional crowns had high survival rates comparable to the conventional placement protocol. Conversely, Chaushu et al [15] showed that immediate placement and restoration of single tooth implants carried a 20% risk of failure. This outcome may be interpreted as being a result of using press-fit rather than conventional screw type implants. Most recently, Paolantonio et al [16]
showed that immediate implant placement minimized post extraction bone resorption, this maintaining the hard tissue topography close to its original contour before extraction and had a positive influence on the soft tissue architecture around the restored implant.

In summary, there are several possible benefits of immediate placement compared with conventional placement. Firstly, there are fewer surgical procedures resulting in less patient morbidity. Secondly, soft tissue stability around the implant supported restoration is improved. Thirdly, time is saved as both post-extraction healing and osseointegration events take place at the same time.

2.4 Limitation of the immediate implant placement and restoration strategy

Immediate placement and restoration of implants in the aesthetic regions appears to offer a success rate that is equal to that associated with conventional treatment. However, case selection is essential and there are several criteria which need to be considered. These criteria include:

- Morphology and configuration of the tooth socket, soft tissue contour is determined by the underlying bone. Therefore any bone defects will potentially compromise the aesthetic outcome of the treatment [17], [18], [19], [20], [21] and [22].

- Gingival tissue configuration, the gingiva should be of healthy and symmetrical harmony to allow an aesthetic outcome. Any gingival disease or defect would compromise the final outcome
Gingival tissue biotype, in general, a thick gingival tissue biotype is preferable in the aesthetic zone as it can mask the metallic hue of the implant neck, as well as being more resistant to recession. In contrast, the thin gingival tissue biotype is more prone to recession and tissue discoloration. In these situations, surgical and prosthetic planning before implant placement is very critical, and the implant may be placed more palatally in order to have a thicker buccal volume of hard and soft tissue in order to reduce the problem of metal showing through the tissues [23], [24], [25] and [26].

Smile line, patients with a high smile line who routinely show their gingival margin are a greater aesthetic risk than patients who don’t show their smile line during speech and laughter.

Presence of pathology/infection, poor oral hygiene and microbial plaque are causative factors that result in the occurrence of peri-implant infection and implant loss. Therefore, evaluation of the oral hygiene of the patient is a mandatory step before commencing immediate implant placement and restoration [27] and [28].

Smoking, studies show that smoking has a deleterious effect on implant integration in the short term and on the peri-implant tissue health in the long term. These effects may be exacerbated in an immediate implant placement and restoration treatment protocol [29], [30], [31], [32], [33] and [34].
2.5 **Review of the literature and search strategy**

The following criteria were considered in the process of selecting studies of immediate implant placement and restoration for this review:

1. **Types of studies:** all longitudinal studies were eligible for inclusion – randomized controlled trials, controlled clinical trials, cohort studies, case control studies and consecutive case report series. Only those studies that included 6 patients or more were selected. A minimum follow up time of 1 year was set as an inclusion criterion. Only studies published in English were included.

2. **Type of treatment modality (intervention):** immediate implantation into the fresh extraction socket followed an immediate placement of a provisional restoration in the aesthetic zone.

3. **Outcomes that were measured:**
   - Implant survival rate.
   - Patient satisfaction.
   - Peri implant soft tissue changes.
   - Peri implant hard tissue changes.
   - Gingival biotype and its relation to recession.

   For this review, a detailed search strategy was used for each selected database in order to identify all of the articles published in relation to the stated aims of this review. The search strategy used was a combination of free text terms and MeSH* terms. The searched data bases were:
# PUB MED, EBSCOhost and Ovid arms of MEDLINE.

# CENTRAL (The Cochrane Central Registrar of Controlled Trials).

# Science Direct.

The terms used in this search were:
Dental Implants, Oral Implants, immediate placement, immediate restoration, Immediate Provisionalization, aesthetic, single tooth replacement, single tooth in the maxilla and extraction socket.

The search strategy was as follows:
(Single Tooth* OR teeth*) AND Maxilla* AND (Immediate OR Immediate placement, OR Immediate Implantation, OR immediate restoration, OR extraction socket)
Single Tooth* AND Maxilla* AND
Single Tooth* AND maxilla * AND
Single Tooth* AND Maxilla* AND (OR provisionalization)
Single Tooth* AND Maxilla* AND

Furthermore, the search was complemented by checking the references of the selected articles for additional useful publications. Also a manual search was carried out of the following major journals in dental implantology: International Journal of Oral and Maxillofacial Implants, Clinical Oral Implants Research, Clinical Implant Dentistry and Related Research.

The search strategy initially yielded 80 articles. From these, 17 articles were considered
to fulfil the criteria for inclusion in this review. The other studies were excluded for the following reasons:

1) Review articles (10 articles): [35], [36], [37], [38], [39], [40], [41], [42], [43] and [44].

2) Implantation into healed sockets only (30 articles): [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73] and [74].

3) Implantation in the mandible or maxilla without any differentiation (7 articles): [45], [46], [52], [56], [59], [74] and [75].

4) Case reports of immediately placed and loaded implants (16 articles): [45], [47], [50], [52], [53], [59], [76], [77], [78], [79], [80], [81], [82], [83], [84], and [85].

5) The 17 included articles, alongside a description of the study type, implant system used and the numbers of included patients/implants are outlined in Table 1.
*Delayed implant placement.

RCT, randomized controlled trial; CS, case series.

Table 1  
Selected studies reporting on immediately placed and provisionally restored single maxillary implants in the aesthetic zone.

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>No. of Patient/implant</th>
<th>Implant systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wohrle (1998)</td>
<td>CS</td>
<td>14/14</td>
<td>Replace Select</td>
</tr>
<tr>
<td>Guirado et al (2002)</td>
<td>CS</td>
<td>13/18 = 9 &amp; 9*</td>
<td>Osseotite 3i</td>
</tr>
<tr>
<td>Groisman et al (2001)</td>
<td>CS</td>
<td>92/92</td>
<td>Replace select</td>
</tr>
<tr>
<td>Kan et al (2003)</td>
<td>CS</td>
<td>35/35</td>
<td>Replace Select</td>
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<tr>
<td>Tsirlis (2005)</td>
<td>CS</td>
<td>38/43 =28 &amp; 15*</td>
<td>Osseotite 3i</td>
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<tr>
<td>Cornelini et al (2005)</td>
<td>CS</td>
<td>22/22</td>
<td>ITI</td>
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<tr>
<td>Canullo et al (2007)</td>
<td>CS</td>
<td>9/10</td>
<td>Defcon®</td>
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<tr>
<td>De Rouck et al (2008)</td>
<td>CS</td>
<td>30/30</td>
<td>Replace select</td>
</tr>
<tr>
<td>Ribeiro et al (2008)</td>
<td>CS</td>
<td>64/82= 46 &amp; 36*</td>
<td>Connexao sistema de protese</td>
</tr>
</tbody>
</table>
2.5-1 Survival rate of immediately placed and restored implants in the aesthetic zone

The term ‘implant survival rate’ is defined as the percentage of implants that present at follow up [99], although it is important to note that the status of the implant not specified [100]. Conversely, implant success is defined as the presence of the implant at the end of an observation period, along with the absence of progressive bone loss, radiolucency, mobility (clinically), pain, discomfort and/or neuro-sensory changes [101].

All studies selected for this review reported on the survival rates of immediate implant placement and restoration in the aesthetic zone. A review of these studies in relation to the implant survival outcome is presented in this part of the review.

The primary goal of Wohrle’s (1988) investigation was to predictably maintain soft tissue morphology in the aesthetic zone of the maxilla and avoid postextraction complications related to hard tissue resorption and soft tissue recession. Fourteen implants were placed in fourteen consecutive patients (14/14). Five of the implants were placed in the lateral incisor position and the other nine were placed in the central incisor position. The implant system used was Replace (Steri-Oss, Yorba Linda, CA, USA) and both screw-type cylindrical and screw-type tapered implants were used. All surgical and prosthetic procedures were carried out by the same clinician. None of the implants were lost with an overall survival rate of 100% in a follow-up period ranging from six to 36 months [12]. In 2001, Hui et al [13] proposed immediate placement and restoration as a treatment modality aimed at provide an immediate and cost effective solution for restoring a single missing tooth in the maxillary aesthetic region. This prospective clinical investigation included twenty-four participants,
thirteen of which had immediate implant placement and restoration while eleven received implants in healed sites. All of the implants were placed in the maxillary aesthetic region. The overall follow-up period ranged from one to 15 months. According to the authors, the desirable goals of patient satisfaction, good aesthetic outcome and reduced treatment cost were achieved in this treatment protocol. The implant system used was Bränemark (Nobel Biocare AB, Göteborg, Sweden), and the implant types were both screw-type tapered and cylindrical. The implant survival rate of this study was 100% within the reported one to 15 months period of follow-up for both groups.

Guirado et al [14] conducted a prospective study involving eighteen implants in thirteen patients using the Osseotite system (3i, Implant Innovation, USA). All of the implants were placed in the maxillary aesthetic zone with nine placed into fresh extraction sockets and nine into healed sites. The observation period was one year and a 100% implant survival rate was reported. Advantages associated with the one stage protocol included immediate aesthetics, comfort and no need for surgical re-entry. Furthermore, the interdental papilla adjacent to the implants were preserved leading to optimal aesthetic results. The author concluded that the placement of implants immediately into fresh extraction sockets was a viable and predictable treatment alternative associated with a high survival rate.

Chaushu et al [15] hypothesised that the immediate restoration of implants replacing single missing teeth could be successfully achieved following immediate implant placement into fresh extraction sockets, as well as healed sockets. This study included twenty-six consecutive patients who received twenty-eight implants. Nineteen implants were placed into fresh extraction sites, and nine were placed into healed sites. The two implant systems used in this study were Steri-Oss, (Yorba Linda, CA, USA), (21 implants) and Alpha Bio hydroxy-
apatite coated cylindrical implants, (7 implants). The follow-up period ranged from six to 18 months, with a mean of 13 months for the immediately placed implants and 16.4 months for implants placed into healed sites. There were three failures among the immediately placed and restored implants, all occurring during the first month following implantation, resulting in an overall survival rate of 82.4% for this group. The patients who lost their implants were over 50 years of age. In each of these patients there was initial discomfort, followed by moderate pain and implant mobility. Another two patients experienced swelling with a purulent exudate. On the other hand, all of the non-immediate implants survived the healing period without any loss leading to a 100% short term survival rate for this group. All surviving implants of both groups were free from any complications. The results of this study revealed a 100% success rate in the healed sites but about a 20% failure rate associated with immediate placement into extraction sites. The use of a press fit cylindrical implant type may explain in part the low success rate in the immediate group.

In another prospective clinical study carried out by Kan et al [87] the implant survival rate, peri-implant tissue response, aesthetic outcomes and patient satisfaction were evaluated. This study included thirty-five patients with a mean age of 36.5 years, and each patient received a single flat platform, screw type tapered implant (Replace, Nobel Biocare, Yorba Linda, CA, USA). All of the implants were placed into fresh extraction sockets. The implant survival rate was 100% after a follow-up period of one year. All of the patients were satisfied with the aesthetic outcome of their restorations. The author concluded that a favourable implant success rate, peri-implant tissue response and aesthetic outcome can be achieved with immediately restored single implants placed in the maxillary aesthetic zone. In a more recent investigation with similar aims, the same author conducted another study, but instead of using flat platform implants, a scalloped implant platform design was used [93]. The introduction
of this new platform design aimed to replicate the irregular bony topography which results after tooth extraction, thus preventing future bone loss. The implant system used was (Nobel perfect; Nobel Biocare, USA). Thirty-eight implants were placed in twenty-nine patients with a mean age of 45.1 years. Fifteen implants were placed into healed sites while the other twenty-three were placed into fresh extraction sites. At the one year follow-up all implants remained in function with an overall survival rate of 100%.

The stated purpose of Groisman’s study [86] was to evaluate the survival rate of ninety-two tapered implants which were immediately placed and restored in the maxillary aesthetic region. The diameter of the inserted implants was selected based upon the size of the tooth sockets (Nobel Biocare, Yorba Linda, CA, USA). The observation period was two years, but only ten implants were followed up for the full 24 months. At the conclusion of the follow up period, 6 implants had been lost resulting in an overall implant survival rate of 93.5%. According to the author, one implant was lost due to trauma and two others due to overload in patients with a deep overbite. The cause of failure for the other three implants was not described. The study concluded that immediately placed and restored tapered implants did not show any adverse effects with regards to osseointegration. Favourable aesthetic outcome was achieved in eighty-two of 92 cases, representing 89% of the total number.

Lorenzoni et al [88] evaluated the clinical outcomes of immediately placed and restored stepped-screw type grit-blasted, acid etched FRIALIT-2 Synchro implants one year after placement in the maxillary anterior region. In the course of this study, nine patients received 12 implants; eight of which were placed into fresh extraction sites and four were placed into healed sites. All implants were immediately restored with acrylic resin provisional crowns,
and patients provided with occlusal splints so that the restorations were free from any direct loading. No implants failed in the 12 months after insertion, resulting in a 100% survival rate.

Norton [89] evaluated the clinical outcome of single-tooth immediately restored implants placed in the upper arch. Twenty-five consecutive patients with a mean age of 48.2 years received twenty-eight Astra Tech ST implants (Lexington, MA). Sixteen of the implants were placed into fresh extraction sockets while the rest were placed into healed sites. The follow-up period ranged from twelve to thirty months. All patients received friction-fit temporary crowns instead of cemented crowns. After a mean duration of four and half months following the surgical procedure, the permanent crowns were placed. Implant survival, along with hard and soft tissue changes, was recorded at follow up with an overall survival rate of 96.4%. One patient, a heavy smoker, lost one implant within one month of surgical placement. Furthermore, unfavourable soft tissue recession was associated with one implant. However, most of the restorations maintained an aesthetic gingival contour and architecture. Eleven of the 28 provisional restorations needed further treatment; six required replacement during the temporization period and five required re-cementation after becoming loose. The study concluded that immediate temporization of maxillary single-tooth implants could be both safe and predictable and the procedure appeared to yield favourable soft tissue aesthetic outcomes. The authors concluded that this treatment protocol utilizing the Astra Tech ST implant system resulted in predictable outcomes following immediate implant placement and restoration with provisional acrylic resin crowns.

In a study using two different implant systems, NT Osseotide (3i Implant Innovations Inc) implants and Frialit-2 (Friatec AG, Mannheim- Germany), forty-three single implants were inserted in thirty-eight patients. A survival rate of 100% was reported following an
observation period of 24 months. The patients were divided into two groups, immediate and delayed implant installation. The first group received twenty-eight immediately placed implants while the rest of the patients received delayed implant placement [90].

In another study using the Straumann TE implant system (Institute Straumann AG, Waldenburg, Switzerland), twenty-two single implants were immediately restored and followed up for one year. Three of these implants were placed into healed sockets while the rest were placed immediately into fresh extraction sockets [91]. The temporary crowns were completely out of occlusion in both centric and eccentric positions. Screw-retained temporary crowns were constructed to avoid the use of adhesive cements which may interfere with the healing process during osseointegration [16]. Nineteen of the implants were placed in the maxilla and three in the mandible. Premolars were the most common teeth to be replaced (13 teeth), followed by central incisors (6 teeth) and lateral incisors (3 teeth). The study reported a survival rate of 100%. All the implants were successful according to the criteria of Smith and Zarb [101]. Within the limits of this investigation, immediate restoration of single-tooth implants placed in fresh extraction sockets was considered to be an acceptable option.

In a study conducted by Ferrara et al [92], thirty-three consecutive patients with a mean age of 41 years received a single implant supported crown to replace a missing maxillary tooth at the time of tooth extraction. The implant system used was Frialit-2 (Friatec AG, Mannheim- Germany). Thirteen central incisors, nine lateral incisors, four canines and seven first premolars were included. The follow-up period ranged from one to four years. There were two implant failures resulting in an overall success rate of 93.9%. One implant did not integrate while another one became unstable as a result of trauma.
Canullo and Rasperini [94] investigated immediately placed and restored implants using the TSATM series 5 Defcon® Impladent (Barcelona, Spain) system. A platform switching design, whereby the trans-mucosal abutment was narrower than the implant platform, was used in order to maintain the surrounding peri-implant tissue dimensions. Ten 6 mm diameter implants were immediately placed into fresh extraction sockets in the aesthetic zone of the maxilla. A provisional 4 mm diameter trans-mucosal abutment was subsequently connected to the implant body, and a provisional crown was adapted and adjusted for non-occlusal contact in centric as well as eccentric positions. The definitive restoration was completed three months following implant placement. Nine patients with 10 sites were treated and the follow-up period was 22 months. All 10 implants were found to be clinically osseointegrated with a 100% survival rate.

Hall et al [95] evaluated the use of immediately placed and temporized tapered implants (Southern Implants Ltd, Irene, South Africa) to replace single teeth in the anterior maxilla. The participants’ mean ages were 43.25 years and the implants were followed up for one year. The patients were randomly divided into conventional (control group = 14 patients) and immediate restoration groups (test group = 14 patients). The test implants received provisional screw-retained crowns within four hours of implant placement, while in the conventional restoration group; temporary crowns were placed after 26 weeks. In the immediate placement/restoration group, one implant was lost for an overall survival rate of 93%, while in the control group two implants were lost at the one year follow-up. This investigation concluded that the immediate placement and restoration protocol used in this study resulted in similar outcomes as conventionally restored implants.

The main aim of Palattella’s study [96] was to compare the immediate restoration of
implants placed using an immediate and a delayed placement protocol. Sixteen patients with a mean age of 35 years were treated for single-tooth substitution in the anterior maxilla. The patient population was randomly divided into two groups. In the first group (test group), eight patients received nine implants placed and restored at the time of tooth extraction. The second group (control group) of eight patients received nine implants placed eight weeks after tooth removal. All implants underwent immediate restoration. All patients received the same implant system in the form of tapered effect (TE) Straumann implants (Institute Straumann AG, Waldenburg, Switzerland). Marginal bone resorption, papilla index and the position of mucosal margin were assessed at the time of provisional restoration fabrication (within 48 hours after implant placement) and at a two year follow-up visit. No implants were lost, resulting in a 100% survival rate for both groups after twenty-four months. The results suggest that immediate implant placement and restoration without functional loading may be considered a valuable therapeutic option for selected cases of single-tooth replacement in the aesthetic area.

A recent study conducted by De Rouck [97] also evaluated implant survival rates, soft and hard tissue changes and patient satisfaction in relation to immediately placed and restored implants in the anterior maxilla. Thirty consecutive patients underwent the same treatment protocol which consisted of flap elevation followed by immediate implant placement and connection of a screw-retained provisional restoration. The implant system used was Nobel Replace Tapered (Nobel Biocare, Goteborg, Sweden). Clinical and radiographic assessments were carried out at 1, 3, 6 and 12 monthly intervals. The results revealed that one implant failed in the first month of follow up resulting in a survival rate of 97%. It was concluded that this particular protocol can be considered to be a valuable treatment modality in carefully selected patients.
Ribeiro et al [98] compared immediately placed implants with those placed into healed sockets. Eighty-two implants were placed in the maxilla of forty-six patients, with forty-six implants inserted using the immediate placement protocol while the other thirty-six were inserted using the delayed placement protocol. The implant system used for this investigation was Conexao Sistema (de Protese Ltda, Sao Paulo, SP, Brazil). Success of implant integration was assessed according to the criteria described by Albrektsson [102]. The follow-up period ranged from 18 to 39.7 months. Three of the implants from the immediate placement group failed, resulting in a survival rate of a 93.5%. The delayed placement group had an overall success rate of 100 %. The differences in survival rate between the two groups were not statistically significant [98].

**Summary and conclusion:**

Table 2 shows the results of studies which investigated the survival rate of immediately placed and restored implants in the aesthetic zone. An implant survival rate of 100% was described in all except five studies, namely, Chaushu et al [15] achieved osseointegration in 78.6% of the cases while Groisman [86] achieved 93.5% and Ferrara et al [92] reported 93.9%. In two other recent studies, the reported implant survival rates were 93% and 97% respectively [95, 97]. Therefore, the majority of the studies reported that the implant survival rate following immediate placement and restoration is comparable to that achieved using conventional therapy.

Based on the results of studies carried out over relatively short time periods, the replacement of single teeth in the maxillary aesthetic region can be predictably achieved using an immediate implant placement and restoration protocol. However, studies with a
longer follow up are needed to further document survival outcomes of this treatment modality.
*Delayed implant placement.

RCT, randomized controlled trial; CS, case series.

Table 2  Implant survival rates for immediately placed and restored implants in the aesthetic zone.
2.5-2 Soft tissue changes following immediate implant placement and restoration

Gingiva can be defined as that part of the oral mucosa immediately surrounding the erupted tooth. It can also be defined as that part of the masticatory mucosa which covers the alveolar process and surrounds the cervical portion of the teeth. It consists of an underlying connective tissue layer (lamina propria) covered by an epithelium layer. It has several roles including protection of the underlying periodontal structures which support the tooth, attachment of the junctional epithelium to the tooth and clearance of food during mastication [103].

The gingiva consists of two functional portions, the keratinized masticatory component which faces the oral cavity and the non-keratinized area facing the tooth, which is involved in the attachment of the gingiva to the tooth.

Anatomically, the normal mucosa surrounding the tooth is subdivided into three main components:

- The marginal gingiva or free gingiva is pink in colour and has a firm consistency. It forms the unattached part of the gingiva. It extends from the top of the gingival margin to the free gingival groove which is localized at the level of the cemento-enamel junction (CEJ). The free gingival groove separates the free gingiva from the attached gingiva. The free gingiva is separated from the tooth via gingival sulcus or crevice [103].
The interdental papilla is that part of the gingiva which occupies the region between adjacent teeth or implants. It has different shapes and forms on anterior compared to posterior teeth. Its shape is determined mainly by the contact point of the adjacent teeth, the width of the proximal surface of the teeth and the position of the cemento-enamel junction. In the anterior region of the dentition it is pyramidal in shape, while in the posterior region it is tent-shaped with wider extension in the bucco-lingual direction. This is a result of the presence of contact areas rather than contact points in the premolar-molar region [103].

The attached gingiva extends from the free gingival groove to the mucogingival line. The mucogingival line separates the attached gingiva from the alveolar mucosa. The attached gingiva is firmly attached to the underlying periostum of the alveolus [103]. It is firm in texture, coral pink in colour and has small depressions on the surface called stippling. There is no mucogingival line present on the palate, as the entire hard palate is covered by attached masticatory mucosa.

The peri-implant mucosa is the soft tissue which immediately surrounds the dental implant. Following the placement of a transmucosal healing abutment, a soft tissue seal begins to form around the implant. This soft tissue seal will act as a barrier which protects the underlying structures, thus supporting the establishment and maintenance of osteointegration [103].

The appearance and dimensions of the buccal soft connective tissue depends mainly on the anatomy of the underlying bony tissue. Indeed, the final architecture and form of buccal tissue is determined by the position and inclination of the fully erupted teeth [104]. A study by Ochenbein et al [105] showed that the anatomy of the gingiva is related mainly to
the shape of the alveolar bone crest. It was suggested that two types of gingival biotype exist, namely a pronounced scalloped (thin) and a flat (thick) biotype. Individuals with the thin biotype have delicate cervical convexity and a small interdental contact area which is located very close to the incisal edge, while the crown form of the associated teeth is slender and tapered. The incisor teeth surrounded by this type of biotype have a thin free gingiva and the outline is highly scalloped [106]. Furthermore, the papillae associated with a thin biotype are long and narrow. In contrast, the flat gingival biotype is associated with square crowns with prominent cervical convexity. The contact area of the thick biotype is broader and located more apically resulting in short interdental papillae.

A study measuring the thickness of gingiva using bone sounding technique [87] reported that the thickness of gingiva varied between subjects of different gingival biotypes. This study concluded that the thick gingival biotype has more soft tissue volume than the thin biotype on the buccal and interdental aspects.

The presence or absence of the interdental papilla may be assessed visually. If there is a space apical to the contact area, which is characterised by a black triangle, the papillae are considered incomplete. On the other hand, if there is no space apical to the contact area, the papillae are considered complete. Tarnow et al [107] measured the distance between the interdental contact point and the crest of the interdental alveolar bone in order to determine if there is a relationship between this dimension and the height of the interdental papilla. The results of this study showed that the papilla was always complete when the distance from the contact area to the crest of interproximal bone was less than or equal to 5 mm. However, when this distance was more than 5 mm, about half of the cases had incomplete papilla fill.
There must be gentle handling of the peri-implant soft tissues during surgical implant placement due to their delicate nature. Any traumatic manipulation of these areas may compromise the aesthetic outcome. The peri-implant soft tissue should be in complete harmony with that of the surrounding tissues in terms of colour, form, shape and contour, resulting in restorations that mimic the lost dentition. In recent years, the success of dental implant restoration is no longer judged solely by successful osseointegration, with aesthetic outcome become of increasingly importance. This is particularly the case when implants are placed in the aesthetic zone, and this represents a challenge to both surgeons and restorative dentists. The peri-implant soft tissue architecture is one of the most important factors in determining the aesthetic outcome of implants placed in the aesthetic zone, especially in patients with a high lip line.

This review identifies and discusses studies which measured the soft tissue outcomes of immediately placed and restored implants in the anterior maxilla. The pioneering study of Wohrle [12] assessed soft tissue changes in 14 consecutive cases involving immediate implant placement and restoration during follow up period ranging from 9 to 36 months. The outcome of this study revealed that only two cases showed facial recession of 2 mm or more, with the remaining cases demonstrating stable soft tissue outcomes.

In the study by Cornelini et al [91] measurements of the soft tissue were taken at the time of implant placement and after one year of follow up. The soft tissue parameters measured included a mucositis score, mucosal margin level, variation of gingival level and variation of papillary position. According to Jemt’s index, no scores of 0, 1 or 4 were found [108]. Twenty-seven of the papillae received a score of two which meant that at least half of the height of interdental papillae was present. The other seventeen papillae presented with a score
of three which meant that the interdental papillae filled the entire interproximal space. In addition, the mid-facial soft tissue level was compared at baseline and at follow up using the gingiva of the adjacent teeth as a reference line. An average recession of approximately 0.75 mm was noted at follow up. The soft tissue condition (mucositis score) was determined using a modification of the criteria of the gingival index system described by Bengazi et al [109], whereby a score of zero denoted no colour or texture alterations, a score of one revealed a slight change in the colour and texture and a score of two indicated that there was a marked change in the colour and texture plus mucosal bleeding was evident following probing. A score of two was not observed in this study which indicated the absence of inflammation [91].

Kan et al [87] also evaluated the soft tissue response and aesthetic outcomes of immediately placed and restored single implants placed in the anterior maxilla. The surgical phase was conducted without flap reflection in an attempt to make the procedure as atraumatic as possible. The rationale for flapless surgery was to maintain continuous blood flow to the labial soft tissues and hence prevent recession. However, other authors [97] have argued that complete flap elevation results in similar soft tissue outcomes as those reported by Kan et al [87], and therefore flapless access does not improve aesthetic outcomes. In Kan et al’s study [87], the cervical gingival emergence of the extracted tooth was reproduced in the temporary crown in order to optimise soft tissue adaptation. Soft tissue parameters, namely the mid-facial gingival position and the height of the papillae, were measured at baseline, 3, 6 and 12 months after implant placement. The soft tissue measurements were obtained using 35 mm slides taken at 1:1 magnification, and the line connecting the mid-facial level of the two adjacent teeth was used as a reference. Changes in the mid-facial tissue level associated with the implant restorations were assessed by measuring the distance from
the reference line at each follow up visit. Similarly, changes in the mesial and distal papillae were measured as the distance from the tip of the papillae to the fixed reference line. The mean mid-facial gingival level changes after one year of follow up were 0.55 mm, which was similar to the result reported by Cornelini at el [91]. The changes in mesial and distal papillae levels were 0.53 mm and 0.30 mm respectively.

A second study by Kan [93], used the same protocol outlined earlier [87] but with a new implant design. In this one year prospective study, the aim was to compare the peri-implant tissue response between a scalloped (test) and a conventional (control) implant design following immediate placement and restoration in the anterior maxilla. In relation to the soft tissue data, only Jemt’s papilla index [108] was recorded. The mean papilla index scores at the test sites at baseline, 3, 6 and 12 months follow up were 2.4, 2.6, 2.6 and 2.7 respectively. Meanwhile, the mean follow up papilla index scores at the healed sites were 2.3, 2.4, and 2.4. The study concluded that there were no differences between the two implant designs in respect to papilla levels.

Groisman et al [86] evaluated 92 immediately placed and restored tapered implants in the maxillary anterior region. The results of this two year study revealed that three implants had more than 2 mm recession on the labial aspect and the shape of the papillae were completely preserved in eighty-two of the 86 surviving implants.

Canullo and Rasperini [94] evaluated the soft tissue changes in relation to immediately placed and restored implants with a platform switching design, whereby the temporary trans-mucosal abutment was smaller in diameter than the implant platform. The study included ten
implants with a diameter of 6 mm which subsequently received a 4 mm diameter provisional abutment. The soft tissue parameters, namely labial tissue levels and papilla height, were measured at the time of prosthesis insertion (baseline) and every six months thereafter. Measurements were taken from the incisal edges of the adjacent teeth and recorded to the nearest 1 mm. No recession of the mid-facial tissues was found at the follow up visits and indeed, a mean gain of about 0.2 mm was observed. Similar findings were noted in relation to the mesial and distal interdental papillae which had a mean gain of 0.25 mm. The gingival biotype was recorded as either thick or thin, but it did not seem to influence the final aesthetic outcome.

Hall et al [95] conducted a randomized controlled clinical trial which involved the placement of fourteen implants according to an immediate placement and restoration protocol (test group) in which a screw-retained crown was placed within 4 hours of implant placement and a definitive restoration inserted 8 weeks later. Another fourteen implants were placed according to a conventional protocol (control group), with temporary crowns placed at second-stage surgery after 26 weeks of healing. The study duration was one year. Recession was measured at the mid-buccal aspect of each crown and the interdental papillae were assessed according to Jemt s’ index [108]. At the one year follow up visit, there was no change for 28.5%, and an improvement for 63% of papillae. However, in this study the baseline measurements were taken 4 weeks after the placement of the definitive restorations. At the completion of the study, only one adverse soft-tissue response was recorded in the form of a mid-buccal recession of 2 mm in the conventional restoration group associated with a buccal bone dehiscence. Two other participants had one papilla which received the lowest papilla index rating.
Palattella et al [96] compared immediately placed and restored implants (test group) with implants placed into healed sites (control group). The follow up period extended over two years. The soft tissue parameters recorded were Jemt’s papilla index [108] and the position of the facial soft tissue margin. The mid-facial measurement was taken from the facial margin to the implant shoulder directly in the patients’ mouth using a periodontal probe. The results for the immediate implant placement group showed mean recession of 0.8 mm compared with 0.5-0.6 mm for the control group. The results were statistically significant when the baseline values were compared with follow-up measurements in both groups, but there was no difference between the two groups. Similarly, the papilla index outcomes were not statistically significant between the two groups.

De Rouck et al [97] also assessed soft tissue changes, as well as patient satisfaction, in relation to immediately placed and restored implants in the anterior maxilla. The surgical protocol involved minimal mucoperiosteal flap elevation following atraumatic tooth removal. The reported mid-facial recession was 0.53 mm; while the mesial and distal papillae lost were 0.41 mm and 0.31 mm of height respectively. The measurements were recorded using an occlusal stent to standardize the data.

Choquet et al [110] investigated interdental papilla dimensional changes adjacent to 27 immediately placed implants. The mean observation period of this study was 6 to 75 months following permanent crown placement. This study concluded that the papilla height measured from the apical aspect of the contact area between the crowns and the crest of alveolar bone using radiographs, was consistently around 4 mm. It was shown that incomplete papilla fill was more common when contact areas were located closer to the incisal edge of the crowns. Chang et al [111] also studied the dimensions of papillae associated with single tooth
implants placed in the anterior maxillary zone, in this case comparing them with papillae at the non-restored contra-lateral natural teeth. Their results revealed that the papilla height for natural teeth was higher and showed more fill of the gingival embrasure than the implant supported single restoration.

**Summary and conclusion:**

It is clear from table 3 that there are a limited number of studies which have adequately assessed soft tissue dimensional change associated with immediately placed and restored implants, with only a few studies reporting adequate one year follow up data on soft tissue changes. Kan *et al* [87] reported a mean loss of interdental papilla which ranged between 0.39 mm and 0.55 mm with mid-facial recession of 0.55 mm. Similarly, De Rouck *et al* [97] reported a mean loss of papilla height ranging from 0.31 mm to 0.41 mm with an average mid-facial recession of 0.53 mm and Cornelini *et al* [91] found 0.75 mm of mid-facial recession, while 61% of interdental papilla received a score of 2 according to Jemts’ index (half of the papilla height present), and 39% presented a score of 3 (papilla fills all of the proximal space). In a contrasting study, Canullo [94] showed gain of 0.2 mm in the mid-facial margin and 0.25 mm mean gain in papilla height. Clearly, more studies with a longer period of follow up are needed to assess the effect of this treatment protocol on soft tissues changes.
## Table 3

Reported soft tissue dimensional changes following immediate implant placement and restoration in the aesthetic zone.

<table>
<thead>
<tr>
<th>Study</th>
<th>Level of mid-facial gum</th>
<th>Tip of mesial papilla</th>
<th>Tip of distal papilla</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WÖhre</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>More than 2 mm change in two cases</td>
</tr>
<tr>
<td>Groisman et al</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2 mm soft tissue loss from buccal aspect</td>
</tr>
<tr>
<td>Kan et al</td>
<td>0.55 ± 0.53 mm loss</td>
<td>0.53 ± 0.39 mm loss</td>
<td>0.39 ± 0.40 mm loss</td>
<td>-</td>
</tr>
<tr>
<td>Cornelini et al</td>
<td>0.75 mm loss</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canullo et al</td>
<td>0.2 mm gain</td>
<td>-</td>
<td>-</td>
<td>0.25 mm mean papilla gain</td>
</tr>
<tr>
<td>Hall et al</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No change in 28.5% of the papilla with gaining in 63% of the sites.</td>
</tr>
<tr>
<td>Palattella et al</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.8 mm loss</td>
</tr>
<tr>
<td>De Rouck et al</td>
<td>0.53 mm loss</td>
<td>0.41 mm loss</td>
<td>0.31 mm loss</td>
<td>-</td>
</tr>
</tbody>
</table>

- Indicates no data.
2.5-3 Hard tissue changes following immediate implant placement and restoration

Alveolar bone is made up of an outer layer of cortical bone and an inner layer of coarse bundle bone which lines the tooth socket. A central spongiosa zone is found between the outer cortical and inner bundle layers. The outer cortical layer and inner bundle bone meet together at the alveolar crest, about 1.5 to 2 mm below the level of the cemento-enamel junction. The alveolar bone is also known as the cribriform plate because of the presence of numerous openings for nerves, blood vessels and lymphatics (Volkmann’s canals) supplying the periodontal ligament [104]. The following structures make up the components of alveolar bone:

- The outer cortical plate which consists of lamellar bone composed of a compact haversian system. These plates form the outer (labial or buccal) and the inner (lingual or palatal) aspects of the alveolar process. The cortical plates are much thinner in the maxilla than in the mandible and are also thinner in anterior compared with posterior regions [104]. It is densest and thickest at the premolar-molar region of the mandible, especially on the buccal aspect (external oblique ridge).

- Cancellous (spongy) bone occupies the middle part of the alveolar process. It does not exist at the alveolar crest in the canine-incisor region where the outer and inner cortical plates fused together, leaving no room for cancellous bone. The cancellous bone is made up of interlacing trabaculae with intervening bone marrow. The volume of cancellous bone is largely dependent on the distribution of stress and functional forces that are generated within the dental arch. For instance, in the canine-
incisor region, cancellous bone is often non-existent, while in the premolar-molar it is thick and present in abundant amounts in response to functional demand [104].

The bundle bone is part of the alveolar bone which immediately lines the tooth socket. It consists of lamellar bone running parallel to the socket wall. The periodontal ligament fibres insert into bundle bone, thus providing attachment for the tooth. Bundle bone is radiographically referred to as lamina dura due to its high radiopacity which is attributed to the presence of thick lamellar bone without any trabeculation [104].

In contrast to the limited literature available on the changes in soft tissue parameters following immediate implant placement and restoration, the changes in hard tissue dimensions are relatively well documented. However, the data shows a wide range of variation, which may be attributed to the use of different implant systems, follow up periods, as well as prosthetic and surgical techniques. Wohrle’s pioneering study [12] included only patients with grade A (fully preserved) or grade B (minor atrophy) osseous ridge contours surrounding the teeth. In terms of bone quality, none of the sites were determined to be type I, nine sites were type II and III, and five of the sites were type IV [112]. This study showed no vertical bone loss greater than 1 mm following comparison between pre- and postoperative x-rays. Furthermore, the harmony and continuity of hard and soft tissues was predictably achieved in all cases.

Hui et al (2001) reported radiographical bone loss of less than one millimetre after one year of follow up. Bone level measurements were carried out from the implant-abutment junction to the first bone-implant contact mesially and distally [13]. In the study by Gurido et
al [14], the radiographs taken at one year post placement indicated crestal bone loss beyond the implant collar and down to the first thread. The authors suggested that a larger implant diameter works well for larger central incisor and canine sites because the coronal implant diameter more closely mimics the cervical cross section of the lost tooth resulting in a superior emergence profile.

In a somewhat different approach, Groisman *et al* [86] placed implants in the lingual aspect of the extraction socket, resulting in approximately 2 mm of space between the socket wall and the implant. A particulate autogenous bone graft was used to fill the space between the neck of the implant and the tooth socket wall. Comparison of preoperative and postoperative radiographs after a follow up of 6 to 24 months showed maximum bone loss of 2 mm. Kan *et al* [87] reported changes of mesial and distal bone levels of 0.26 ± 0.4 mm and 0.22 ± 0.28 mm from the time of implant placement up to one year of follow up. In this study, the marginal bone change was measured using sequential peri-apical radiographs and the long cone paralleling technique. Standardization of the peri-apical x-rays was achieved using an occlusal jig, so that both the angulation and the position of the films were fixed. The measurements were taken using the apical corner of the implant shoulder as a reference point. The lower values of bone loss in this study were explained by the author as being the result of bone gain in some cases which may be attributed to bone filling into the gap between the implant and the socket wall following immediate implant placement.

Lorenzoni *et al* [88] reported bone resorption of 0.48 mm in the first six months and 0.75 mm after 12 to 14 month of follow up at both immediately and conventionally placed implants. The maximum bone resorption reported at 6 and 12 months after implant placement was 2 mm. In this study, intraoral radiographs (Sidexis-Intraoral, Sirona) with a digital sensor
positioning system (XCP-DS, Sirona) were taken monthly.

Norton’s 2004 study reported no bone loss or bone gain in 37.5% of cases treated with the immediate implant placement and restoration protocol [89]. Standardized intraoral radiographs were taken using a Rinn device (Dentsply-Rinn) prior to the cementation of the definitive restoration and again at recall. The follow up period ranged from 12 to 30 months. The mean marginal bone loss was 0.40 mm (range 0 to 1.53 mm) one year after placement of implants, and a considerable number of implants (37.5%) had no observed bone loss. Similarly, Ferrara et al [94] concluded that there was no apparent bone loss around the immediate placed and restored implants after one to four years follow up period.

A study by Tsirlis et al [90] which had a follow up period of two years revealed average bone loss of 0.75±1.05 mm around immediately placed and restored implants. Similarly, Cornelini’s [91] investigation reported mean bone resorption on the mesial and distal aspects of 0.5 mm at 12 months follow up. These measurements were relative to the baseline readings taken at the time of implant placement. A manual technique was used to take the measurements from x-rays. A transparent ruler and magnifying lens measured the distance between the implant neck and the point of contact between bone and implant.

In the second study by Kan in 2007 [93] which utilised the scalloped platform implant design, standardized x-rays were used to assess mesial and distal bone levels using the apical corner of the implant collar as a reference. The readings with positive values indicated a level coronal to the reference point and negative readings indicated a level apical to the reference point. A mean bone gain of 1.0 mm was reported at the one year follow up. The bone gain was attributed to the placement of bone graft into the gap between the implant and the wall of
the extraction socket. The mean marginal bone levels at baseline, 3, 6, and 12 months following implant placement were 1.1 mm, 1.2 mm, 0.9 mm and 0.2 mm, respectively. The corresponding mean marginal bone levels for healed sites were 1.8 mm, 0.3 mm, 0.3 mm and 0.1 mm, respectively. Bone quality [112], clinically evaluated at time of implant placement was categorized as either type II (10 implants) or type III (28 implants).

Canullo and Rasperini [94] reported an overall bone loss of 0.78 ± 0.36 mm with more loss in the distal aspect (1.01 mm) than the mesial aspect (0.57 mm) in their study which utilized a platform switching implant design (TSATM series 5 Defcon® Impladent, Barcelona, Spain). Periapical radiographs were obtained every 6 months to compare bone changes relative to baseline measurements. The peri-implant marginal changes were evaluated using a computerized measuring technique. The distances from both mesial and distal margins of the implant collar to the point where bone appeared to be in contact with implant were measured using image analysis software (Scion Image 4.02). This study concluded that immediately placed and restored implants with platform switching could preserve soft and hard tissue architecture and therefore may have the ability to provide better aesthetic outcomes.

Palattella at el [96] assessed bone level changes using radiographs taken at the time of implant placement and at two years of follow up. The distance between the most coronal bone–implant contact and the implant shoulder was measured. Radiographs were not standardized but care was taken to ensure a parallel position of the film. The mean bone loss after 2 years was 0.54 ± 0.51 mm in the test group (immediate placement) and 0.46 ± 0.54 mm in the control group (late placement). The difference was not statistically significant.
The radiographic assessment carried out by De Rouck [97] showed 0.98 mm of mesial bone loss and 0.78 mm of distal bone loss. The largest amount of bone loss happened in the first three months (0.58 mm mesially and 0.47 mm distally). Thereafter, diminished bone loss was observed. The x-rays were taken at the time of placement, 3, 6 and 12 months. An occlusal jig was used in order to standardize angulations and film position.

**Summary and conclusion:**

Table 4 shows that most studies investigating the immediate placement and restoration protocol report a mean bone loss ranging from 0.2 mm to 1 mm following one year [13], [87], [88], [89], [91], [94], and [97]. However, for periods beyond one year the average peri-implant bone loss increased [12], [86], [90], and [96]. Conversely, Ferrara [92] et al showed no evidence of bone loss around immediately placed and restored implants. Overall, the treatment concept of immediate implant placement and restoration seems at least as favourable as the standard two stage protocol in terms of preserving the marginal peri-implant hard tissues, at least in the short term (up to 3 years). More studies with a prolonged follow up period are required to more precisely assess the long term dimensional bone tissue changes in response to immediate implant placement and restoration.
<table>
<thead>
<tr>
<th>Study</th>
<th>Bone level mesial</th>
<th>Bone level distal</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wohrlé et al</td>
<td>-</td>
<td>-</td>
<td>1 mm bone loss</td>
</tr>
<tr>
<td>Hui et al</td>
<td>-</td>
<td>-</td>
<td>Maximum 0.6 mm bone loss</td>
</tr>
<tr>
<td>Guirado et al</td>
<td>-</td>
<td>-</td>
<td>Bone loss to the first thread</td>
</tr>
<tr>
<td>Chaushu et al</td>
<td>-</td>
<td>-</td>
<td>Bone loss not extend beyond the junction</td>
</tr>
<tr>
<td>Groisman et al</td>
<td>0.26 ± 0.40 mm</td>
<td>0.22 ± 0.28 mm</td>
<td>Maximum 2 mm of bone loss</td>
</tr>
<tr>
<td>Kan et al</td>
<td>-</td>
<td>-</td>
<td>Maximum 2 mm of bone loss</td>
</tr>
<tr>
<td>Lorentzoni et al</td>
<td>-</td>
<td>-</td>
<td>0.75 ± 0.50 mm bone loss</td>
</tr>
<tr>
<td>Norton</td>
<td>-</td>
<td>-</td>
<td>0.5 mm bone loss</td>
</tr>
<tr>
<td>Tisirli</td>
<td>-</td>
<td>-</td>
<td>0.75 ± 1.05 mm bone loss</td>
</tr>
<tr>
<td>Cornelini et al</td>
<td>-</td>
<td>-</td>
<td>0.5 mm bone loss</td>
</tr>
<tr>
<td>Ferrara et al</td>
<td>0.57 mm bone loss</td>
<td>1.01 mm bone loss</td>
<td>Maximum 2 mm of bone loss</td>
</tr>
<tr>
<td>Palattella et al</td>
<td>-</td>
<td>-</td>
<td>0.78 ± 0.36 mm bone loss</td>
</tr>
<tr>
<td>De Rouck et al</td>
<td>0.98 mm bone loss</td>
<td>0.78 mm bone loss</td>
<td>0.54 ± 0.51 mm bone loss</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 4** Reported hard tissue dimensional changes following immediate implant placement and restoration in the aesthetic zone.
3.0 Materials and Methods

This retrospective study aims to investigate the survival rate of immediately placed and restored implants in the aesthetic zone, as well as the soft and hard tissues changes associated with this treatment protocol. Thirty-four consecutive patients who received at least one immediately placed and restored implant in the aesthetic zone were identified as eligible to participate in this study. Six of these patients could not be contacted as they had relocated and had not left a forwarding address. From the remaining twenty-eight patients, thirteen returned for the clinical examination. The main reason for the refusal of the other fifteen subjects to attend the follow-up examination appointments was related to their residence in remote areas, in many cases hundreds or even thousands of kilometres away. All of the patients that were unable to attend were contacted by telephone and indicated that their implants were functioning well and that they were satisfied with the outcome.

3.1 Patient selection (the inclusion criteria)

All patients included in the study fulfilled the following criteria:

1. Minimum age of 20 years.

2. Received at least one immediate and immediately provisionalised implant in the esthetic zone, with bilateral presence of neighbouring teeth

3. Primary implant stability was achieved.

4. There was adequate amount of bone to accommodate the implant without the need of bone grafts and bone regeneration procedures other than use of bone graft to fill the
gap between the implant and the extraction socket wall or grafting of non-crestal bony areas.

5. There was no contact of the temporary restoration in both centric and eccentric relations prior to the final restoration.

6. All patients received screw retained temporary crowns.

7. All patients received screw type Astra tech implants.

8. Minimum insertion torque of 30 Ncm.

9. All implants were inserted by the same operator using the same treatment protocol, as described in section 3.2.

The research protocol was reviewed and granted ethical approval by Griffith University (DOH/09/09/HREC). All treatment was conducted in a periodontal private clinic in Brisbane, QLD, Australia.

3.2 Surgical protocol and techniques

Contra-indications of the surgical protocol:

1. Presence of active infection around the tooth.

2. Medical history contraindicating elective surgery.

3. Dental history of parafunction (habits like bruxism, clenching), anterior deep bite and unstable occlusion.
4. Heavy smoking (more than ten cigarettes/day).

5. Failure to achieve primary implant stability following placement.

All surgical procedures were conducted under local anesthesia. Preoperative antibiotics were given to all patients. This prophylactic dose was 500 mg Amoxicillin three times daily (20 caps) for 1 week. If the patients were allergic to penicillin, they were given Clindamycin 150 mg qid (25 caps) for one week. Postoperative instructions included chlorhexidine mouthwash (20 ml) for 2 minutes twice daily for two weeks. Patients were instructed to not brush the implant site for at least two weeks and to avoid biting on the provisional restoration. NSAIDs were recommended for pain control as needed, using either 1g of Paracetamol or 400 mg of Ibuprofen, according to the patient’s preference.

Implant treatment was undertaken according to the following protocol:

- Diagnostic evaluations of the site of placement including clinical examination, radiographic analysis to assess the suitability for immediate implant placement, and occlusal analysis with study models.
- Patient information and consent.
- Minimally traumatic extraction using a periotome without flap elevation.
- Surgical placement according to the instructions of the implant manufacturer (Astra Tech®). Briefly, osteotomy was carried out in order to prepare the implant recipient bed. Implant placement was carried out according to the manufacturer’s instructions.
- Primary stability was achieved to a minimum insertion torque of 30Ncm.
- The buccal space between the implant and the socket wall was filled using a xenogenic bone graft (Bioss, Geistlich).

- Patients given post-operative instructions to avoid the surgical site during brushing and eating, use a chlorhexidine mouthwash (20 ml) twice daily for a period of two weeks and use post-operative medication (Paracetamol or Ibuprofen) as needed.

(PHOTOS COURTESY PROF. SASO IVANOVSKI, 2007).

**Figure 1** Surgical techniques- failed tooth before extraction.
Figure 2  Tooth extraction.

Figure 3  Implant placed in final position.
3.3 Temporary crown placement

After abutment connection (figure 4), a prefabricated screw retained temporary crown was adjusted and placed on the abutment (Figures 5 and 6). Appropriate adjustment of the occlusal scheme was carried out in order to ensure that the placed restoration was free of any contact in both centric and eccentric excursions. Final finishing of the provisional crown was carried out with rubber cups and pumice.

Figure 4 Temporary crown placement.
Figure 5  Temporary crown placement.

Figure 6  Temporary crown adjustment.
3.4 Permanent crown placement

After 3 to 4 months the temporary restorations were replaced by permanent metal ceramic restorations by a prosthodontist (Figure 7).

Figure 7   Permanent crown placement- 3 months postoperatively.

Figure 8   Permanent crown placement- 6 months postoperatively.
3.5 Hard tissue measurements

Periapical x-rays were used to measure the changes in alveolar bone height surrounding the implant from the time of placement (baseline) to the follow up assessment which was at least 1 year later. The parallel technique was used in order to obtain comparable x-rays, and further standardization was carried out by using the known implant length to calibrate the before and after measurements. The apical aspect of the implant was used as a reference level from which mesial (Mbc) and distal (Dbc) lines were drawn in a coronal direction towards the first point of contact between bone and the implant (Figure 9). Computer software (ImageJ) was used to calculate the length of these lines (Mbc and Dbc) and express it as both percentage of the full implant length and as an absolute measurement in millimetres.

The measurements were performed independently by both the principal investigator (NK) and a second investigator (NM).
Figure 9  Illustration of hard tissue measurements on periapical x-ray.

AL= apical line, Mbc= mesial bone contact, Dbc= distal bone contact.
3.6 Soft tissue measurements

The soft tissue data were collected from photographs taken with a fixed zoom ratio, immediately after the placement of the temporary restoration (baseline) and at the follow up visit (at least 1 year later). Study models, when available, confirmed the soft tissue measurements at baseline. Two different protocols were used for assessment of tissue conditions at the follow up examination:

1: For six of the subjects, standardised photographs were taken with a fixed angle and zoom ratio and also with a periodontal probe within the frame. This allowed for measurement of changes as percentages, but also direct measurement of soft tissue changes in millimetres.

2: For the other five subjects, standardised photographs were taken with a fixed angle and zoom ratio but without the use of a periodontal probe. This allowed for relative measurement expressed as percentage of a fixed length, without translating these measurements in absolute mm values. The crown length of the tooth mesial to the implant was accepted as the reference length, based on the assumption that no changes in the gingival attachment had occurred between the baseline and the follow up examination.

This allowed comparisons of the changes that occurred before and after tooth removal with regard to the position of the gingiva and the amount of recession.
An imaginary line extending from the incisal edges of the teeth adjacent to the implant (Ocl) was the starting point for the measurements. From this line, perpendicular lines were drawn extending to the tip of the mesial (Mp) and distal (Dp) papilla, as well as the middle of the mid-buccal gingival margin (Bm). The length of these lines was calculated based on the clinical photographs using a software program (ImageJ). The length was expressed as percentage of the initial crown length for all patients and additionally in millimeters for patients examined under protocol 3.6-1. The measurements were performed by the principal investigator (NK) and also by a second investigator (NM).
Figure 10  Illustration of the measurements of soft tissue on photographs.

Ocl= occlusal line, Mp= distance to mesial papilla, Dp= distance to distal papilla

Bm= distance to middle of buccal gingival margin.
3.7 Other measurements

3.7-1 Implant survival rate

The criteria for successful osseointegration according to Smith and Zarb [101] were adopted. These criteria include:

- Lack of continuous bone loss. It is widely accepted that continuous loss of bone around osseointegrated implants over time can lead to implant failure. The main factor that leads to bone loss around implants over time is plaque induced inflammation, known as peri-implantitis [113]. Careful monitoring by using standardized radiography, as well as probing around the peri-implant tissues, is mandatory for the assessment of bone levels around implants. In establishing valid criteria for success, a mean bone loss of no more than 0.2 mm per year following the first year of implant placement has historically been considered to be acceptable [101].

- Lack of mobility. Implant mobility remains the cardinal sign of implant failure, and hence the detection of mobility is a vital diagnostic parameter.

- Lack of peri-implant radiolucency. Healthy peri-implant bone is a prerequisite for successful osseointegration and long term implant success.

- Lack of discomfort and/or neurosensory changes. An implant cannot be considered successful if its existence causes pain and discomfort to the patient [101].
3.7-2 Assessment of interdental papilla

The triangular interdental papillae occupying the space between the implant retained restoration and the adjacent teeth were assessed using Jemt s’ index [108]:

Score 0  (no papilla)
Score 1  (<½ of papilla)
Score 2  (½ of papilla)
Score 3  (papilla fills entire space)
Score 4  (hyperplastic papilla)

3.7-3 Plaque levels

Presence of plaque on the facial surface of the mesial neighbouring tooth was dichotomously recorded from the photographic records at placement and follow up.

3.7-4 Gingival tissue biotype

Gingival tissue biotype was assessed as being thick or thin based on the Müller s’ criteria [117]:

1) Thick gingival tissue biotype- a periodontal probe placed into the labial gingival crevice cannot be seen through the gingival tissue.

2) Thin gingival tissue biotype- a periodontal probe placed into the labial gingival crevice can be seen through the gingival tissue.

3.8 Statistical analysis
The primary hypothesis of this study is that there is no significant change between implant placement and follow-up with regards to the hard and soft tissues, Jemt’s index and plaque index. All these variables are paired (placement/follow-up). In case of parametric data a paired t-test was used, while in non-parametric data a Wilcoxon signed rank test was used. A frequency analysis was used to describe the distribution of hard and soft tissue changes among the patients. All calculations were performed with the SPSS statistical software program (version 16.0, SPSS Inc., Chicago, IL, USA).
4.0 RESULTS

4.1 Participant enrolment and demographics

Thirty-four patients (13 male and 21 female) with 37 immediately placed and restored implants were identified as eligible to participate in this retrospective study. The patients’ age ranged between 21 and 81 years, with a mean age of 50.8 ± 1.7 years. These patients were then invited to a follow up examination through a letter and a follow up telephone call. Thirteen patients accepted the invitation and appeared for a follow up examination by the periodontist. Consequently, data from 13 patients (4 males and 9 females, mean age 44.67 ± 18.68 years) with 15 implants (thirteen incisors, one canine and one premolar), was made available for analysis (table 5). No one in this sample was a smoker. The range of observation period was between 12 to 27 months with a mean period of 16 ± 5 months (table 6). The twenty-one participants could not return for a follow up appointment due to their remote residency. However, all patients reported that their implants were still functioning and they were satisfied with the treatment.
The patient recruitment process is summarized in the following flowchart:

- **Patient’s flow chart**
- 34 patients eligible (13 male and 21 female)
- 21 patients were unable to come for the follow up
- 13 patients available for follow up, (4 males and 9 females)
- 13 patients have X-rays
- 11 Patients have photographs
- 6 patients photographed with protocol A (see M&M)
- 5 patients photographed with protocol B (see M&M)
The reasons for tooth loss are outlined in Table 5. The patient demographics, implant characteristics and follow up times are shown in Table 6.

<table>
<thead>
<tr>
<th>Tooth type/reason for extraction</th>
<th>Endodontic</th>
<th>Fracture</th>
<th>Root resorption</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisors</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Canines</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Premolars</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>8</td>
<td>1</td>
<td>15</td>
</tr>
</tbody>
</table>

**Table 5** Tooth types and reason for tooth extraction.

<table>
<thead>
<tr>
<th>Patient name</th>
<th>Sex</th>
<th>Age (ys)</th>
<th>Follow up (mths)</th>
<th>Site of implant</th>
<th>Length (mm)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV1</td>
<td>1</td>
<td>37</td>
<td>12</td>
<td>11</td>
<td>15</td>
<td>5.0</td>
</tr>
<tr>
<td>AV2</td>
<td>1</td>
<td>37</td>
<td>12</td>
<td>21</td>
<td>13</td>
<td>4.0</td>
</tr>
<tr>
<td>DC</td>
<td>2</td>
<td>21</td>
<td>12</td>
<td>11</td>
<td>15</td>
<td>5.0</td>
</tr>
<tr>
<td>EC1</td>
<td>2</td>
<td>31</td>
<td>12</td>
<td>11</td>
<td>13</td>
<td>4.5</td>
</tr>
<tr>
<td>EC2</td>
<td>2</td>
<td>31</td>
<td>12</td>
<td>21</td>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>FR</td>
<td>2</td>
<td>60</td>
<td>14</td>
<td>21</td>
<td>13</td>
<td>5.0</td>
</tr>
<tr>
<td>HB</td>
<td>1</td>
<td>64</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>4.0</td>
</tr>
<tr>
<td>MC</td>
<td>1</td>
<td>62</td>
<td>21</td>
<td>12</td>
<td>13</td>
<td>3.5</td>
</tr>
<tr>
<td>MD</td>
<td>2</td>
<td>25</td>
<td>17</td>
<td>13</td>
<td>15</td>
<td>4.0</td>
</tr>
<tr>
<td>ML</td>
<td>2</td>
<td>42</td>
<td>27</td>
<td>21</td>
<td>13</td>
<td>4.5</td>
</tr>
<tr>
<td>PC</td>
<td>1</td>
<td>25</td>
<td>19</td>
<td>22</td>
<td>15</td>
<td>4.0</td>
</tr>
<tr>
<td>SM</td>
<td>2</td>
<td>81</td>
<td>12</td>
<td>22</td>
<td>15</td>
<td>4.0</td>
</tr>
<tr>
<td>TK1</td>
<td>2</td>
<td>60</td>
<td>18</td>
<td>11</td>
<td>13</td>
<td>4.0</td>
</tr>
<tr>
<td>TK2</td>
<td>2</td>
<td>30</td>
<td>24</td>
<td>21</td>
<td>13</td>
<td>5.0</td>
</tr>
<tr>
<td>WE</td>
<td>2</td>
<td>64</td>
<td>12</td>
<td>22</td>
<td>15</td>
<td>4.0</td>
</tr>
</tbody>
</table>

1= male, 2= female

**Table 6** Overview of clinical data.
4.2 Hard tissue parameters

A paired t-test was conducted to investigate if there was a significant change in the mesial bone level at the time of implant placement and at the follow-up assessment. Furthermore, a separate test for the distal bone level change was also conducted. The results in Table 7 showed that there was no significant change in either the mesial or distal bone level between the time of implant placement and the follow-up assessment (P-value was 0.944 and 0.916 respectively for millimetres and 0.963 and 0.955 respectively for percentage).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>The change in mm</th>
<th>P-value</th>
<th>The change in %</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesial bone level</td>
<td>-0.023 ± 1.253</td>
<td>0.944</td>
<td>0.106 ± 8.761</td>
<td>0.963</td>
</tr>
<tr>
<td>Distal bone level</td>
<td>-0.040 ± 1.436</td>
<td>0.916</td>
<td>0.156 ± 10.628</td>
<td>0.955</td>
</tr>
</tbody>
</table>

Mean± SD

Table 7 Bone level changes (presented as percentage change).
Table 8 shows the distribution of bone gain and loss in millimetres at the mesial aspect of implants for individual patients. The values range from 1.6 mm loss to 2.1 mm of bone gain. The majority of the readings demonstrated either bone gain or bone loss < 0.5 mm (11/15 cases) (Table 8). Similar findings were noted when percentage bone loss was used (table 9).

<table>
<thead>
<tr>
<th>Bone changes in mm/</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 &amp; 2 mm</td>
<td>2.138 (EC1) 2.138 (FR) - -</td>
</tr>
<tr>
<td>2 &amp; 1.5 mm</td>
<td>1.676 (SM) - - -</td>
</tr>
<tr>
<td>1.5 &amp; 1 mm</td>
<td>- - - -</td>
</tr>
<tr>
<td>1 &amp; 0.5 mm</td>
<td>0.645 (MK) - - -</td>
</tr>
<tr>
<td>0.5 &amp; 0 mm</td>
<td>0.309 (EC2) 0.115 (PC) - -</td>
</tr>
<tr>
<td>0 &amp; -0.5 mm</td>
<td>0.1940.372 0.411 (HB) 0.329 (MC) 0.448 (TK1) (AV1,2)</td>
</tr>
<tr>
<td>-0.5 &amp; -1 mm</td>
<td>- - - -</td>
</tr>
<tr>
<td>-1 &amp; -1.5 mm</td>
<td>1.475 (MD) 1.007 (TK2) - -</td>
</tr>
<tr>
<td>-1.5 &amp; -2 mm</td>
<td>1.586 (DC) 1.647 (WE) - -</td>
</tr>
<tr>
<td>-2 &amp; -2.5 mm</td>
<td>- - - -</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 8**  Frequency analysis of hard tissue changes (mesial measurement in millimetres).
**Bone changes in %/**

<table>
<thead>
<tr>
<th>Patients</th>
<th>25 &amp; 20%</th>
<th>20 &amp; 15%</th>
<th>15 &amp; 10%</th>
<th>10 &amp; 5%</th>
<th>5 &amp; 0%</th>
<th>0 &amp; -5%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>16.444(FR)</td>
<td>14.931(EC2)</td>
<td>-</td>
<td>2.373(EC1)</td>
<td>1.496,2.485</td>
</tr>
<tr>
<td></td>
<td>20 &amp; 15%</td>
<td>-</td>
<td>11.175(CM)</td>
<td>-</td>
<td>4.964(MK)</td>
<td>2.533(MC)</td>
</tr>
<tr>
<td></td>
<td>15 &amp; 10%</td>
<td>16.444(FR)</td>
<td>-</td>
<td>-</td>
<td>0.769(PK)</td>
<td>3.162(HB)</td>
</tr>
<tr>
<td></td>
<td>10 &amp; 5%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.444(TK1)</td>
</tr>
<tr>
<td></td>
<td>5 &amp; 0%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(AV1,2)</td>
</tr>
<tr>
<td></td>
<td>0 &amp; -5%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 9** Frequency analysis of hard tissue changes (mesial measurement in percentage).
Table 10 shows the distribution of bone loss on the distal aspect of the implants which reached a maximum of 1.9 mm, while maximum bone gain of 2.2 mm was noted. Most of the cases (12/15) showed either bone gain or bone loss < 1 mm (Table 10). Similar findings were noted with the percentage bone loss readings (Table 11).

<table>
<thead>
<tr>
<th>Bone changes in mm/ Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 &amp; 2 mm</td>
</tr>
<tr>
<td>2 &amp; 1.5 mm</td>
</tr>
<tr>
<td>1.5 &amp; 1 mm</td>
</tr>
<tr>
<td>1 &amp; 0.5 mm</td>
</tr>
<tr>
<td>0.5 &amp; 0 mm</td>
</tr>
<tr>
<td>0 &amp; -0.5 mm</td>
</tr>
<tr>
<td>-0.5 &amp; -1 mm</td>
</tr>
<tr>
<td>-1 &amp; -1.5 mm</td>
</tr>
<tr>
<td>-1.5 &amp; -2 mm</td>
</tr>
<tr>
<td>-2 &amp; -2.5 mm</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 10** Frequency analysis of hard tissue changes (distal measurement in millimetres).
## Bone changes in %/

### Patients

<table>
<thead>
<tr>
<th>Range</th>
<th>Frequency (10^3)</th>
<th>Table</th>
<th>Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 &amp; 20%</td>
<td>24.905(FR)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20 &amp; 15%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15 &amp; 10%</td>
<td>13.902(HB)</td>
<td>10.189(SM)</td>
<td>-</td>
</tr>
<tr>
<td>10 &amp; 5%</td>
<td>5.195(EC2)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5 &amp; 0%</td>
<td>4.772(EC1)</td>
<td>4.653(MK)</td>
<td>-</td>
</tr>
<tr>
<td>0 &amp; -5%</td>
<td>1.154(PC)</td>
<td>4.241(WE)</td>
<td>-</td>
</tr>
<tr>
<td>-5 &amp; -10%</td>
<td>6.973,6.026</td>
<td>5.953(DC)</td>
<td>6.823(TK1)</td>
</tr>
<tr>
<td>-10 &amp; -15%</td>
<td>12.908(MD)</td>
<td>10.321(MC)</td>
<td>11.561(TK2)</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 11**  
Frequency analysis of hard tissue changes (distal measurement in percentage).
4.3 Soft tissue parameters

A paired t-test was conducted to investigate the changes in the soft tissue architecture of the interdental papillae and the mid-facial gingival level, as expressed in percentage of the neighbouring tooth crown length. The mesial papilla showed the highest value of recession which may be attributed to the fact that the sample included four implants replacing four central incisors in two patients. In this case, the mesial papillae will be bordered by implants on both sides, while for the rest of the sample the mesial papilla is bordered by a natural tooth on one side. The results in Table 12 show that there was no statistically significant change in either the mesial or distal interdental papillae, as well as mid-buccal gingival level between the time of implant placement and the follow-up assessment (P-value was 0.107, 0.598 and 0.508 respectively).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>The change in %</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mesial papilla level in %</strong></td>
<td>-6.056±11.340</td>
<td>0.107</td>
</tr>
<tr>
<td><strong>Distal papilla level in %</strong></td>
<td>-1.373±8.353</td>
<td>0.598</td>
</tr>
<tr>
<td><strong>Mid-buccal gum level in %</strong></td>
<td>-1.461±7.068</td>
<td>0.508</td>
</tr>
</tbody>
</table>

Mean±SD

**Table 12** Soft tissue level changes (presented as percentage change).
Table 13, 14 and 15 show the distribution of soft tissue changes on the mesial, distal and mid-facial aspects of individual implants presented in percentages. Most of the readings remain within 10% of the baseline value (Tables 14 and 15).

**Table 13**  
Frequency analysis for mesial papilla change in percentage.
### Table 14

**Soft tissue changes in %**

(Patient initials)

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 &amp; 20%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20 &amp; 15%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15 &amp; 10%</td>
<td>13.881(TK2)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10 &amp; 5%</td>
<td>5.001(AV2)</td>
<td>5.708(MC)</td>
<td>-</td>
</tr>
<tr>
<td>5 &amp; 0%</td>
<td>1.501(PC)</td>
<td>1.981(TK1)</td>
<td>-</td>
</tr>
<tr>
<td>0 &amp; -5%</td>
<td>1.456(AV1)</td>
<td>1.7(SM)</td>
<td>-</td>
</tr>
<tr>
<td>-5 &amp; -10%</td>
<td>6.908(EC1)</td>
<td>6.193(EC2)</td>
<td>-</td>
</tr>
<tr>
<td>-10 &amp; -15%</td>
<td>11.397(MK)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-15 &amp; -20%</td>
<td>15.524(FR)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-25 &amp; -20%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-30 &amp; -25%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Indicate no data

Frequency analysis for distal papilla change in percentage.
### Soft tissue changes in%
(Patient initials)

<table>
<thead>
<tr>
<th>Percentage Range</th>
<th>Soft Tissue Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 &amp; 20%</td>
<td>-</td>
</tr>
<tr>
<td>20 &amp; 15%</td>
<td>-</td>
</tr>
<tr>
<td>15 &amp; 10%</td>
<td>12.141(TK2)</td>
</tr>
<tr>
<td>10 &amp; 5%</td>
<td>-</td>
</tr>
<tr>
<td>5 &amp; 0%</td>
<td>2.391(AV1)</td>
</tr>
<tr>
<td>0 &amp; -5%</td>
<td>1.755(EC2)</td>
</tr>
<tr>
<td>-5 &amp; -10%</td>
<td>8.026(AV2)</td>
</tr>
<tr>
<td>-10 &amp; -15%</td>
<td>12.756(FR)</td>
</tr>
<tr>
<td>-15 &amp; -20%</td>
<td>-</td>
</tr>
<tr>
<td>-25 &amp; -20%</td>
<td>-</td>
</tr>
<tr>
<td>-30 &amp; -25%</td>
<td>-</td>
</tr>
</tbody>
</table>

- Indicates no data

**Table 15**  
Frequency analysis for mid-facial change in percentage.
A paired t-test was conducted to investigate the changes in the soft tissue architecture of the interdental papillae and the mid-facial gingival level for the six patients who had measurements available in millimetres. These results also showed (Table 16) that there were no statistically significant changes in either the mesial or distal interdental papillae, as well as the mid-facial gingival level between the time of implant placement and the follow-up assessment (P-values were 0.214, 0.138 and 0.124 respectively).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>The change in mm</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesial papilla level in mm</td>
<td>-0.708±1.219</td>
<td>0.214</td>
</tr>
<tr>
<td>Distal papilla level in mm</td>
<td>-0.602±0.525</td>
<td>0.138</td>
</tr>
<tr>
<td>Mid-facial gum level in mm</td>
<td>-0.385±0.510</td>
<td>0.124</td>
</tr>
</tbody>
</table>

Mean±SD

**Table 16** Changes in soft tissue levels in millimetres.
4.4 Jemt s’ index

Wilcoxon signed rank test did not reveal any significant difference in the Jemt s’ index score for either mesial or distal papilla between implant placement and follow-up observations (P-values 0.655 and 0.564 respectively).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>The amount of change</th>
<th>P- value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesial papilla level</td>
<td>- 0.447*</td>
<td>0.655</td>
</tr>
<tr>
<td>Distal papilla level</td>
<td>-0.564*</td>
<td>0.564</td>
</tr>
</tbody>
</table>

*Z value

Table 17 Changes in the interdental papilla.

4.5 Presence of plaque

Plaque was noted in 8 out of 11 patients at the time of implant placement, while plaque was noted in only one case at the follow up.
5.0 DISCUSSION

Increased awareness of dental implants has resulted in more patients seeking treatment with implant supported restorations instead of other types of conventional dental therapy. The procedure of single tooth replacement by immediate and provisionally restored implants in the aesthetic region seems to be a successful treatment option. This one stage surgical procedure has advantages including immediate aesthetic outcomes, no need for temporary fixed and/or removable partial denture, elimination of second stage surgical intervention and finally, shorter treatment times as post extraction events and healing coincide with osseointegration.

5.1 Patient enrolment

The objective of the current retrospective study was to assess changes in the hard and soft tissues and implant survival rates associated with immediately placed and provisionally restored implants replacing a single tooth in the aesthetic zone. Although thirty-four consecutive patients were invited to participate in this clinical investigation, only thirteen of patients (with fifteen implants) presented at the recall visits. The main reason for non-attendance at the follow-up examination appointments was related to patients living in remote areas. Indeed, this was the main reason that many of the patients included in this study chose this mode of treatment. Another reason for non-attendance was the narrow time frame of the data collection period, which did not suit many of the remote patients.
5.2 Implant survival rate

In this study, immediately placed and restored single-tooth implants in the maxillary aesthetic zone were found to have an implant survival rate of 100% after 16 ± 5 months of follow up. This result may be attributed to the fact that only one implant system was used (15 Astra Tech® implants), all patients were not smokers and all implants included in the study had achieved good primary stability after the surgical placement. This attainment of good primary stability appears to be important, as a study carried out by Ottoni et al [56] in 2005 showed that there is a strong relationship between the placement torque and the survival of single tooth-implants. The author concluded that appropriate insertion torque is crucial and should be more than 20 Ncm. However the placement torque of all of the implants used in our study was more than 30 Ncm.

Another reason contributing to the high survival rate observed in this study may be the fact that the implant temporary crown was out of occlusion in both centric and eccentric positions of the lower jaw. This strategy makes the implant free from any loading from the opposite dentition during the period of osseointegration. This freedom of the temporary crown is very important for the biology of osseointegration. Absence of occlusal contacts minimises the possibility of micromotion at the implant-bone contact area, which jeopardises osseointegration [118]. Furthermore, the use of a screw retained, instead of cemented, prosthetic restorations prevents the ingress of cement in the area of early healing which may lead to growth of granulation tissue between the implant and provisional crown resulting in inflammation, formation of fistula and plaque retention [119].
The findings of the present study are consistent with other reported results using a similar treatment protocol (Table 18).

<table>
<thead>
<tr>
<th>Study</th>
<th>Implant survival rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>WÖhrle 12 (1998)</td>
<td>100</td>
</tr>
<tr>
<td>Hui et al 13 (2001)</td>
<td>100</td>
</tr>
<tr>
<td>Calvo et al 14 (2002)</td>
<td>100</td>
</tr>
<tr>
<td>Chaushu et al 15 (2001)</td>
<td>78.6</td>
</tr>
<tr>
<td>Groisman et al 86 (2003)</td>
<td>93.5</td>
</tr>
<tr>
<td>Kan et al 87 (2003)</td>
<td>100</td>
</tr>
<tr>
<td>Lorenzoni et al 88 (2003)</td>
<td>100</td>
</tr>
<tr>
<td>Norton 89 (2004)</td>
<td>100</td>
</tr>
<tr>
<td>Tsirlis 90 (2005)</td>
<td>100</td>
</tr>
<tr>
<td>Cornelini et al 91 (2005)</td>
<td>100</td>
</tr>
<tr>
<td>Ferrarra et al 92 (2006)</td>
<td>93.9</td>
</tr>
<tr>
<td>Kan et al 93 (2007)</td>
<td>100</td>
</tr>
<tr>
<td>Canullo et al 94 (2007)</td>
<td>100</td>
</tr>
<tr>
<td>Hall et al 95 (2007)</td>
<td>93</td>
</tr>
<tr>
<td>Palattella et al 96 (2008)</td>
<td>100</td>
</tr>
<tr>
<td>De Rouck et al 97 (2008)</td>
<td>97</td>
</tr>
<tr>
<td>Ribeiro et al 98</td>
<td>96.3</td>
</tr>
</tbody>
</table>

**Table 18**  Implant survival rates, as reported in studies using similar treatment protocol.
5.3 Hard tissue measurements

A paired t-test revealed no statistically significant changes in the bone levels around immediately placed and restored implants in this study. The assessment was carried out radiographically, with the entire length of the implant being visible on the radiographs. Measurements were conducted from the apical to the coronal part of the implant. Knowing the exact implant length and diameter meant that precise measurement of the bone level in millimetres was possible, compensating for any distortion of the radiograph. That was an important element of the methodology of this study, in contrast to much of the literature, where only the cervical portion of the radiograph is seen and measurements are made with the use of the apical end [13], [14] or the coronal end [87] of the implant shoulder as a reference line. Other studies used the contact area as a reference point. However, this point is not going to be constant as provisional crowns will undergo replacement with permanent restorations, while the radiographic location of the contact point is easily affected by image distortion [90].

The results of the present study which showed no significant bone loss are consistent with the findings of Ferrara et al [92]. Several other studies have reported changes in bone levels following the immediate placement and restoration protocol. The study by Chaushu et al [15], reported that marginal bone loss did not extend beyond the implant-abutment junction (1 mm). Similarly, the study by Kan et al [87], with one year follow up showed a mean marginal bone loss ranging from 0.26 to 0.40 mm on the mesial aspect of the implant and from 0.22 to 0.28 mm on the distal aspect of the implant. These results which showed relatively minor amounts of bone loss are in accordance with other investigations [13], [89], [91] and [96].
Several other studies have shown larger amounts of bone loss. The study by De Rouck et al [97] revealed a mean bone loss of 0.98 mm on the mesial aspect of the implant and 0.78 mm distally. These results are in accordance with other studies which use the same treatment strategy [88], [90] and [94].

On the other hand, Kan et al [93] reported that scalloped implants placed into extraction sites showed a mean bone gain of 1.0 mm after one year follow up. The amount of gain attributed in this study was the result of bone graft placement into the gap between the implant and walls of the extraction socket that appeared to have led to rapid bone fill.

Our study used a ‘platform switching’ implant design, flapless surgery and applied a particulate bone graft between the tooth socket and the implant, which may account for the reported stability of the bone levels.
<table>
<thead>
<tr>
<th>Study</th>
<th>Bone level mesial</th>
<th>Bone level distal</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wohrle 12</td>
<td>-</td>
<td>-</td>
<td>1 mm bone loss</td>
</tr>
<tr>
<td>Hui et al 13</td>
<td>-</td>
<td>-</td>
<td>Maximum 0.6 mm bone loss</td>
</tr>
<tr>
<td>Guirado et al 14</td>
<td>-</td>
<td>-</td>
<td>Bone loss to the first thread</td>
</tr>
<tr>
<td>Chaushu et al 15</td>
<td>-</td>
<td>-</td>
<td>Bone loss not extend beyond the junction</td>
</tr>
<tr>
<td>Groisman et al 86</td>
<td>-</td>
<td>-</td>
<td>Maximum 2 mm of bone loss</td>
</tr>
<tr>
<td>Kan et al 87</td>
<td>0.26 ± 0.40 mm</td>
<td>0.22 ± 0.28 mm</td>
<td>-</td>
</tr>
<tr>
<td>Lorenzoni et al 88</td>
<td>-</td>
<td>-</td>
<td>0.75 ± 0.50 mm bone loss</td>
</tr>
<tr>
<td>Norton 89</td>
<td>-</td>
<td>-</td>
<td>0.5 mm bone loss</td>
</tr>
<tr>
<td>Tisirlis 90</td>
<td>-</td>
<td>-</td>
<td>0.75± 1.05 bone loss</td>
</tr>
<tr>
<td>Cornelini et al 91</td>
<td>-</td>
<td>-</td>
<td>0.5 mm bone loss</td>
</tr>
<tr>
<td>Ferrara et al 92</td>
<td>-</td>
<td>-</td>
<td>No bone loss</td>
</tr>
<tr>
<td>Kan et al 93</td>
<td>-</td>
<td>-</td>
<td>1 mm bone loss</td>
</tr>
<tr>
<td>Canullo et al 94</td>
<td>0.57 mm bone loss</td>
<td>1.01 mm bone loss</td>
<td>0.78 ± 0.36 mm bone loss</td>
</tr>
<tr>
<td>Palattella et al 96</td>
<td>-</td>
<td>-</td>
<td>0.54 ± 0.51 mm bone loss</td>
</tr>
<tr>
<td>De Rouck et al 97</td>
<td>0.98 mm bone loss</td>
<td>0.78 mm bone loss</td>
<td>-</td>
</tr>
</tbody>
</table>

*Indicate no data

**Table 19**  Changes in hard tissue (mesially and distally) as reported in published studies.
5.4 **Soft tissue measurements**

Although there are a number of studies describing the outcomes of immediate implant placement and provisional restoration in the maxillary aesthetic zone, only a few reports on soft tissue changes. Consequently, it was one of the primary aims of this study to investigate changes in the soft tissue topography.

A paired t-test revealed no statistically significant difference in the topography of the soft tissues around immediately placed and provisionally restored single maxillary implants during the period of observations. This indicates that there is short-medium term stability of the soft tissue architecture around immediately placed and restored implants. This result is based on eleven Astra implants. Although no significant different was found when comparing the data taken at implant placement and at the follow up, there was apical drift of the mesial papillae more than that of the distal papillae and mid-facial gum. However, the changes outlined above were still within the range of a favourable aesthetic outcome. The greater mesial papilla tissue loss attributed to the fact that the sample included four implants replacing four central incisors in two patients. In this case, the mesial papillae will be bordered by implants on both sides, and it is widely recognised that greater soft tissue loss occurs between two implants compared with an implant and an adjacent natural tooth.

In six of the cases, a periodontal probe was included in the photograph as a point or reference. This allowed for the measurements to be done with precision in millimetres. Again, no statistically significant change was found. The results in millimetres are in accordance with the soft tissue changes expressed in percentages.
The method being used for this study to record soft tissue measurements is different from other studies [87], [91] and [92]. Other studies used a reference line connecting the mid-facial gum level of the two teeth adjacent to the implant restoration. Furthermore, in these studies flap elevation was used in order to have access to the implant site. This might lead to variability of the position of the reference line connecting the mid-facial gingiva of the adjacent teeth, as some soft tissue recession generally occurs following the elevation of a full mucoperiosteal flap. Hence the imaginary reference line used in our study was different in order to have more accurate readings. The reference line of our investigation extended from the incisal edges of the teeth adjacent to the implant which acts as a fixed and non-changeable reference.

In the current study, there was mean mid-facial recession at the implant site of $0.385 \pm 0.510$ mm after a follow up of $16 \pm 5$ months. This apical drift may be attributed to the thin buccal cortical plate underling the gum [120]. A previous investigation [87] assessed 35 patients with single immediately placed and restored maxillary implants. The reported results for soft tissue loss from the facial aspect were close to our results with $0.55$ mm loss at the follow up period of one year. Similar results were found in another recent study by De Rouck et al [97] with an average mid-buccal recession of $0.53$ mm in the first year of function. Another study by Cornelini et al [91] reported $0.75$ mm mid-facial tissue loss after one year; another investigation reported a gaining of the buccal gum of $0.2$ mm instead of recession [95]. Therefore, the results of these studies are broadly in line with the results of our study, with differences in outcomes possibly attributable to different implant design (platform switch, internal versus external attachment), different measurement protocols, and different
surgical protocols (Flap elevation versus flapless, augmentation of gap between tooth implant and socket).

Some studies with data on the soft tissue changes following single tooth implant placement in healed sockets reveal around 0.6 mm mid-facial recession within the first year of placement [121], [122]. In a study using the conventional technique (two stages) with a follow up period of three years, the recession on mid-facial aspect of the implant was found to be 1 mm [110]. These finding indicate that soft tissue changes and remodelling is a continuous process, the understanding of which requires long term observation. This has implications for the interpretations of the results of our study, which is of a relatively short duration.

The results of the present investigation demonstrate a very limited loss of soft tissue on the mid-facial aspect. This fact can be attributed to atraumatic extraction of the failed teeth, flapless surgical approach and the use of Bio Oss particles. Flapless surgery might present increased risk for perforation, yet the experience of the surgeon might be a factor that minimises that risk [123]. Insertion of bone grafting material (Bio Oss) into the gap between the implant and the walls of the extraction socket might have helped to preserve a stable level of hard tissues, as the Bio Oss particles do not get resorbed. Finally, the use of screw-retained instead of cemented temporary restoration may contribute to the absence of complications during the initial stages of wound healing and maturation. In contrast, fistula formation was reported in study conducted by Kan and his associates using a cemented type of temporary crowns [87].
It is important to note that mid-facial recession doesn’t necessarily imply an aesthetic compromise. An interesting finding in one case was that the recession at the mid-facial aspect actually improved the patient aesthetic, as the level of the adjacent tooth buccal soft tissue was already apically displaced (FR, Figure 12, 13).

**Figure 11**  Level of mid-buccal gingiva at placement of temporary restoration.
Figure 12  Level of mid-buccal gingival at the follow-up.
<table>
<thead>
<tr>
<th>Study</th>
<th>Level of mid-facial gum</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wöhlre</td>
<td>-</td>
<td>More than 2 mm change in Two cases</td>
</tr>
<tr>
<td>Groisman et al</td>
<td>-</td>
<td>2 mm soft tissue loss from buccal</td>
</tr>
<tr>
<td>Kan et al</td>
<td>0.55 ± 0.53 mm loss</td>
<td>-</td>
</tr>
<tr>
<td>Cornelini et al</td>
<td>0.75 mm loss</td>
<td>-</td>
</tr>
<tr>
<td>Canullo et al</td>
<td>0.2 mm gain</td>
<td>0.25 mm Mean papilla gain</td>
</tr>
<tr>
<td>Hall et al</td>
<td>-</td>
<td>No change in 28.5% of the papilla with gaining in 63% of the sites.</td>
</tr>
<tr>
<td>Palattella et al</td>
<td>-</td>
<td>-0.8 mm loss</td>
</tr>
<tr>
<td>De Rouck et al</td>
<td>0.53 mm loss</td>
<td>-</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 20**    Changes in soft tissue levels (mid-buccal aspect) as reported in published studies.
Although there was no statistical significance in the changes observed with regards to soft tissues, there was a papilla recession of 0.708 mm (P-value 0.214) at the mesial papillae and 0.602 mm (P-value 0.138) at the distal papillae. This observation might be attributed to the fact that two patients (AV, EC) had both central incisors replaced with immediate implants. This resulted in surrounding the mid-line papilla with two implants, instead of the papillae being bordered by a tooth and an implant as was the case with the other implants (Figure 13, 14).
Figure 13  Level of mesial papilla at the placement of the temporary restoration.

Figure 14  Level of mesial papilla at the follow-up.
The papillary height observed in this study appears greater than that reported in other studies. Kan et al [87] reported a mean loss of 0.50 mm for the mesial papillae and 0.30 mm mean loss of the distal papillae. De Rouck and his associates [97] showed a reduction in the papillae height of 0.41 mm on average for mesial papillae and 0.31 mm for distal papillae.

<table>
<thead>
<tr>
<th>Study</th>
<th>Tip of mesial papilla</th>
<th>Tip of distal papilla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wöhle</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Groisman et al 86</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kan et al 87</td>
<td>0.53 ± 0.39 mm loss</td>
<td>0.39 ± 0.40 mm loss</td>
</tr>
<tr>
<td>Cornelini et al 91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canullo et al 94</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hall et al 95</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Palattella et al 96</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>De Rouck et al 97</td>
<td>0.41 mm loss</td>
<td>0.31 mm loss</td>
</tr>
</tbody>
</table>

- Indicate no data

**Table 21** Changes in soft tissue levels (mesial and distal papillae) as reported in published studies.
Changes in Jemt’s index were analysed using Wilcoxon signed rank test assessing eleven patients with twenty two papillae. No statistically significant differences were found between the papillae level at placement and at follow up during the observation period of 16 ± 5 months. Although there was no significant difference statistically between the mesial and distal papillae, at follow up 50% of the mesial papillae received score 3 which means that full height of the interdental papillae was present (normal) while the same score was recorded in 60% of distal papillae. The rest of the results showed scores of 1, 2 and 4. No score of zero was recorded.

A study by Cornelini et al [91], found no score of 0, 1 or 4 in their sample with 60% of papillae receiving a score of 2, with the remainder scoring a 3. In another study by Kan [93], the papilla index was measured at pre-treatment and 3, 6, and 12 months following implant placement with no differences noted between baseline and any of the follow up observations. In a study by Hall [95], the follow up was extended over one year and showed no change for 28.5% of the papilla with an improvement or gaining for about 63% of the sites. Therefore, the findings of our study in relation to Jemt’s index are consistent with the published literature.

5.5 Plaque levels

It is generally accepted that plaque retention and accumulation around the implant may cause peri-implantitis [124], [125]. According to this study there was high improvement in the plaque level (good oral hygiene) at the time of follow up in comparison to the time of implant placement. This may be because the patient was aware that their natural tooth was
failing and were not able or not willing to brush them thoroughly. Generally, good oral hygiene was a prerequisite for the provision of this implant treatment protocol.

5.6 Gingival tissue biotype

Few studies have investigated the impact of gingival biotype and its relation to gum recession. In a study conducted by Canullo [94] it was revealed that there is no influence of the gingival biotype (thin or thick) on the final aesthetic outcomes which is in accordance with the findings of this study. However, this result may be due to the small number of patients included in this study and the relatively short follow up period.

5.7 Future considerations

This pilot clinical investigation was limited by the retrospective nature, the small number of samples, the inability to secure a fully standardised follow up examination protocol and the relatively small length of observation period. All of these factors can have a significant impact on the results obtained from this study and hence should be interpreted with caution. Nevertheless, the study has provided some indications as to the nature and extent of soft and hard tissue changes that may be expected with this protocol, although it remains unclear if hard and soft tissue measures will remain stable over time. A longer observation period and larger samples are needed to support more definite conclusions.

This pilot study has used a new set of reference lines to measure the changes in soft and hard tissues surrounding the implants, which can provide more reliable observations in
comparison to previous studies. The methodology used in this study constitutes an improvement over previous attempts to investigate similar changes. This investigation will be continued and expanded both in terms of sample numbers but also in the length of the observation period.
6.0 CONCLUSIONS

Within the limits of the current retrospective, pilot clinical investigation, the results indicate that the immediate placement and provisional restoration of a single tooth implant in the aesthetic zone of the maxilla can result in acceptable implant integration as well as stable peri-implant tissues up to 16 ± 5 months using the Astra Tech implant system. In particular:

1- All implants were found to be clinical integrated leading to 100% survival rate throughout the follow up period of this study.

2- Hard tissue data (from mesial and distal side) at the follow up visit showed there were no significant differences throughout the entire follow up period (P > 0.05).

3- Soft tissue data (from mid-facial, mesial and distal papillae) at the follow up visit showed there were no significant differences throughout the entire follow up period (P > 0.05).

4- Plaque index measurements showed a statistically significant improvement of the oral hygiene between the time of the implant placement and the follow up examination (P < 0.05).
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