# The Influence of Restorative Procedures on Esthetic Outcomes in Implant Dentistry: A Systematic Review

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***Purpose:*** The objectives of this review were to *(1)* identify if prosthodontic parameters influence the esthetic outcome of implant-supported restorations and *(2)* make clinically relevant recommendations based upon the findings. ***Materials and Methods:*** Electronic and manual searches of dental literature were performed to collect information on esthetic outcomes based on objective criteria. The prosthodontic parameters included optimal three-dimensional implant position, the utilization of provisional restorations, the timing of provisional restoration with regard to implant placement, the choice of prosthodontic platform size and form, the abutment and definitive restoration material, and the mode of prosthesis retention. Regions including maxillary and mandibular anterior teeth and premolars were considered. All levels of evidence, including case studies, were accepted. ***Results:*** From 472 titles, 152 full-text articles were evaluated and 58 records included for data extraction (15 randomized controlled trials, 6 cohort studies, and 37 case series studies). Considerable heterogeneity in study design was found. A meta-analysis of controlled studies was not possible. It was consistently reported that facial malpositioning of implants increases the likelihood of mucosal recession. No studies directly compared esthetic outcomes associated with the use or non-use of provisional restorations. The literature contains a greater number of case series studies evaluating esthetic outcomes for protocols including, rather than excluding, provisional restorations. It is not possible to identify any significant variation in esthetic outcomes based on the character of the abutment platform from the current literature. Based on the findings, no significant difference can be established between all-ceramic and metal-ceramic prostheses with regard to esthetic indices over short observation periods. No firm conclusions relating esthetic benefits for cement in comparison to screw retention can be identified. ***Conclusions:*** There is a need for RCTs comparing accepted procedures in routine practice. The utilization of provisional restorations remains strongly recommended in order to trial the planned definitive restoration, to facilitate maturation of healing tissues and for patient convenience. Implant positioning according to the planned prosthesis remains a requirement to achieve a long-lasting esthetic outcome. The majority of studies reported on single-tooth replacement, and many of the outcomes may not be relevant or applicable to the large number of esthetic indications involving more than one tooth. Int J Oral Maxillofac Implants 2014;29(Suppl):142–154. doi: 10.11607/jomi.2014suppl.g3.1

**Key words:** *abutment material, final restoration material, implant position, implant restoration mode of retention, implant-supported provisional restoration, restorative implant platform size and form, timing of provisional restoration*

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Implant therapy has evolved to routinely include rehabilitation of patients missing teeth of esthetic significance. From the perspective of the restorative dentist or prosthodontist, several procedural options may be identified as capable of influencing both the esthetic quality of the treatment, and the predictability of the esthetic outcome. These procedures include:

- The implant position, as well as the communication of the optimal implant position through the use of templates
- The utilization of implant-supported provisional prostheses

- The timing of provisional prostheses with regard to implant placement
- The restorative platform size and form
- The abutment material
- The final prosthetic material
- The mode of retention for the final prosthesis

This systematic review examined the existing literature specific to these procedures. Literature was identified via an electronic search and was restricted to partially edentulous adult patients. The literature was confined to articles published in the most recent 10 years, and to randomized controlled trials (RCTs), cohort studies, and case series involving more than five patients. Treatment interventions and cross-sectional comparisons included the presence or absence of the above identified procedures.

The objectives of the review were to both identify procedures confirmed by the literature to influence the esthetic outcome of implant-based therapy, and to make clinically relevant recommendations based upon these procedures.

## MATERIALS AND METHODS

### Search Strategy

This systematic review was intended to assess restorative procedures that influence the esthetic outcomes of therapy involving dental implants. Keywords were chosen to include restorative treatment interventions, including the use of templates or guides in the placement of implants, the utilization of provisional restorations, the timing of provisional restoration, the nature of the restorative platform on the implant, the abutment material, the restorative material, and the mode of prosthesis retention. The reporting of esthetic outcomes was required for inclusion.

A Medline (PubMed) search was undertaken to identify randomized controlled trials, cohort studies and case series involving a minimum of five patients. A search of The Cochrane Central Register of Controlled Trials (CENTRAL), and a hand search of journals, was additionally undertaken to maximize the likelihood of capturing all relevant publications. The reporting of this review is based upon PRISMA guidelines.

### Selection of Studies

Two of the authors independently screened the titles and abstracts obtained from the electronic search for inclusion or exclusion. Disagreements were resolved via direct discussion. Full-text versions of articles were obtained when compliance with the criteria required for the review was positive, or when exclusion could not be confirmed. Two reviewers independently performed a review of the full-text articles and disagreements were again managed via reviewer discussion prior to final inclusion or exclusion. The search protocol is summarized in Table 1.

### Excluded Studies

Criteria for exclusion included:

- Failure to identify the inclusion criteria
- Methodology or review article
- Presence of more recent follow-up publication including the same patient pool
- Inability to differentiate procedures in the esthetic zone
- Lack of identifiable information relating to specific prosthodontic procedures
- Patient pool of five or less patients
- Animal, histologic, or nonclinical outcomes
- Non English language
- Failure to report on esthetic outcomes

### Quality Assessment

RCTs were assessed for bias according to the Cochrane Collaboration tool. This tool uses domains, including adequacy of sequence generation, allocation concealment, blinding of participants, the handling of incomplete outcome data, and steps to minimize selective outcome reporting to evaluate bias. The quality of cohort studies was assessed using the Newcastle-Ottawa scale. This scale includes eight domains.

### Data Extraction

A standardized descriptive table was utilized to record data for each study, with inclusion and exclusion criteria. Two reviewers evaluated the descriptive tables independently, and any disagreement was resolved via discussion.

### Statistical Analysis

The literature identified in this review does not meet criteria required for quantitative data or meta-analysis. Further, the heterogeneity of the case series prevents the plotting of outcomes to feature results.

## RESULTS

The Medline (PubMed) search identified 305 titles, to which an additional 31 articles were added subsequent to hand searching. Of the 336 titles identified via PubMed and the hand-search, 193 were excluded with author agreement subsequent to title and abstract review. A search of the Cochrane Central Register of Controlled Trials identified 136 citations, of which 127 were excluded with author agreement (Fig 1).

**Table 1 Systematic Search Strategy**

| | |
|---|---|
| **Focus question:** | What is the influence of restorative or prosthodontic procedures on esthetic outcomes in implant dentistry? |
| **Search strategy** | |
| Population | 1) dental implants [MeSH Terms] OR oral implant OR endosseous implant OR dental implants, single tooth [MeSH Terms] |
| Intervention or exposure | 2) implant restoration OR implant supported prosthesis OR implant supported fixed dental prosthesis OR implant supported FDP OR implant supported FPD |
| Comparison | 3) implant position OR implant positioning<br>4) diameter OR platform OR abutment OR abutment material OR zirconia OR PFM<br>5) immediate provisional OR immediate provisionalization OR immediate temporary OR immediate temporization<br>6) provisional crown OR provisional fdp OR provisional fpd OR temporary crown OR temporary fdp OR temporary fpd OR immediate temporization OR immediate loading |
| Outcome | 7) papilla OR papilla index OR keratinized mucosa OR width of keratinized mucosa OR PES/WES OR pink esthetic score OR white esthetic score OR esthetic outcome |
| Search combination | 1 OR 2 AND (3 or 4 or 5 or 6) AND 7 |
| **Database search** | |
| Language | English |
| Electronic | PubMed (Medline), Cochrane Central Register of Controlled Trials (CENTRAL) |
| Journals | *Clinical Oral Implants Research, International Journal of Oral Maxillofacial Implants, Clinical Implant Dentistry and Related Research, Journal of Prosthetic Dentistry, Journal of Prosthodontics, International Journal of Prosthodontics* |
| **Selection criteria** | |
| Inclusion criteria | Clinical trials<br>Controlled clinical trials<br>Multicenter studies<br>Randomized controlled trials<br>Case reports<br>Published last ten years<br>Humans<br>Adult (19+) |
| Exclusion criteria | Failure to identify inclusion criteria<br>Methodology or review article<br>Multiple publications on the same patient population<br>Inability to differentiate procedures in the esthetic zone<br>Lack of identifiable information specific to prosthodontic procedures<br>Patient pool of 5 or less<br>Non-English language<br>Animal studies<br>Histologic or nonclinical outcomes<br>Discussion, technique, or review articles<br>Failure to report esthetic outcomes |

**Table 2 Studies Included for Data Extraction**

| Type | Number | Studies |
|---|---|---|
| Randomized controlled studies (RCTs) | 15 | Lindeboom et al,[1] Oh et al,[2] den Hartog et al,[3] den Hartog et al,[4] De Rouck et al,[5] Hall et al,[6] Canullo et al,[7] Pieri et al,[8] Tymstra et al,[9] Gallucci et al,[10] Gallucci et al,[11] Hosseini et al,[12] Jung et al,[13] Donati et al,[14] Degidi et al[15] |
| Cohort studies | 6 | Sherif et al,[16] Henrikson and Jemt,[17] Lops et al,[18] Santing et al,[19] Cosyn et al,[20] Ottoni et al[21] |
| Case series studies | 37 | Cabello et al,[22] Noelken et al,[23] Cosyn et al,[24] Chang and Wennström,[25] Di Alberti et al,[26] Oyama et al,[27] Lee et al,[28] Furze et al,[29] Malchiodi et al,[30] Hof et al,[31] Cosyn et al,[32] Tsuda et al,[33] Kan et al,[34] Chung et al,[35] Buser et al,[36] Nisapakultorn et al,[37] Tortamano et al,[38] Belser et al,[39] Chen et al,[40] Buser et al,[41] Reddy et al,[42] Kan et al,[43] Canullo and Rasperini,[44] Degidi et al,[45] Cardaropoli et al,[46] Cornelini et al,[47] Jemt and Lekholm,[48] Juodzbalys and Wang,[49] Noelken et al,[50] Brown and Payne,[51] Cooper et al,[52] Gallucci et al,[53] Crespi et al,[54] Botticelli et al,[55] Vandeweghe et al,[56] Zarone et al,[57] Cutrim et al[58] |
| Total | 58 | |

**Table 3 Risk of Bias for Randomized Controlled Trials**

| Study | Adequate sequence generation? | Allocation concealment? | Blinding of participants? | Incomplete outcome data addressed? | Free of selective outcome reporting? | Other sources of bias? |
|---|---|---|---|---|---|---|
| Tymstra et al[9] | Yes | No | Yes | Yes | Yes | No |
| Pieri et al[8] | Yes | Yes | No | Yes | Yes | No |
| Hosseini et al[12] | No | Yes | Yes | No | Yes | No |
| De Rouck et al[5] | Yes | Yes | Yes | Yes | Yes | No |
| Canullo et al[7] | Yes | Yes | Yes | Yes | Yes | No |
| Oh et al[2] | No | No | No | Yes | Yes | No |
| Lindeboom et al[1] | Yes | No | No | Yes | Yes | No |
| Jung et al[13] | No | No | No | Yes | No | No |
| Hall et al[6] | No | Yes | No | Yes | Yes | Yes |
| Gallucci et al[10] | Yes | Yes | Yes | Yes | Yes | No |
| Gallucci et al[11] | Yes | Yes | Yes | Yes | Yes | No |
| den Hartog et al[3] | Yes | Yes | Yes | Yes | Yes | No |
| den Hartog et al[4] | Yes | Yes | Yes | Yes | Yes | No |
| Donati et al[14] | Yes | No | No | Yes | Yes | No |
| Degidi et al[15] | Yes | Yes | No | Yes | Yes | No |

Full-text versions of the 152 identified titles were obtained and evaluated independently by two reviewers. Ninety-four of the full-text articles were excluded based on the established criteria. This process identified 58 articles for inclusion and data extraction, including 15 randomized controlled trials, 6 cohort studies, and 37 case series studies (Table 2).

Of the 15 randomized controlled trials, 11 were considered to be at high risk of bias according to the Cochrane Collaboration tool (Table 3). This was primarily the result of non-concealment or non-blinding. The six cohort studies were assessed using the Newcastle-Ottawa method (Table 4). The outcomes for the 44 case series studies were, as a result of the broad heterogeneity of the data, evaluated for overall trends with regard to papilla scores, pink and white esthetic scores (PES/WES), and midfacial mucosal levels, rather than comparative data. Significant variations exist in the methods of measuring these criteria, and the scales for measurement also vary between articles using the same criteria (eg PES/WES).

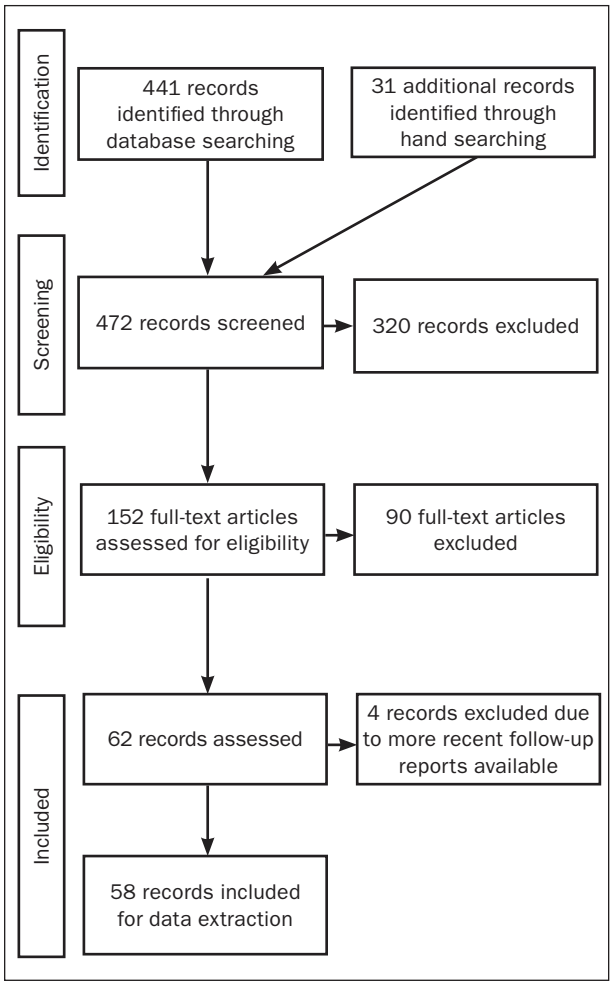


**Fig 1** Search strategy.

## DISCUSSION

### Implant Positioning

No studies were identified comparing esthetic outcomes obtained with or without a surgical guide or template designed to facilitate a specific implant position. Therefore, there is no scientific basis for any conclusion, positive or negative, with regard to template use and effect on esthetic outcomes. Several studies,

**Table 4 Quality Assessment and Risk of Bias for Nonrandomized Trials**

| Study | Representative of the exposed cohort | Selection of the nonexposed cohort | Ascertainment of exposure | Outcome of risk not present at commencement of study | Comparability of cases and controls (maximum 2 stars) |
|---|---|---|---|---|---|
| Cosyn et al[20] | * | | * | * | |
| Santing et al[19] | * | * | * | * | |
| Sherif et al[16] | * | | * | * | |
| Henriksson and Jemt[17] | * | * | * | * | * |
| Lops et al[18] | * | | * | * | * |
| Ottoni et al[21] | * | * | * | * | * |

however, identified poorly positioned implants (particularly in the orofacial dimension) as a negative influence on esthetic outcomes.

Cosyn et al[20] in a retrospective cohort study, concluded using logistic regression analysis that facial positioning of the implant shoulder increased the likelihood of midfacial mucosal recession. Chen et al,[40] in a retrospective case series study analyzed 85 implants after 7 (± 3.4) months. A facial implant shoulder position was significantly associated with recession of the midfacial mucosa.

In a retrospective cross-sectional study, Nisapakultorn et al[37] were not able to identify a correlation between orofacial implant position and recession when using logistic regression analysis. The authors did, however, report that a proclined implant angle was significantly associated with an increased risk of apical mucosal migration.

Only retrospective studies are available evaluating the influence of orofacial implant position on esthetic outcomes. It is, however, consistently reported that facial malpositioning of implants increases the likelihood of mucosal recession.

## Provisional or Temporary Restorations and Timing of Loading

The search identified 43 articles addressing provisional or temporary restorations. None of the identified studies directly compared esthetic outcomes associated with the use or non-use of provisional prostheses as the primarily experimental focus. Therefore, articles reporting esthetic outcomes for treatments utilizing provisional prostheses and outcomes for treatments excluding the use of provisional prostheses are presented.

In a RCT, Degidi et al[15] reported on 60 single-tooth maxillary lateral incisor replacements in healed ridges. Sites were randomly assigned to an immediate restoration protocol (30), or a delayed loading protocol utilizing only a healing abutment (30). All sites were definitively restored after 6 months of healing. Using the papilla index score (PSI), no statistically significant differences were identified between the groups.

In a randomized controlled trial, Oh et al[2] reported outcomes for 24 patients treated with implant-supported restorations for single missing teeth in healed sites. Twelve patients were randomly assigned to the test group, receiving a provisional prosthesis in an immediate load protocol, and 12 patients served as the control group, receiving no prosthesis as part of a conventional protocol. For the control group a healing abutment was utilized for 4 months prior to restoration. Patients were evaluated 6 months subsequent to final restoration, and no statistically significant variation between test and control groups was established for PSI, recession of midfacial mucosa, or width of keratinized mucosa. This article represents the only RCT identified whereby the comparison treatments include the use versus non-use of provisional prostheses; however, the primary focus of the study was the loading protocol. It is possible, therefore, that outcomes are associated with the loading protocol rather than use of the provisional restoration. Therefore, meaningful conclusions are difficult to determine. Further, this study is limited by a short follow-up period.

The literature contains a greater number of case series studies evaluating esthetic outcomes for protocols including, rather than excluding, provisional restorations. The majority of case series studies describe outcomes for single missing teeth, and the heterogeneity in *(1)* study design, *(2)* follow-up period, *(3)* timing of implant placement, and *(4)* surgical protocol prevents identification of firm conclusions.

Of the 31 case series studies reporting outcomes of therapy that included use of a provisional restoration, 17 described alterations in mid-facial mucosal levels during follow-up. Of these, eight studies described mucosal stability (Di Alberti et al,[26] Brown and Payne,[51] Buser et al,[36] Chung et al,[35] Tsuda et al,[33] Tortamano et al,[38] Canullo and Rasperini,[44] and Cooper et al[52]). Importantly, nine authors reported recession (Cabello et al,[22] Cosyn et al,[24] Crespi et al,[54] Cosyn et al,[32] Gallucci

| Assessment of outcome | Sufficient follow-up time for outcome to occur | Adequacy of follow-up | Total |
|---|---|---|---|
| | * | * | 5 |
| * | | | 5 |
| | * | * | 5 |
| * | * | * | 8 |
| * | | | 5 |
| * | | | 6 |

et al,[53] Kan et al,[34] Malchiodi et al,[30] Zarone et al,[57] and Cornelini et al[47]). It is important to note that the loss of facial mucosal height reported (recession) may be associated with other treatment variables.

In a retrospective case series study, Buser et al[41] reported outcomes associated with 45 single-tooth replacements, where implants were placed and restored according to early protocols. Follow-up was reported as between 2 and 4 years, at which time all implants had maintained an esthetic subgingival margin according to implant shoulder to mucosal margin measurements.

Degidi et al,[15] in a retrospective case series, reported on 52 single-tooth implants placed in extraction sockets or healed ridges in the anterior region. Implants were restored according to an immediate restoration protocol. Papilla height changes showed no statistically significant variation over the follow-up period (from 6 months to 48 to 72 months after implant placement).

Four case series studies including the use of provisional restorations in the treatment protocol evaluated the esthetic outcome using the PES.[23,31,40,50] Four additional studies[24,29,32,39] assessed esthetic outcomes using both PES and WES. The significance of outcomes measured using PES/WES is difficult to determine for several reasons. The measured parameters vary between citations, and there is no accepted numerical value differentiating favorable versus nonfavorable esthetic outcomes. What constitutes an acceptable esthetic outcome therefore varies at an author's discretion.

Several studies with a primary focus on the timing of implant loading and using a protocol associated with provisional prostheses reported on esthetic outcomes. Lindeboom et al[1] in a RCT reported outcomes associated with placement of 50 implants into healed ridges. Treatment was randomly allocated to either an immediate loading or immediate restoration protocol. Although no statistical analysis was provided, the authors reported mesial and distal papillae regeneration in 70% and 91% of instances, respectively, for the immediate loading group versus 91% for both mesial and distal papillae for the immediate restoration group. The midfacial gingival levels were considered ideal for 100% of the immediate loading group, versus 91% of the immediate restoration group, with two implants demonstrating recession between 1 and 2 mm.

Donati et al,[14] in a multicenter RCT, reported on 159 single-tooth replacements where a provisional restoration was utilized. Fifty-seven sites were randomly assigned to conventional loading (control), 50 sites to immediate loading with conventional implant bed preparation, and 52 sites to immediate loading with osteotome site preparation. No statistical difference was determined throughout the follow-up period (time of restoration and six months subsequent) in papilla height or width of keratinized mucosa, based on the loading protocol assigned.

These two studies do not identify a positive or negative influence of provisional restorations on measureable esthetic outcomes based on immediate loading or immediate restoration protocols for implants placed in healed ridges. Therefore, although the volume of evidence is limited, based on existing evidence the decision to immediately load or restore implants positioned into healed ridges cannot be based on esthetic outcomes.

De Rouck et al,[5] in a RCT of 49 single implants positioned in extraction sockets, compared delayed loading after 3 months of healing (25) with immediate restoration (24). Patients were evaluated 1 year after implant placement, and no significant variation in papilla levels was identified. The authors reported significantly greater midfacial recession for the delayed loading group compared to the immediately restored group, with mean values of –1.16 mm and –0.41 mm, respectively. The mean difference in recession noted between the two groups was 0.75 mm.

Den Hartog et al[3] reported on 62 implants positioned into healed sites, with treatment randomly allocated to immediate restoration (31), and conventional loading (31) after three months of healing. Patients were evaluated 12 months after crown placement, and although papilla gain was observed for both groups, there was no significant difference in gain or PSI. For each group, midfacial mucosal levels remained stable with no significant variation between groups. Further, no significant variation between groups was identified using PES/WES.

Hall et al[6] evaluated 28 single implants positioned into healed ridges, randomly assigned to an immediate restoration (14 patients) or conventional loading protocol (14 patients). Follow-up evaluation was undertaken 10 months subsequent to the placement of the definitive crown and no significant variation was identified with regard to PSI. For the combined patient pool, the papilla was considered unchanged in 28.5%

of instances and improved in 63%. No significant variation in midfacial mucosal levels was identified, nor was a significant variation identified in the width of keratinized mucosa.

The heterogeneity in study design, follow-up period, and treatment protocols prevents strong conclusions from being drawn; however, the limited evidence suggests that esthetic outcomes may not be influenced either positively or negatively based on the provisional restoration of implants placed according to different protocols.

In a split mouth, prospective cohort study, Ottoni et al[21] positioned two implants each in 23 patients and restored one immediately and one with a conventional protocol. No detailed information was available with regard to ridge condition at the time of placement, delay of loading for the conventional loading group, or for timing of definitive restoration placement. The soft tissue condition associated with each implant was evaluated 1 and 6 months subsequent to implant placement. For the test group (immediate restoration), the authors reported an improvement in papilla score for 88.2% of mesial sites and 65% of distal. For the control group, the corresponding papilla score improvements were 83.3% and 50%, respectively. For the test group, gingival levels were considered stable in 49.17% of instances, with recession noted in 31.66%. For the control group, these figures were 59.52% and 21.43%, respectively.

Therefore, based on these studies, the literature does not identify strong scientific evidence that esthetic outcomes are influenced positively or negatively by utilization of a provisional prosthesis. The utilization of provisional prostheses remains strongly recommended in order to test the planned final prosthesis, to facilitate maturation of healing tissues, and for patient convenience.

## Abutments and Implant Platform

Several articles compare horizontal and vertical offset (platform switching) implant designs. In a RCT involving 22 implants, Canullo et al[7] compared immediately positioned and restored implants cemented onto abutments that were horizontally offset (platform switched) or conventional (abutment diameter fit the implant diameter). The treatment provided was randomly generated, and definitive abutment allocation was similar to that of the provisional restoration. At an average of 25 months subsequent to provisional restoration placement, a significant difference was identified with regard to midfacial mucosal margin levels, with the horizontally offset group showing a mean gain of 0.18 mm, and the conventional abutment design characterized by a mean loss of 0.45 mm. Soft tissue (papilla) levels (with mesial and distal papillae considered as one group) were also significantly different, with the horizontally offset group associated with a mean gain of 0.045 mm, and the conventional group associated with a mean 0.88 mm loss.

Pieri et al[8] evaluated 40 implants positioned immediately into extraction sockets. In this RCT patients were randomly assigned to immediate restoration on a horizontally offset implant abutment or to immediate restoration on an abutment whose diameter matched the implant. The definitive abutments shared the morphology of the provisional abutment in each instance. No significance between groups was identified with regard to papilla height, with loss of height on the mesial and distal papillae being 0.3 mm and 0.25 mm for the horizontally offset design, and 0.36 mm for both the mesial and distal papillae for the conventional design group. Significant recession of the midfacial mucosa was reported for both the horizontally offset and conventional groups (mean 0.61 mm and 0.71 mm, respectively), although the difference between the two was not considered to be significant.

These two RCTs report similar test protocols that compare esthetic outcomes associated with the platform design. It is difficult, however, to draw conclusions due to the variation in outcomes reported.

In a retrospective cross-sectional study, Chang and Wennström[25] reported on 32 single-tooth implants placed in the anterior maxilla and characterized by a horizontal offset. No information about implant placement timing was provided. Provisional restorations were positioned after 6 months of healing and left in place for 4 weeks prior to final cementation of definitive metal ceramic restorations. After an average of 7.5 years of follow-up subsequent to implant placement (range 19 months to 14 years), PSI was recorded. A complete papilla was reported in 21 sites (38%) while 34 sites had what was described as deficient papillae (62%).

In a prospective case series, Oyama et al[27] reported on 17 reduced diameter (3 mm) implants positioned in maxillary and mandibular incisor sites. The implants were positioned into healed sites and immediately restored with provisional prostheses. Definitive metal ceramic prostheses were delivered 3 months subsequent to implant positioning. Papilla index scores were obtained 12 months after implant placement, and a statistically significant increase in both mesial and distal papillae scores was recorded. At the 12-month follow-up, 11 of 17 mesial papillae (64%) and 10 of 17 distal papillae (59%) were given maximum scores.

Lops et al,[18] in a prospective cohort study, compared a conventional vertical offset platform design with an abutment platform design characterized by horizontal offset. As part of the outcome evaluation, the mesial and distal papillae were evaluated 6 months

subsequent to definitive restoration, with no significant difference being revealed.

As a result of the heterogeneity in study design, follow-up period, timing of implant placement, surgical protocols and pretreatment conditions, no firm conclusions can be drawn from the case series studies. Among the case series describing horizontally offset designs, six featured results including the midfacial mucosal levels. Of these, five[33,35,36,44,52] illustrated stability or a slight gain in midfacial mucosal height. One study[24] identified slight recession.

Of the 10 case series studies reporting on findings with conventional abutment connections, 8 identified slight recession,[32,34,46,47,49,54,55,57] and two authors reported stability of the midfacial mucosa.[38,48]

Three case series studies of implant platforms characterized by a horizontal offset,[24,29,36] and four characterized by conventional platforms,[31,32,49,58] reported outcomes using PES or PES/WES. As a result of inconsistency in measured parameters or scales considered esthetically acceptable, comparison of reported findings is not possible.

Two studies described esthetic outcomes from case series studies reporting on abutments inclined from the long axis of the implant.[51,56] Brown identified an overall improvement in height for both the mesial and distal papilla, while Vandeweghe reported improvement only for the mesial papilla. Brown reported midfacial mucosal stability, while Vandeweghe reported slight recession.

Two RCTs evaluated the contour of the implant abutment connection. den Hartog et al[4] reported esthetic outcomes associated with 93 single-tooth replacements. The implant design was randomly assigned as a smooth implant collar (31), a roughened implant collar (31), and a scalloped platform (31). At 18 months after implant placement, no significant variation was identified between groups for papilla height, with each showing a slight gain. PSI improved significantly for all groups; however, there was no significant difference between groups. The midfacial mucosal levels remained stable throughout the follow-up period, with no significant variation identified between groups.

Tymstra et al[9] compared adjacent implants characterized by a conventional (flat) platform to those characterized by a scalloped platform. A total of 80 implants were positioned in 40 patients, with implant type by platform randomly generated. All implants were allowed to heal for four months prior to loading. The sites were evaluated 1 year subsequent to the positioning of the final crowns. No significant difference in recession was noted based on platform design at the proximal surface between the implants and adjacent teeth; however, significantly greater recession was identified between the scalloped platform implants than between the implants with the conventional platform design. The scalloped implant design was also associated with significant midfacial mucosal recession.

Three additional case series studies reported on platform variables. Kan et al[43] reported papilla as being stable throughout follow-up, while the other two studies[23,50] reported PES only with no comparisons. None of these three studies evaluated midfacial mucosal changes. One case series study reported outcomes in papilla score index associated with monolithic implants.[42] For restorations in the anterior maxilla, 93% of sites were highly scored (3).

The volume of identified literature associating platform design and esthetic outcomes is small. It is not possible to identify any significant variation in esthetic outcomes based on the character of the abutment platform from the current literature volume.

## Definitive Restorative Material

In a RCT, Gallucci et al[10] reported on 20 single-tooth implant restorations placed according to an early loading protocol. According to a randomized allocation, 10 implants received a screw-retained all-ceramic restoration, while 10 received a screw-retained metal-ceramic restoration. Patients were evaluated 1 and 2 years subsequent to insertion of the definitive restorations, and no significant differences were identified between groups with regard to papilla height. After 1 year both groups recorded a significant increase in both mesial and distal papilla heights (0.23 mm and 0.17 mm, respectively). Between years 1 and 2 of follow-up, a significant increase was observed only in mesial sites (0.36 mm). No significant difference during follow-up was noted between groups with regard to clinical crown length. In both groups the mucosal showed significant recession (0.26 mm). Between groups there was no significant difference noted in the width of keratinized mucosa throughout follow-up, with the dimension being 4.83 mm and 4.67 mm for the all-ceramic and metal-ceramic restorations, respectively. No significant difference was identified between groups with regard to the combined PES/WES score, with the all-ceramic group and the metal-ceramic group recording 13.2 and 13.89, respectively. Interestingly, with blinded observation, there was no significant variation from random guessing with regard to differentiation of restorative material.

In a second article reporting on the same patient pool, Gallucci et al[11] reported outcomes of different parameters. While no significant differences were identified between the all-ceramic and metal-ceramic groups, in contrast to the outcomes in the previous study (Gallucci et al[10]) where 0.26 mm of recession was noted, the distance recorded from the implant shoulder to peri-implant mucosa was reported as stable over the follow-up period.

Hosseini et al[12] described outcomes of a RCT involving 36 patients and 75 single-tooth premolar restorations. According to randomized assignment, 38 of the implants were restored with an all-ceramic cemented definitive restoration, while 37 implants received a cement retained metal-ceramic option. At an average of 13.5 months subsequent to the positioning of the definitive restoration, each site was evaluated according to the Copenhagen Index Score (CIS). This protocol included crown morphology, crown color, mucosal discoloration, and the levels of the mesial and distal papillae. The only parameter associated with a significant variation between the groups was the crown color match. The all-ceramic groups identified a significantly lower score, associated with a statistically superior esthetic outcome. There was no significant difference in overall CIS between the groups.

Jung et al[13] evaluated 30 single-tooth implant supported replacements positioned in the anterior maxilla or mandible. Fifteen implants were randomly assigned to receive cement- or screw-retained all-ceramic definitive restorations, and 15 were assigned to receive cement- or screw-retained metal-ceramic restorations. Baseline was considered to be immediately prior to placement of the definitive restoration. The color of the peri-implant mucosa was assessed using a standardized reflectance spectrometer at both the implant site and at an adjacent tooth. No significant differences were noted in the color of the gingival tissues between implant and adjacent tooth sites prior to the positioning of the definitive restorations. Gingival thickness was recorded 1 mm apical to the free gingival margin for all sites and no significant difference between groups was identified. Subsequent to the positioning of the definitive restorations, gingival color was considered significantly more favorable (improved match to the adjacent tooth) when associated with the all-ceramic crowns in comparison to the metal-ceramic crowns, especially in sites characterized by thin tissue. It should be emphasized that the follow-up period was very short (1 to 2 weeks), and the longer-term outcome remains unknown.

Based on the results of the RCTs, no significant difference can be established between all-ceramic and metal-ceramic restorations with regard to esthetic indices (CIS, PES/WES) over short observation periods. There may be a favorable trend towards all-ceramic restorations with regard to color stability of peri-implant tissues, and the correlation with thin tissue requires additional investigation.

In a nonrandomized retrospective cohort study, Henriksson and Jemt[17] evaluated 18 patients receiving 18 single-tooth implants in healed sites. A standard (prefabricated) abutment was used in conjunction with a metal-ceramic crown in 9 patients, and a customized ceramic abutment was used with an all-ceramic restoration for the remaining 9 patients. All implants were restored using a delayed loading protocol. While each group was associated with a significant increase in PSI through the 1-year follow up, no statistical variation was identified between the groups. Through the 1-year follow-up, both groups were also reported to have been associated with a significant decrease in buccal marginal soft tissue volume (rather than recession), although again there was no significant variation between groups.

The heterogeneity in study design, follow-up period, timing of implant placement, surgical protocol, and pretreatment conditions prevents firm conclusions being established from the case series studies addressing this topic. Of the 13 case series studies reporting findings associated with metal-ceramic restorations, eight reported midfacial mucosal level changes, with tissue stability being reported by three authors,[35,38,48] and slight recession being reported by five authors.[28,32,34,54,57] Two studies reported PES and WES.[32,39]

Of the seven case series studies describing outcomes associated with all-ceramic restorations, six reported changes in the midfacial mucosal levels. Stability was reported by four authors,[33,36,44,51] and two authors described slight recession.[46,56] PES and WES outcomes were reported by three authors.[29,36,56]

For each of the above combinations metal abutments supported metal-ceramic restorations, while ceramic abutments supported all-ceramic restorations. With regard to materials utilized for abutments and definitive restorations, it is clear that additional RCTs are required in order to identify clear esthetic benefits. There is a need to evaluate these materials in combination with tissue thickness. There are no studies evaluating different metal or ceramic options with esthetic parameters. Lastly, no advantage or disadvantage could be established based on material choice.

## Mode of Restoration Retention

No RCTs were identified comparing cement and screw retention with regard to esthetic outcomes. Twenty-four studies (1 cohort study, 1 retrospective cross-sectional study, and 22 case series) were identified where a defined cement or screw retention was defined in the protocol, and esthetic outcomes were reported.

In a prospective, multicenter cohort study, Sherif et al[16] reported outcomes for 214 single or multiple implants positioned in healed ridges. Of the surviving implants, 103 of the implants were restored using a screw-retained restoration, and 90 were restored with a cement-retained restoration. All were restored using a conventional loading protocol. No significant differences in the width of facial keratinized tissue between

groups were noted 60 months subsequent to restoration placement. In addition, no significant difference was observed in the distance measured from the top of the implant collar to the midfacial marginal gingiva between the cement- and screw-retained groups.

Santing et al[19] reported findings of their prospective cohort study primarily focused on grafted versus non-grafted sites, although the authors also compared screw and cement retention using WES, and marginal gingival recession. The results relating the mode of restoration retention are therefore reported here as a case series study. Of the 60 implants, 29 were placed in previously grafted sites, and 31 were positioned in sites that had not been grafted. Of the definitive restorations, 27 were cemented and 33 were screw retained. No significant difference was reported with regard to buccal midfacial recession through 5 months of follow-up. No significant difference was reported with regard to WES.

In a cross-sectional, retrospective study comparing PES of screw- and cement-retained single crowns, Cutrim et al[58] concluded after at least 1 year of follow-up, that no significant differences existed between the groups.

The heterogeneity in study design, follow-up period, timing of implant placement, surgical protocol, and pretreatment conditions prevents the drawing of meaningful conclusions from the case series studies. Seven case series studies reported outcomes associated with definitive screw-retained restorations. Six reported midfacial mucosal level changes, three noting stability[36,38,51] and three reporting slight recession.[28,53,56] One study[36] reported PES and WES, and one study[31] reported only PES. It should be noted that each of these case series studies described single-tooth situations with the exception of Gallucci et al,[53] which reported on full-arch restorations.

Fifteen case series studies described outcomes associated with definitive cement-retained prostheses. Of these, eight reported midfacial mucosal level changes, with two reporting stability[33,44] and six describing slight recession.[30,32,34,49,46,57] Two additional studies reported on PES,[31,49] and two reported PES and WES.[24,29] Meaningful conclusions regarding PES and/or WES are difficult to identify.

No firm conclusions relating esthetic benefits for cement in comparison to screw retention can be identified from the literature. Further, the heterogeneity of the existing literature prevents meaningful comparisons and conclusions being drawn.

### Outcomes and Objective Esthetic Indices

Two RCTs reported on outcomes based on objective esthetic indices. Den Hartog et al[3] reported on outcomes associated with 62 nonhorizontally offset implants positioned into healed sites. Of this total, 31 implants were allocated to an immediate restoration protocol and 31 implants to a conventional loading protocol. Definitive restorations were all-ceramic screw- or cement-retained. One year subsequent to the placement of the definitive restorations, mean PES for the immediate restoration group and the conventional loading group were respectively 7.1 (1.5) (range 3 to 10) and 6.5 (1.63) (range 4 to 10). Mean WES for immediate restoration group and conventional loading group were respectively 7.8 (1.5) (range 4 to 10) and 7.6 (1.6) (range 4 to 10). The differences between the two groups were not considered statistically significant.

Gallucci et al[10] reported on findings associated with 20 single-tooth implant restorations placed at least 2 months after implant placement. According to a randomized allocation, 10 implants received a screw-retained all-ceramic restoration while 10 received a screw-retained metal-ceramic restoration. At 2 years subsequent to insertion of the definitive restorations, no significant difference was identified between groups with regard to the combined modified PES/WES score. The all-ceramic group and metal-ceramic group recorded 13.12 and 13.89, respectively.

Several non-randomized studies reported outcomes using objective esthetic indices. Four case series studies including the use of provisional restorations in the treatment protocol evaluated the esthetic outcome using the PES.[23,31,40,50] Five additional studies assessed esthetic outcomes using both PES or modified PES and WES.[24,29,32,36,39]

Three case series studies assessed implants with a platform characterized by horizontal offset[24,29,36] and six studies assessed conventional platforms.[31,32,39,40,49,58] Two case series studies reported on a platform variable in correlation to PES.[23,50]

Two studies reported PES or modified PES combined with WES for metal-ceramic prostheses.[32,39] Three studies reported PES or modified PES combined with WES for all-ceramic restorations.[29,36,56] One study included both all-ceramic and metal-ceramic in its protocol and reported on PES and WES.[24]

Three studies reported on objective esthetic outcomes including both screw- and cement-retained restorations in their protocol; one study described WES,[19] and two studies reported on PES.[31,58] Three studies reported on screw-retained restorations only, one described modified PES/WES,[36] and one reported on PES/WES.[56] Three studies reported on cemented restoration only, one study described only PES,[49] and two studies reported on PES and WES.[29,32]

In a prospective case series, Vandeweghe et al[56] reported on 15 single-tooth implants (nonhorizontally offset) placed in healed ridges and restored according to an immediate loading protocol. The implant platform had a 12-degree angulation to the long axis. All

ceramic screw–retained definitive restorations were delivered 24 hours after implant placement. One year after baseline the authors described a mean PES of 8.53 with a range 6 to 10. At the same follow-up, 80% of sites had at least a score of 8. The mean value for WES was 6.53 with a range of 4 to 9, with 67% of sites exhibiting a score of at least 6.

In a cross-sectional retrospective study, Cutrim et al[58] reported on 40 single-tooth implants (nonhorizontally offset), 23 of which received screw-retained prostheses and 17 cemented prostheses. At least 1 year after definitive crown placement, the mean PES for the screw-retained group was 10.73 with a range 5 to 13, with 74% of restorations exhibiting a score superior to 10. For the cemented group, the mean PES was 10.41 with a range 5 to 14, with 64% of the prostheses exhibiting a score superior to 10. There was no statistically significant difference between groups.

In a cross-sectional retrospective study, Belser et al[39] reported on 45 tissue-level single-tooth implants placed according to an early placement protocol. Implants received provisional prostheses 6 to 12 weeks after surgical placement and were subsequently restored with metal-ceramic definitive prostheses. At 2 to 4 years from baseline, the mean value for modified PES was 7.8 with a range 6 to 9, and mean value for WES was 6.9 with a range of 4 to 10. The combined modified PES/WES was 14.7 with a range 11 to 18. At last follow-up, 22% of sites had an excellent modified PES (9 to 10), 78% had acceptable modified PES (6 to 8), and 0% had a poor modified PES (< 6).

In a prospective case series, Noelken et al[23] reported on 24 scalloped-platform implants restored according to an immediate restoration protocol. At 5 years follow-up, the mean PES was 10.5 with a range of 3 to 13. In 16 patients, preoperative and 5 years postoperative scores were available. Improvement was noticed in 18.75% of sites. Esthetic status was unchanged in 37.5%, and 43.75% showed a slight to moderate decrease on the esthetic rating scale.

In another prospective case series, Noelken et al[50] reported on 18 scalloped platform implants placed in extraction sockets with complete loss of the facial bony lamella. The implants were restored according to an immediate restoration protocol. The mean preoperative PES score was 12.2 with a range 8 to 14. After 13 to 36 months of follow-up (median 22 months), the mean PES score was 12.5 with a range 10 to 14. From preoperative situation to last follow-up, 44% of sites showed improvement, 28% featured unchanged PES, and 28% featured slight to moderate decrease on PES value.

In a prospective case series, Buser et al[36] reported on 20 bone-level implants (horizontal offset) placed according to an early implant protocol. Provisional prostheses were delivered between 8 and 12 weeks after implant placement. Subsequently, all-ceramic screw-retained definitive prostheses were delivered. At the 1-year follow-up, mean modified PES scores were 8.1 and mean WES 8.65. After 3 years of follow-up, mean modified PES were 8.1 and WES 8.65. After 3 years, modified PES was considered excellent (9 to 10) for 45% of sites, acceptable (6 to 8) for 50% of sites, and poor (< 6) for 5% of sites.

In a retrospective case series, Chen et al[40] reported on 85 tissue-level single-tooth implants placed according to type 1 protocol and restored according to a conventional loading protocol. After a mean follow-up period of 26 months, with a range 10.3 to 46.7 months, the mean PES score was 10.95 with a range of 8 to 14. Of the sites, 39% featured an excellent PES score (12 to 14), 52% of sites showed an acceptable PES score (9 to 11), and a poor score (PES 0 to 8) was noticed in 9% of sites.

In a prospective case series, Juodzbalys and Wang[49] reported on 14 single-tooth implants (nonhorizontally offset) placed according to a type 1 protocol. Implants were restored according to a conventional loading protocol and the definitive prostheses were cemented. At the 1-year follow-up, mean PES was 11.1 with a range of 10 to 14. Excellent PES (12 to 14) was recorded in 29% of sites, acceptable PES (9 to 11) was noted in 71% of sites, and poor PES (0 to 8) in 0% of sites.

In a prospective case series, Cosyn et al[24] reported on 22 horizontally offset, single-tooth implants placed according to a type 1 protocol. The provisional prostheses were delivered according to an immediate restoration protocol. Definitive prostheses included both all-ceramic and metal-ceramic crowns. At the 1-year follow-up, the mean PES was 12.15 with a range 10 to 13, and the mean WES was 8.63 with a range 7 to 10. There were no significant differences in WES between all-ceramic and metal-ceramic restorations at the 1-year follow-up.

In another prospective case series, Cosyn et al[32] reported on 25 single-tooth implants (nonhorizontally offset) placed according to a type 1 protocol and restored according to an immediate restoration protocol. The final prostheses were metal-ceramic and cemented. At 3 years follow-up, the mean PES was 10.48 with a range of 5 to 14. Mean WES was 8.17 with a range of 5 to 10. Excellent PES (12 to 14) was recorded in 36% of sites, acceptable PES (9 to 11) was noticed in 56% and poor PES (0 to 8) in 8%. Combined PES/WES was excellent (PES ≥ 12, WES ≥ 9) in 21% of sites, acceptable (PES 8 to 11,WES 6 to 8) in 58%, and poor (PES < 8,WES < 6) in 21%.

In a retrospective case series, Hof et al[31] reported on 60 single implants (nonhorizontally offset) placed in healed ridges. Provisional prostheses were delivered according to a conventional loading protocol. Of the definitive prostheses, 28% were screw retained and 72% were cemented. After a mean 4.1 years (range 1.2 to 8.1) follow-up period, the median PES was 11.

Excellent PES (12 to 14) was described in 35% of sites, acceptable PES (9 to 11) was noticed in 38% and poor PES (0 to 8) was recorded in 27%. There were no statistical significant differences between screw- and cement-retained restorations according to PES scores.

In a prospective case series, Furze et al[29] reported on 10 single-tooth implants (horizontally offset) placed according to early placement protocol. Provisional prostheses were placed 2 to 3 months subsequent to implant positioning. Definitive prostheses were all-ceramic and cemented. After 1 year of follow-up, the mean modified PES score was 7.9 and the mean WES score was 7.0.

Santing et al[19] reported findings of a prospective cohort study primarily focused on grafted versus nongrafted sites, although the authors also compared screw and cement retention using WES. The results relating the mode of retention are therefore reported as a case series study. Of 60 single definitive restorations, 27 were cemented and 33 were screw retained. The mean WES score was 7.5 with a range of 4 to 10. There was no significant difference between screw- and cement-retained prostheses 12 months after definitive crown delivery.

## CONCLUSIONS

The existing literature reporting on the influence of restorative procedures on esthetic outcomes is small in volume and can be considered of generally low quality. There is a need for RCTs comparing accepted procedures in routine practice. There is some standardization for papilla evaluation, with PSI being widely reported. The reporting of midfacial mucosal levels (recession) is varied and a more accepted protocol for reporting is required. PES/WES is a promising method for the reporting of esthetic outcomes; however, at present there is no consistency in reference scale, making comparison between studies difficult at best. In addition, the majority of studies report on single-tooth replacement, and many of the outcomes may not be relevant or applicable to the large number of esthetic indications involving more than one tooth.

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## REFERENCES

1. Lindeboom JA, Frenken JW, Dubois L, Frank M, Abbink I, Kroon FH. Immediate loading versus immediate provisionalization of maxillary single-tooth replacements: A prospective randomized study with BioComp implants. J Oral Maxillofac Surg 2006;64:936–942.
2. Oh TJ, Shotwell JL, Billy EJ, Wang HL. Effect of flapless implant surgery on soft tissue profile: A randomized controlled clinical trial. J Periodontol 2006;77:874–882.
3. den Hartog L, Raghoebar GM, Stellingsma K, Vissink A, Meijer HJ. Immediate non-occlusal loading of single implants in the aesthetic zone: A randomized clinical trial. J Clin Periodontol 2011;38:186–194.
4. den Hartog L, Meijer HJ, Stegenga B, Tymstra N, Vissink A, Raghoebar GM. Single implants with different neck designs in the aesthetic zone: A randomized clinical trial. Clin Oral Implants Res 2011;22: 1289–1297.
5. De Rouck T, Collys K, Wyn I, Cosyn J. Instant provisionalization of immediate single-tooth implants is essential to optimize esthetic treatment outcome. Clin Oral Implants Res 2009;20:566–570.
6. Hall JA, Payne AG, Purton DG, Torr B, Duncan WJ, De Silva RK. Immediately restored, single-tapered implants in the anterior maxilla: Prosthodontic and aesthetic outcomes after 1 year. Clin Implant Dent Relat Res 2007;9:34–45.
7. Canullo L, Iurlaro G, Iannello G. Double-blind randomized controlled trial study on post-extraction immediately restored implants using the switching platform concept: Soft tissue response. Preliminary report. Clin Oral Implants Res 2009;20:414–420.
8. Pieri F, Aldini NN, Marchetti C, Corinaldesi G.Influence of implant-abutment interface design on bone and soft tissue levels around immediately placed and restored single-tooth implants: A randomized controlled clinical trial. Int J Oral Maxillofac Implants 2011;26:169–178.
9. Tymstra N, Raghoebar GM, Vissink A, Den Hartog L, Stellingsma K, Meijer HJ. Treatment outcome of two adjacent implant crowns with different implant platform designs in the aesthetic zone: A 1-year randomized clinical trial. J Clin Periodontol 2011;38:74–85.
10. Gallucci GO, Grütter L, Nedir R, Bischof M, Belser UC. Esthetic outcomes with porcelain-fused-to-ceramic and all-ceramic single-implant crowns: A randomized clinical trial. Clin Oral Implants Res 2011;22:62–69.
11. Gallucci GO, Grütter L, Chuang SK, Belser UC. Dimensional changes of peri-implant soft tissue over 2 years with single-implant crowns in the anterior maxilla. J Clin Periodontol 2011;38:293–299.
12. Hosseini M, Worsaae N, Schiodt M, Gotfredsen K. A 1-year randomised controlled trial comparing zirconia versus metal-ceramic implant supported single-tooth restorations. Eur J Oral Implantol 2011;4:347–361.
13. Jung RE, Holderegger C, Sailer I, Khraisat A, Suter A, Hämmerle CH. The effect of all-ceramic and porcelain-fused-to-metal restorations on marginal peri-implant soft tissue color: A randomized controlled clinical trial. Int J Periodontics Restorative Dent 2008;28:357–365.
14. Donati M, La Scala V, Billi M, Di Dino B, Torrisi P, Berglundh T. Immediate functional loading of implants in single tooth replacement: A prospective clinical multicenter study. Clin Oral Implants Res 2008; 19:740–748.
15. Degidi M, Nardi D, Piattelli A. Immediate versus one-stage restoration of small-diameter implants for a single missing maxillary lateral incisor: A 3-year randomized clinical trial. J Periodontol 2009;80: 1393–1398.
16. Sherif S, Susarla SM, Hwang JW, Weber HP, Wright RF. Clinician- and patient-reported long-term evaluation of screw- and cement-retained implant restorations: A 5-year prospective study. Clin Oral Investig 2011;15:993–999.
17. Henriksson K, Jemt T. Measurements of soft tissue volume in association with single-implant restorations: A 1-year comparative study after abutment connection surgery. Clin Implant Dent Relat Res 2004;6:181–189.
18. Lops D, Mosca D, Müller A, Rossi A, Rozza R, Romeo E. Management of peri-implant soft tissues between tooth and adjacent immediate implant placed into fresh extraction single socket: A one-year prospective study on two different types of implant-abutment connection design. Minerva Stomatol 2011;60:403–415.
19. Santing HJ, Raghoebar GM, Vissink A, den Hartog L, Meijer HJ. Performance of the Straumann Bone Level Implant system for anterior single-tooth replacements in augmented and nonaugmented sites: A prospective cohort study with 60 consecutive patients. Clin Oral Implants Res 2013;24:941–948.
20. Cosyn J, Sabzevar MM, De Bruyn H. Predictors of inter-proximal and midfacial recession following single implant treatment in the anterior maxilla: A multivariate analysis. J Clin Periodontol 2012;39:895–903.

21. Ottoni JM, Oliveira ZF, Mansini R, Cabral AM. Correlation between placement torque and survival of single-tooth implants. Int J Oral Maxillofac Implants 2005;20:769–776.
22. Cabello G, Rioboo M, Fábrega JG. Immediate placement and restoration of implants in the aesthetic zone with a trimodal approach: Soft tissue alterations and its relation to gingival biotype. Clin Oral Implants Res 2012 Jul 9 [epub ahead of print].
23. Noelken R, Kunkel M, Jung BA, Wagner W. Immediate Nonfunctional Loading of NobelPerfect Implants in the Anterior Dental Arch in Private Practice—5-Year Data. Clin Implant Dent Relat Res 2012 Feb 29 [epub ahead of print].
24. Cosyn J, De Bruyn H, Cleymaet R. Soft tissue preservation and pink aesthetics around single immediate implant restorations: A 1-year prospective study. Clin Implant Dent Relat Res 2012 Feb 29 [epub ahead of print].
25. Chang M, Wennström JL. Soft tissue topography and dimensions lateral to single implant-supported restorations. A cross-sectional study. Clin Oral Implants Res 2013;24:556–562.
26. Di Alberti L, Donnini F, Di Alberti C, Camerino M, Sgaramella N, Lo Muzio L. Clinical and radiologic evaluation of 70 immediately loaded single implants in the maxillary esthetic zone: Preliminary results after 1 year of functional loading. Int J Oral Maxillofac Implants 2012; 27:181–186.
27. Oyama K, Kan JY, Rungcharassaeng K, Lozada J. Immediate provisionalization of 3.0-mm-diameter implants replacing single missing maxillary and mandibular incisors: 1-year prospective study. Int J Oral Maxillofac Implants 2012;27:173–180.
28. Lee YM, Kim DY, Kim JY, et al. Peri-implant soft tissue level secondary to a connective tissue graft in conjunction with immediate implant placement: A 2-year follow-up report of 11 consecutive cases. Int J Periodontics Restorative Dent 2012;32:213–222.
29. Furze D, Byrne A, Donos N, Mardas N. Clinical and esthetic outcomes of single-tooth implants in the anterior maxilla. Quintessence Int 2012;43:127–134.
30. Malchiodi L, Cucchi A, Ghensi P, Nocini PF. Evaluation of the esthetic results of 64 nonfunctional immediately loaded postextraction implants in the maxilla: Correlation between interproximal alveolar crest and soft tissues at 3 years of follow-up. Clin Implant Dent Relat Res 2013;15:130–142.
31. Hof M, Pommer B, Strbac GD, Sütö D, Watzek G, Zechner W. Esthetic evaluation of single-tooth implants in the anterior maxilla following autologous bone augmentation. Clin Oral Implants Res 2013;24 (suppl A100):88–93.
32. Cosyn J, Eghbali A, De Bruyn H, Collys K, Cleymaet R, De Rouck T. Immediate single-tooth implants in the anterior maxilla: 3-year results of a case series on hard and soft tissue response and aesthetics. J Clin Periodontol 2011;38:746–753.
33. Tsuda H, Rungcharassaeng K, Kan JY, Roe P, Lozada JL, Zimmerman G. Peri-implant tissue response following connective tissue and bone grafting in conjunction with immediate single-tooth replacement in the esthetic zone: A case series. Int J Oral Maxillofac Implants 2011; 26:427–436.
34. Kan JY, Rungcharassaeng K, Lozada JL, Zimmerman G. Facial gingival tissue stability following immediate placement and provisionalization of maxillary anterior single implants: A 2- to 8-year follow-up. Int J Oral Maxillofac Implants 2011;26:179–187.
35. Chung S, Rungcharassaeng K, Kan JY, Roe P, Lozada JL. Immediate single tooth replacement with subepithelial connective tissue graft using platform switching implants: A case series. J Oral Implantol 2011;37:559–569.
36. Buser D, Wittneben J, Bornstein MM, Grütter L, Chappuis V, Belser UC. Stability of contour augmentation and esthetic outcomes of implant-supported single crowns in the esthetic zone: 3-year results of a prospective study with early implant placement postextraction. J Periodontol 2011;82:342–349.
37. Nisapakultorn K, Suphanantachat S, Silkosessak O, Rattanamongkolgul S. Factors affecting soft tissue level around anterior maxillary single-tooth implants. Clin Oral Implants Res 2010;21:662–670.
38. Tortamano P, Camargo LO, Bello-Silva MS, Kanashiro LH. Immediate implant placement and restoration in the esthetic zone: A prospective study with 18 months of follow-up. Int J Oral Maxillofac Implants 2010;25:345–350.
39. Belser U, Grütter L, Vailati F, Bornstein M, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implant using objective esthetic criteria: A cross-sectional, retrospective study using pink and white esthetic scores. J Periodontol 2009;80:140–151.
40. Chen ST, Darby IB, Reynolds EC, Clement JG. Immediate implant placement post extraction without flap elevation. J Periodontol 2009;80:163–172.
41. Buser D, Bornstein MM, Weber HP, Grütter L, Schmid B, Belser UC. Early implant placement with simultaneous guided bone regeneration following single-tooth extraction in the esthetic zone: A cross-sectional, retrospective study in 45 subjects with a 2- to 4-year follow-up. J Periodontol 2008;79:1773–1781.
42. Reddy MS, O'Neal SJ, Haigh S, Aponte-Wesson R, Geurs NC. Initial clinical efficacy of 3-mm implants immediately placed into function in conditions of limited spacing. Int J Oral Maxillofac Implants 2008; 23:281–288.
43. Kan JY, Rungcharassaeng K, Liddelow G, Henry P, Goodacre CJ. Periimplant tissue response following immediate provisional restoration of scalloped implants in the esthetic zone: A one-year pilot prospective multicenter study. J Prosthet Dent 2007;97(6 suppl):109–118.
44. Canullo L, Rasperini G. Preservation of peri-implant soft and hard tissues using platform switching of implants placed in immediate extraction sockets: A proof-of-concept study with 12- to 36-month follow-up. Int J Oral Maxillofac Implants 2007;22:995–1000.
45. Degidi M, Nardi D, Piattelli A. Peri-implant tissue and radiographic bone levels in the immediately restored single-tooth implant: A retrospective analysis. J Periodontol 2008;79:252–259.
46. Cardaropoli G, Lekholm U, Wennström JL. Tissue alterations at implant-supported single-tooth replacements: A 1-year prospective clinical study. Clin Oral Implants Res 2006;17:165–171.
47. Cornelini R, Cangini F, Covani U, Wilson TG Jr. Immediate restoration of implants placed into fresh extraction sockets for single-tooth replacement: A prospective clinical study. Int J Periodontics Restorative Dent 2005;25:439–447.
48. Jemt T, Lekholm U. Single implants and buccal bone grafts in the anterior maxilla: Measurements of buccal crestal contours in a 6-year prospective clinical study. Clin Implant Dent Relat Res 2005;7:127–135.
49. Juodzbalys G, Wang HL. Soft and hard tissue assessment of immediate implant placement: A case series. Clin Oral Implants Res 2007;18:237–243.
50. Noelken R, Kunkel M, Wagner W. Immediate implant placement and provisionalization after long-axis root fracture and complete loss of the facial bony lamella. Int J Periodontics Restorative Dent 2011;31:175–183.
51. Brown SD, Payne AG. Immediately restored single implants in the aesthetic zone of the maxilla using a novel design: 1-year report. Clin Oral Implants Res 2011;22:445–454.
52. Cooper LF, Ellner S, Moriarty J, et al. Three-year evaluation of single-tooth implants restored 3 weeks after 1-stage surgery. Int J Oral Maxillofac Implants 2007;22:791–800.
53. Gallucci GO, Mavropoulos A, Bernard JP, Belser UC. Influence of immediate implant loading on peri-implant soft tissue morphology in the edentulous maxilla. Int J Oral Maxillofac Implants 2007;22:595–602.
54. Crespi R, Capparè P, Gherlone E, Romanos G. Immediate provisionalization of dental implants placed in fresh extraction sockets using a flapless technique. Int J Periodontics Restorative Dent 2012;32:29–37.
55. Botticelli D, Renzi A, Lindhe J, Berglundh T. Implants in fresh extraction sockets: A prospective 5-year follow-up clinical study. Clin Oral Implants Res 2008;19:1226–1232.
56. Vandeweghe S, Cosyn J, Thevissen E, Van den Berghe L, De Bruyn H. A 1-year prospective study on Co-Axis implants immediately loaded with a full ceramic crown. Clin Implant Dent Relat Res 2012;14(suppl 1): e126–e138.
57. Zarone F, Sorrentino R, Vaccaro F, Russo S. Prosthetic treatment of maxillary lateral incisor agenesis with osseointegrated implants: A 24–39-month prospective clinical study. Clin Oral Implants Res 2006;17:94–101.
58. Cutrim ES, Peruzzo DC, Benatti B. Evaluation of soft tissues around single tooth implants in the anterior maxilla restored with cemented and screw-retained crowns. J Oral Implantol 2012;38:700–705.