Usefulness of the Aesthetic Result as a Success Criterion for Implant Therapy: A Review

Susanna Annibali, MD, DDS;* Isabella Bignozzi, DDS;† Gerardo La Monaca, DDS, PhD;‡
Maria Paola Cristalli, DDS, PhD‡

ABSTRACT

Purpose: The purpose of this study was to review the reported evaluation criteria of the aesthetic result in oral implant rehabilitation.

Materials and Methods: A literature search of MEDLINE, the Cochrane Collaboration, and EMBASE was performed to retrieve studies published between January 1990 and December 2008 using the following key words: "dental implants," "clinical trial," and "aesthetic index" (and their synonyms). A manual search of the literature published in the same period was also carried out using the following publications: *Clinical Oral Implant Research*, *The International Journal of Oral and Maxillofacial Implants*, and *The International Journal of Periodontics and Restorative Dentistry*. The inclusion criteria of the published studies were the following: human clinical trial, oral implant rehabilitation, at least 10 implants, at least 6 months of follow-up from insertion of the prosthesis, and evaluation of the aesthetic result by means of an index.

Results: The literature search revealed 650 relevant bibliographic references, of which 89 were selected for further analysis. A final total of 29 articles fulfilled the inclusion criteria; these included 10 retrospective case series, 11 prospective case series, 1 retrospective controlled clinical trial, 1 prospective controlled clinical trial, and 6 randomized controlled clinical trials. In general, evaluations of aesthetic results appear only in the more recent studies and refer mostly to implant rehabilitation in the maxillary anterior zone; the index used, in most cases, was the Papilla Index of Jemt.

Conclusions: Although there appears to be a growing interest in aesthetics in dental implantology, there are as yet no universally accepted evaluation criteria of the aesthetic result. Therefore, further research is necessary to establish a common, complete, and reproducible index for the evaluation of aesthetic outcome that can add in the success criteria for implant therapy in the maxillary and mandibular anterior areas.

KEY WORDS: aesthetic index, dental implants, success criteria

INTRODUCTION

Osseointegrated oral implantology is a highly successful therapy in the treatment of complete, partial, and single edentulism.[1–3] There is now a plethora of scientific literature that deals with oral implantology, and the quality of that literature is ever increasing. The aim of today's clinicians and researchers is to provide "evidence-based" implant dentistry[4] that, like evidence-based medicine, identifies a clinical practice based on the best available scientific evidence.[5] To this end, the most important themes are developed by means of systematic reviews and, when possible, meta-analysis of the results.

However, there exist some obstacles to the study of existing publications, beginning with the choice of selection criteria for eligible studies. If selection criteria are too restrictive, for example, including only prospective studies that are controlled and randomized, then only a small number of articles will be uncovered; if wider, with the inclusion of retrospective studies and/or case series, a greater amount of data will be retrieved, but they may be difficult to compare and have poor scientific value.

Moreover, the lack of data concerning the clinical protocol and the methodological differences in the design of the studies retrieved often represents a further

*Associate Professor of Oral Surgery, Department of Oral Surgery, School of Dentistry, "Sapienza" University of Rome, Rome, Italy; †PhD student, Department of Oral Surgery, School of Dentistry, "Sapienza" University of Rome, Rome, Italy; ‡clinical instructor, Department of Oral Surgery, School of Dentistry, "Sapienza" University of Rome, Rome, Italy

Reprint requests: Prof. Susanna Annibali, "Sapienza" University of Rome, Oral Science Department, via Caserta, 6-00161-Rome, Italy; e-mail: susanna.annibali@uniroma1.it

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TABLE 1 Comparison of the Main Implant Success Criteria Presented in the Literature

Success Criteria	Albrektsson and colleagues[6]	Smith and Zarb[8]	Albrektsson and Isidor[9]	Schwartz-Arad and colleagues[10]
Absence of pain	X	X	X	X
Alteration in sensitivity	X	X	X	X
Absence of infection	X	X	X	X
Absence of clinical mobility (of the nonsplinted implant)	X	X	X	X
Absence of peri-implant radiolucency	X	X	X	X
Marginal bone loss after loading	≤1 mm during the first year of loading ≤0.2 mm yearly	≤1 mm during the first year of loading ≤0.2 mm yearly	≤1 mm during the first year of loading ≤0.2 mm yearly	Pattern I Pattern II Pattern III Pattern IV
Implant in a harmonious position and restoration aesthetically pleasing to the patient	—	X	—	—
Parameters of peri-implant inflammation Probing depth Bleeding on probing	—	—	X	—

difficulty with regard to comparisons between studies, sometimes preventing meta-analysis of the results, and thus lowering the scientific evidence level.

The evaluation criteria of clinical outcomes in implant therapy have yet to be established. Albrektsson and colleagues[6] codified some of the more widely used success criteria from several authors,[6] and these have since been rehashed, sometimes with slight variations,[7,8] but without considerable changes. Emphasis has been placed on some topics that had not been previously stressed, such as the health of the soft tissues or inflammation around the implant, or the pattern of peri-implant bone loss (Table 1).[9]

The clearest change in the clinical outcome evaluation parameters in implantology concerns the introduction of the concept of survival, which differs from that of success on the basis of the radiographic assessment of the marginal bone loss (MBL) that may occur after prosthetic loading. Therefore, an endosseous implant that is osseointegrated, functional, nonsymptomatic, and with an MBL that is lower than 50% must be considered as a success (Table 2).

Although the survival criterion is relevant for the back maxillary and mandibular areas, where functional restoration is the main clinical objective, in the anterior areas, where the aspect of the prosthetic rehabilitation is also a matter of concern for patient quality of life, the aesthetic result should be considered as a criterion that is distinct from survival and success and, as such, should be included among the evaluation parameters. It is therefore necessary to perform well-structured, prospective, controlled, randomized clinical studies that evaluate results clearly and rigorously through the use of universally approved survival and success criteria that

TABLE 2 Implant Survival and Success Criteria according to Proskin and colleagues[11]

	Implant Survival	Implant Success
Implant in the mouth and functioning	X	X
No pain	X	X
No mobility (if it can be measured)	X	X
No infection	X	X
Less than 50% bone loss	Not reported	X

are complete and relevant to the goal of the treatment. The purpose of this review was to analyze the currently available internationally published literature on aesthetic implantology in order to provide answers to the following two questions:

1. Is the aesthetic result included among the success criteria for oral implant rehabilitation?
2. Are there currently any indices of aesthetic evaluation that are universally accepted by the authors of the clinical trials?

MATERIALS AND METHODS

Before beginning the review, a protocol was developed that satisfies the authors' strategy of search, inclusion and exclusion criteria of the studies, and method of data extraction.

Data Source and Search Strategy

A bibliographic electronic search was carried out on the MEDLINE, EMBASE, and Cochrane Central Register of Controlled Trials databases, selecting all articles published between January 1990 and December 2008 that contain the following key words (either alone or linked to one another): "dental implants," "aesthetics," "outcomes," and all existing synonyms of these. The terms "dental implants" and "aesthetics" were used as "medical subject headings" terms, while all other words were used as free-text terms. Limits to the PubMed database have been set with the expression "clinical trial," the temporal interval 1990 to 2008, and the English language.

The beginning search date was set at 1990 because prior to that time researchers were primarily interested in the functional aspects of implant therapy and not in aesthetic results, which only became of interest once the predictability of the osseointegration process had been proven.

The listed key words and all of their synonyms were linked in a total of 140 different combinations (Table 3).

The search identified 432 articles from the electronic databases. The electronic search was complemented by a manual search limited to articles published between January 1990 and December 2008 in three highly relevant peer-reviewed dental journals: *Clinical Oral Implant Research*, *The International Journal of Oral and Maxillofacial Implants*, and *The International Journal of Periodontics and Restorative Dentistry*. These journals were chosen because they deal with surgical and periodontal topics; those focusing on the prosthetic point of view were not chosen because the specific concept of implant aesthetics is determined mainly by prosthetic rehabilitation within the soft tissues, while prosthetic aspects such as translucency of the crown, its symmetry toward the homologous contralateral to its surface, and weaving are common to conventional prostheses and thus have already been encoded elsewhere.

Selection of the Literature

Among the articles retrieved by electronic and manual search, the first selection involved only clinical studies concerned with root-form osseointegrated implants

TABLE 3 Keywords and Limits Used for the Electronic Literature Search

MeSH Terms	Free-Text Terms			Limits
Dental implants Aesthetics	Oral implants OR endosseous implants OR implant restoration AND	Soft tissue OR marginal tissue AND OR gingival margin OR	Outcomes OR index OR parameters OR success OR assessment OR evaluation OR score	Clinical trial English language 1990 to 2008

MeSH = medical subject headings.

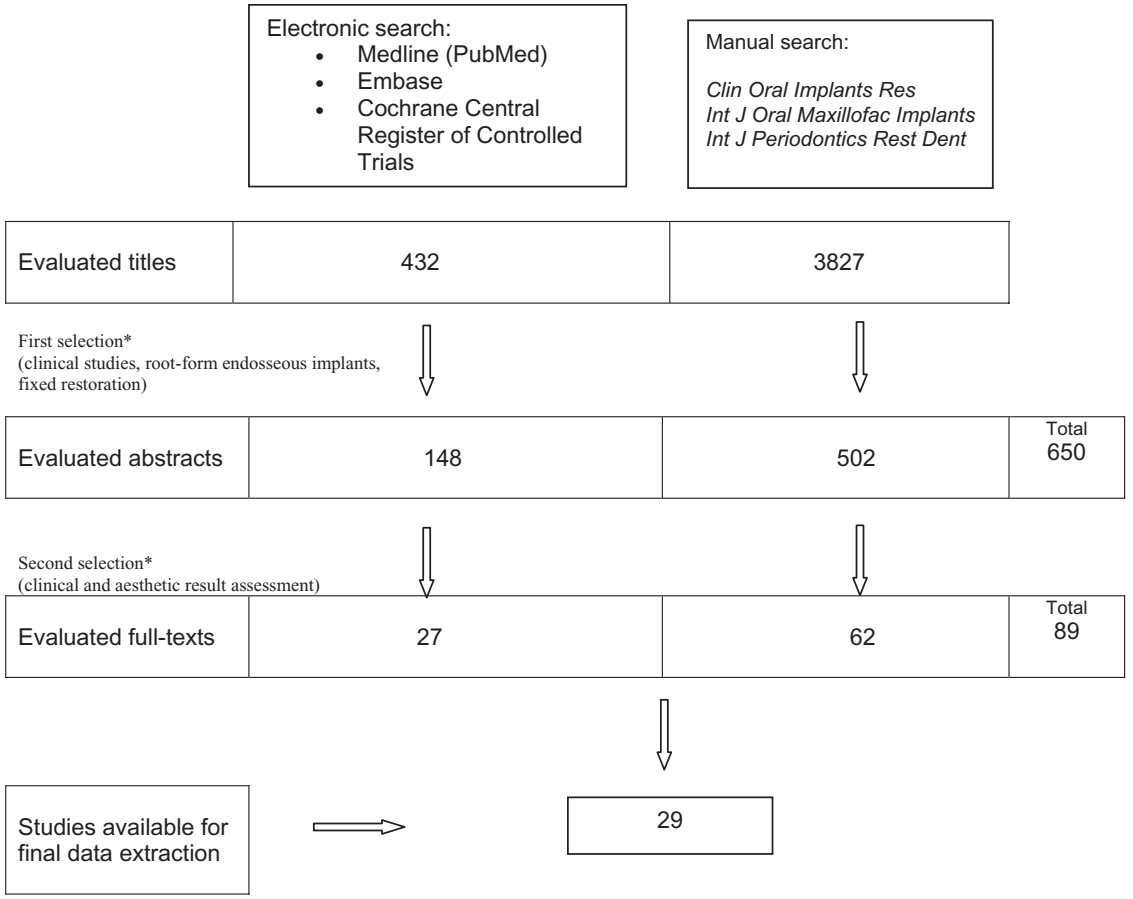

Figure 1 Screening process used to identify eligible studies.

restored with fixed prostheses, and excluded animal or in vitro studies and those on humans that were not clinical studies. In cases for which the title did not provide enough information, the abstracts and/or the full-text articles were retrieved. All of the articles thus retrieved were assessed independently by two examiners who selected only those in which explicit reference was made to clinical and aesthetic evaluations of the therapy outcome.

A second selection was then made, whereby the full-text versions of 27 studies from the electronic search and 62 from the manual search were acquired. A further search was carried out using the bibliographic references of all of the selected articles and of previously selected relevant review articles.

All of these full-text versions of articles were reanalysed in a double-blind manner by both of the examiners using the following more restrictive inclusion criteria: clinical study, fixed prosthetic implant-supported rehabilitation in the anterior maxillary/mandibular zone, at least 10 implants, at least 6 months of follow-up from the restoration, and analysis of the aesthetic results according to an index already present in literature or newly presented (Figure 1).

The level of scientific evidence of the studies was assessed according to Proskin and colleagues[11] (Table 4). The extraction of data from the studies and the estimation of their validity were performed independently by two reviewers and checked by a third.

TABLE 4 Critical Appraisal of the Evidence[11]

Level of Evidence	Study Type
Fair	Retrospective study
Average	Prospective case study
Good	Prospective study with historical controls
Better	Prospective study with concurrent controls
Best	Double-blind randomized controlled trial
Unknown	None of the above

RESULTS

The search after the first selection produced 650 articles for which the abstract was retrieved and analyzed; 89 were selected for full-text analysis. Of these, 29 fulfilled the inclusion criteria: 10 retrospective case series, 11 prospective case series, 1 prospective controlled clinical trial, 1 retrospective controlled clinical trial, and 6 randomized controlled clinical trials (Table 5). Seven of these 29 studies proposed, and in some cases tested, indices of aesthetic evaluation and were structured in an attempt to standardize the judgment, while the remaining 22 simply used already known indices, sometimes integrating them with other measurements of a purely descriptive nature.

It was possible to extrapolate some useful data from these studies despite the notable existing heterogeneity among the publications with respect to the patients included; the protocol, surgical techniques, and implants used; the measurements of the results; and the period of observation:

1. A systematic aesthetic evaluation of the results of implant therapy is included among the success criteria in the most recent studies (see Table 5) and in those concerning the anterior sectors of the superior maxilla, with particular reference to the conventional single implant (Figure 2).
2. To date, the most frequently used index is the Papilla Index of Jemt,[39] which is often used in combination with other indices or integrated with further measurements (Figure 3).
3. The methodological rigor of the study design is not correlated with either the selected index or its validation (Figure 4); not all the authors analyzed the reliability of the used index according to the same methodology (Figure 5).

DISCUSSION

Analysis of the literature has revealed that the aesthetic result is rarely included among the success criteria for implant therapy, although there is an increasing tendency to do so in the most recent studies, and especially in those that deal with implant-supported rehabilitation in the maxillary anterior areas. It has not been possible to make any type of meaningful comparison between the data reported in the selected articles because of the heterogeneity of the parameters taken into consideration and the inaccuracy with which the authors have reported the number and the position in the arch of elements that were submitted to evaluation. The only remarkable observation is that, in most studies, the aesthetic appraisal concerned the maxillary frontal implant-supported prosthetic elements (Table 6) because in these cases it is considered to be a key factor of the final result. The importance of the aesthetic appearance in conferring the success (or not) of an implant-supported rehabilitation has induced some investigators to try to make objective judgments using indices that could also act as references to other authors, although it is well known that harmony and beauty are, by definition, subjective. The first author to propose such an index was Jemt,[39] who, in judging the aesthetic result of 25 implant-supported single crowns with a mean follow-up of 18 months, proposed to estimate the degree of filling of the interproximal space by the tooth implant pseudopapilla (Table 7).

The Papilla Index of Jemt is perhaps the first attempt to apply a scientific feature to the aesthetic judgment. In addition, the author has tested the reproducibility of the evaluation by repeating it 11 days later, the second evaluation producing numerical values similar to the first (see Table 6).

However, by considering only a single variable, this index runs the risk of producing misleading results and only a partial judgment. It is not a sensitive tool because it does not consider other possible aesthetic defects, such as the level of the marginal buccal tissues, the surface color and appearance, the convexity of the alveolar process, and the matching of the implant-supported element with the adjoining teeth and its symmetry compared with the homologous contralateral tooth. The index thus lacks specificity, possibly leading to an unsatisfactory aesthetic judgment. Notwithstanding this limitation, Jemt's index is currently the most frequently reported in literature, but even if it seems to be used, it is not so much because it is a suitable tool for making a real and complete judgment – in fact authors often combine or integrate it with other indices or with further measurements (see Figure 3) – but rather because it is the first of its kind and it is easy to apply.

Another system that considers just the interproximal papilla is that proposed by Nordland and Tarnow.[47] The function of this index is to estimate the appearance of the natural teeth; it enables a description of the degree of filling of the interproximal space by the interdental papilla based on three anatomical landmarks: the

TABLE 5 Distribution of the Selected Articles according to Publication Year and Study Design

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Palattella and colleagues[12]												◦ R-CT
Degidi and colleagues[13]												◦ P-CS
HC Lai and colleagues[14]												◦ P-CS
Evans and Chen[15]												•◦◦◦ R-CS
Jemt and colleagues[16]											• R-CS	
Steigmann and colleagues[17]											◦ P-CS	
Noelken and colleagues[18]											◦ P-CS	
Juodzbalys and colleagues[19]											◦◦ P-CS	
Palmer and colleagues[20]											◦ R-CS	
Meijndert and colleagues[21]											◦ RCT	
Hall and colleagues[22]										◦ RCT		
Lindeboom and colleagues[23]										◦ RCT		
Zarone and colleagues[24]										◦ P-CS		
Tae-Ju Oh and colleagues[25]										◦ RCT		
Cardaropoli and colleagues[26]										◦ P-CS		
Cordaro and colleagues[27]										◦ R-CS		
Schropp and colleagues[28]									◦ RCT			
Meijer and colleagues[29]									• R-CS			
Fürhauser and colleagues[30]									• R-CS			
Ryser and colleagues[31]									◦ P-CS			
Cornelini and colleagues[32]									◦ P-CS			
Henriksson and Jemt[33]								◦ P-CCT				
Kan and Rungcharassaeng[34]							◦ P-CS					
Choquet and colleagues[35]					◦ R-CS							
Nemcovsky and colleagues[36]				◦ P-CS								
Kinsel and colleagues[37]				◦ R-CS								
Chang and colleagues[38]			• R-CS									
Jemt[39]	• R-CS		◦ R-CCT									

• = the study uses a newly proposed index; ◦ = the study uses an index drawn from literature; P-CCT = prospective controlled clinical trial; P-CS = prospective case series; R-CCT = retrospective controlled clinical trial; R-CS = retrospective case series; RCT = randomized controlled clinical trial.

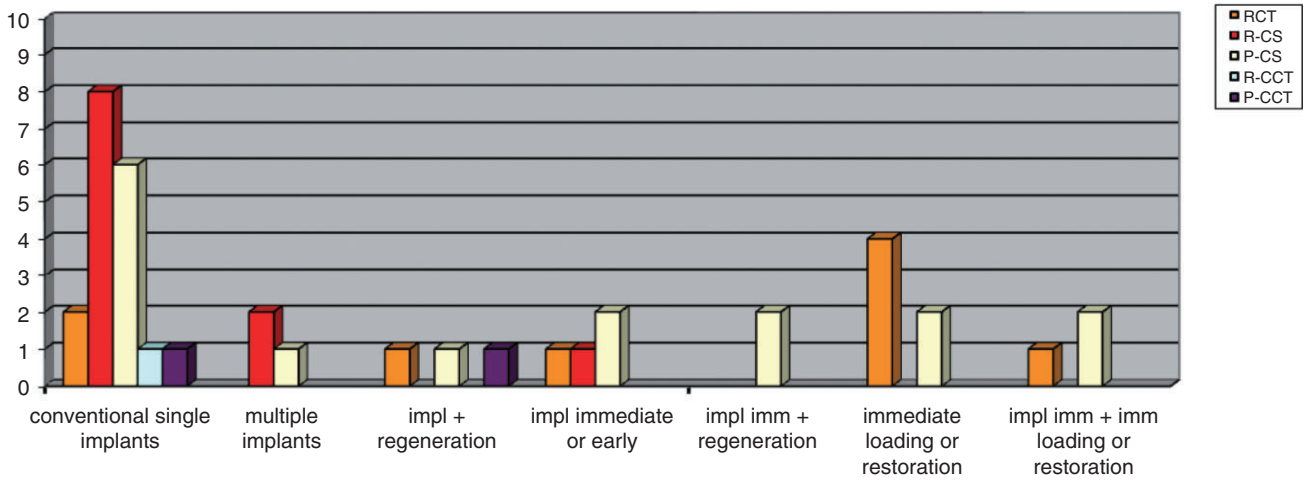

Figure 2 Distribution of selected articles according to clinical treatment and study design. Note: where a study compares different kinds of treatment (e.g., Schropp and colleagues[28]: early vs delayed protocol; Cordaro and colleagues[27]: single vs multiple implants; Oh and colleagues[25]: immediate vs delayed loading; Hall and colleagues[22]: immediate vs conventional loading; Noelken and colleagues[18]: implants conventional, immediate, multiples, with augmentation procedures; Ryser and colleagues[31]: two-stage vs one-stage implants, both with immediate loading; Henriksson and Jemt[33]: conventional single implant and implant with augmentation procedures), it is depicted in the graph wherever the relevant treatment groups are described. x-axis = clinical treatment and study design. y-axis = number of articles. imm = immediate; impl = implant.

interdental contact point, the facial apical extent of the cementoenamel junction (CEJ), and the interproximal coronal extent of the CEJ.

The "Classification system for loss of papillary height"[47] defines the papilla "normal" when it fills the embrasure space to the apical extent of the interdental contact point/area; "Class I" when the tip of the interdental papilla lies between the interdental contact point and the most coronal extent of the interproximal CEJ; "Class II" when it lies at, or apical to, the interproximal CEJ but coronal to the apical extent of the facial CEJ; and "Class III" when it lies level with, or apical to, the facial CEJ.

Nordland and Tarnow's system is not appropriate for implant-supported prosthetic elements, as all three of the anatomical points that are considered can

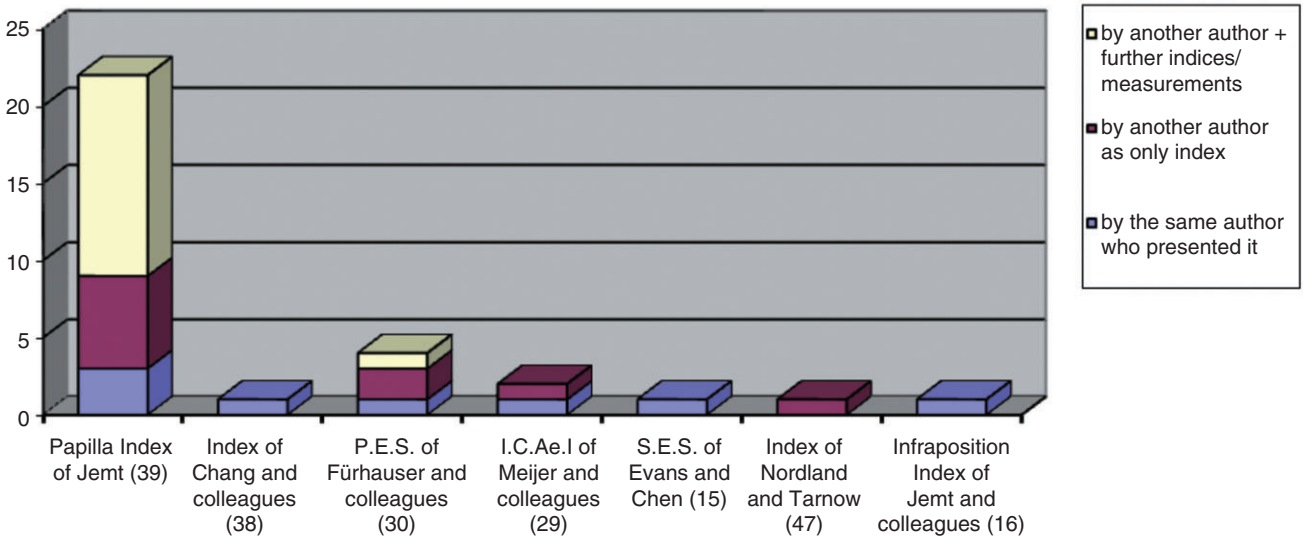

Figure 3 Most frequently adopted aesthetic indices. Note: the index of Meijer and colleagues[29] presented in this graph at first glance appears to also have been used by another author; it was actually used again by the same study group that created it, but the work is published under a different first author. x-axis = used aesthetic indices. y-axis = number of studies. I.C.Ae.I = Implant Crown Aesthetic Index; P.E.S. = Pink Esthetic Score; S.E.S. = Subjective Esthetic Score.

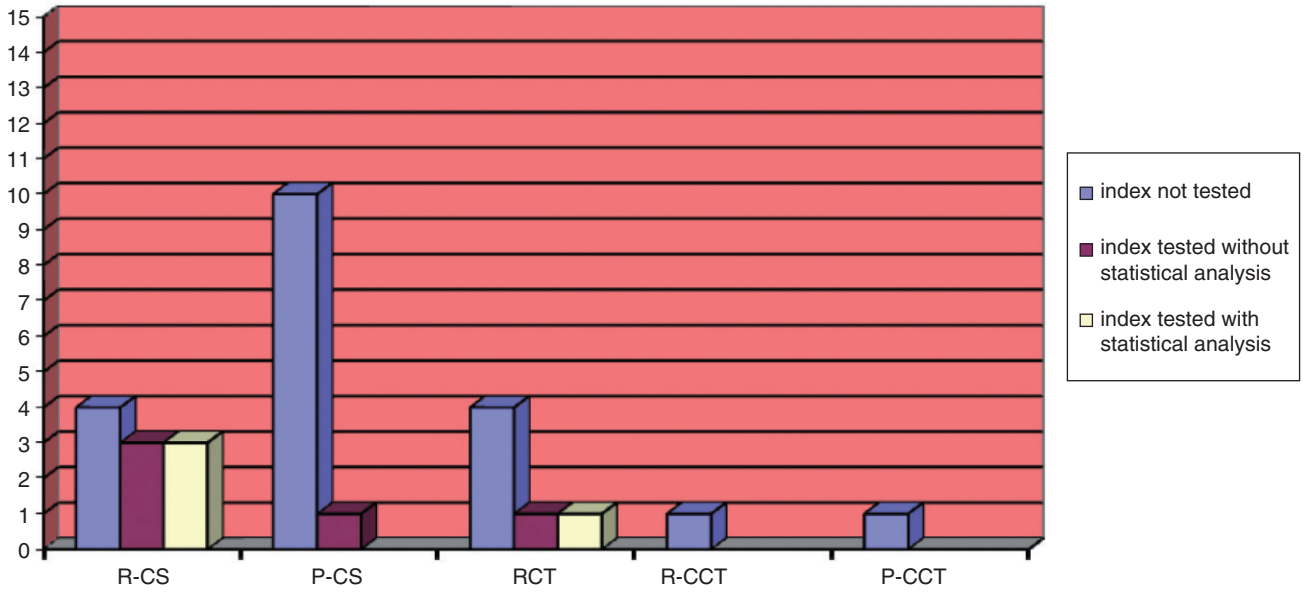

Figure 4 Relationship between study design and method to validate or statistically check the used aesthetic index. x-axis = study design. y-axis = number of studies. P-CCT = prospective controlled clinical trial; P-CS = prospective case series; R-CCT = retrospective controlled clinical trial; R-CS = retrospective case series; RCT = randomized controlled clinical trial.

undergo changes and may no longer be precise reference points. For example, the apical extent of the contact point can be shifted as a result of placement of the prosthetic crown, and the interproximal and facial CEJs are not present in the prosthetic elements, although the line of finish of the prosthetic crown on the abutment could be considered instead. However, Steigmann and colleagues[17] who examined single immediate implants in the anterior maxilla, were able to adopt this index of evaluation of the aesthetic result because they used the natural tooth (just extracted and adequately readapted) as an immediate provisional restoration. As such, they reestablished approximately the three anatomical landmarks – the interdental contact point, the most coronal interproximal CEJ, and the most apical facial CEJ – which could thus be used as reference points for the evaluation of papillary height.

Jemt's index is more suitable for the aesthetic evaluation of implant rehabilitations with regard to the presence and the height of the interproximal papilla. Nevertheless, both the indices consider only the interproximal papilla, while an accurate and reliable method

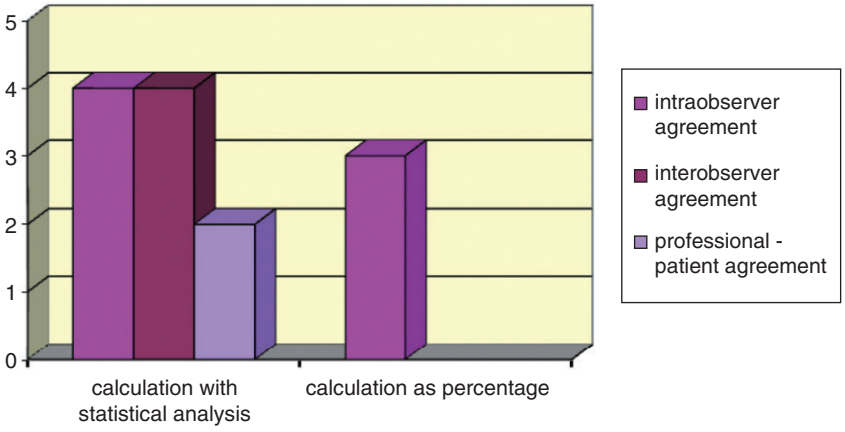

Figure 5 Distribution of articles according to the validation index adopted. Note: Jemt[39] reports differences in the Papilla Index between the first and second assessment as mean and SD values without checking the statistical significance and without information concerning observer number and specialization. x-axis = index-validating method. y-axis = number of studies.

TABLE 6 Characteristics of the Selected Articles

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Jemt IJPRD[39]	R-CS	To propose an index to clinically evaluate the papillae adjacent to single-implant restorations and to test this proposed index	21 patients – 12 ♀ – 9 ♂ mean age = 23.7 years (SD = 7.0 years; range = 14–42 years)	25 implants: (maxilla): – 5 central incisors – 13 lateral incisors – 3 canines – 2 premolars (mandible): – 2 premolars	25 single-implant restorations	Mean follow-up: 1.5 years (SD = 0.6 years)	NR	Newly proposed index: Papilla Index (on photographs) – no. of observers NR – Two evaluations with a time interval of 11 days	NR	Assessments of papillae on two separate occasions; mean difference between the two registrations was 0.11 (SD = 0.53)	Baseline versus follow-up: Sign test for paired comparisons ($p < .05$)
Chang and colleagues COIR[38]	R-CS	To make a comparative evaluation of the crown and soft-tissue dimensions between the implant-supported single tooth and the contralateral natural tooth	20 patients – 7 ♀ – 13 ♂ – mean age = 34 years (range = 18–49 years) – nonrestored contralateral natural tooth	21 implants (maxilla): – 13 central incisors – 6 lateral incisors – 2 canines – 1 first premolar	Implant-supported single crown	Mean follow-up: 38 months (range = 6–89 months) – 12 patients (13 implants): 4 years of follow-up (range = 1–7 years)	Implant survival and success: 100% (by Albrektsson and Isidor[9])	Newly proposed index (clinical assessment) + – Papilla Index (Jemt[39]) (on photographs projected onto a screen; repeated assessments with an interval of 1 month; no. of observers NR)	VAS (0–10) = median value 96% of satisfaction; range = 70 to 100%	To determine methodological error: repeated assessments with an interval of 1 month; scorings identical at 90% of the sites	Differences in clinical variables between implant-supported crowns and contralateral control teeth: (paired *t*-test) Papilla Index (Jemt[39]) score at time of crown placement versus follow-up examination: (Wilcoxon's signed-rank test with $p = .01$)

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Jemt IJPRD[40]	R-CCT	To propose a clinical technique to create gingival papillae and to evaluate the results by means of the Papilla Index[39]	55 patients Test group: 21 patients – 8 ♀ – 13 ♂ mean age = 30.2 years (SD = 14.7 years; range = 17–72 years) – 4 patients received two implants – 17 patients received one implant dropout: 2 patients Control group: 34 patients – 14 ♀ – 20 ♂ mean age = 28.8 years (SD = 9.5 years; range = 16–46 years) – 4 patients received two implants – 30 patients received one implant dropout: 7 patients → 27 patients	63 implants: Test group: 25 implants (maxilla): – 12 central incisors – 11 lateral incisors – 1 canine – 1 premolar Control group: 38 implants (maxilla): – 17 central incisors – 11 lateral incisors – 6 canines – 2 premolars (mandible): – 1 premolar	Implant-supported single crown After second-stage surgery, soft tissue healing with: – provisional resin crown (test) – healing abutment (control)	Baseline = second-stage surgery Follow-up = 2 years later Test group: 22.5 months (SD = 7.5 months) Control group: 21.9 months (SD = 7.0 months)	NR	– Papilla Index[39]) – on photographs – no. of observers NR – One observation (follow-up vs baseline) + MBL	NR	NR	Papilla Index score changes from baseline to follow-up: Sign test for paired comparisons – soft tissue index (test group vs control group): Chi-square test – MBL test group versus control group: Student's *t*-test $p < .05$ = SS*

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Nemcovsky and colleagues J Periodontol[36]	P-CS	To evaluate a surgical approach performed at implant exposure to reconstruct interdental papillae around maxillary implant-supported crowns	32 patients mean age = 46.3 years (SD = 9.43 years, range = 29–65 years)	36 single implants maxilla: – 10 central incisors – 8 lateral incisors – 6 canines – 6 first premolars – 6 second premolars	Single implant exposure by means of a full-thickness buccal flap split in its center and separated in its mesial and distal parts to reconstruct the interdental papillae	Baseline = prior to implant exposure Follow-up = 6 months after implant exposure	NR	Modified Papilla Index[39] by means of imaginary contour of the future implant-supported restoration	NR	NR	– PI at follow-up versus baseline: Paired *t*-test and repeated-measures ANOVA – correlation between PI at follow-up and age: Pearson's correlation test
Kinsel and colleagues JOMI[37]	R-CS	To present a new surgical technique for dental implants placed into edentulous arches and immediately restored: semicircular incisions connected with crestal incisions; crest of the alveolar ridge flattened, leaving osseous peaks to support interdental papillae; after implant insertion, the facial flap is repositioned laterally to reconstruct the interdental papillae	22 patients no further data	– 151 implants – 22 full arch – 14 in the maxilla – 8 in the mandible	Dental implants placed into an edentulous arch and immediately restored with a one-piece fixed prosthesis	NR	Cumulative implant survival = 98% maxilla = 98.1% mandible = 97.9%	Papilla Index (Jemt[39])	NR	NR	NR

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Choquet and colleagues J Periodontol[35]	R-CS	– To characterize bone level and papilla height in relation to contact points adjacent to single-tooth implant-supported restorations – To determine whether a new surgical technique has any influence on the papilla height compared with conventional exposure techniques	26 patients – 18 ♀ – 8 ♂ mean age = 43 years (range = 21–68 years)	27 implants maxilla: – 12 central incisors – 6 lateral incisors – 3 canines – 2 first premolars – 4 second premolars	Implant-supported single crown into maxilla with two-stage surgery: – test group = exposure technique to augment interdental papillae (by Adriaenssens and colleagues[41]) – control group = conventional technique	Baseline = crown insertion Follow-up = 6 months later	NR	Papilla Index (Jemt[39]) Clinical examination + examination of photographic slides taken perpendicular to the buccal surface of the single-tooth restorations; two blind observers	NR	In 10 implants (= 20 papillae) a second set of measurements was performed randomly to evaluate the intraobserver variability (mean difference between first and second assessment: NSS)	NR
Kan and Rungcharassaeng IJPRD[34]	P-CS	To evaluate clinical and aesthetic results of alternate immediate implant placement and provisionalization to preserve gingival architecture	6 patients ♀, mean age = 38.5 years (range = 27–53 years)	14 implants – 10 central incisors – 4 lateral incisors	Implant-supported single crown: alternate immediate implant placement and provisionalization to replace multiple adjacent failing teeth into anterior maxilla	Baseline: before implant treatment Follow-up (mean): 22.6 months (range = 12–34 months) after final implant restoration	Implant success = 100% (criteria NR)	– Papilla Index (Jemt[39]) – gingival recession on photographs and study casts	Subjective evaluation of aesthetic outcome on a scale of 0 to 10 (where 0 = worst)	NR	NR

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Henriksson and Jemt CIDRR[33]	P-CCT	– To measure changes in buccal tissue volume using two different abutment systems – To measure changes in soft tissue volume during the first year of function	18 patients – 15 ♀ – 7 ♂ First group (CeraOne® abutment, Nobel Biocare AB, Göteborg, Sweden): 9 patients mean age = 26.1 years (SD = 4.9; range = 21–36 years) Second group (Procera® abutment, Nobem Biocare AB): 9 patients mean age = 31.1 years (SD = 8.2; range = 18–44 years)	18 implants: maxilla: 18 single central incisors	First group: – bone-grafting procedure – implant insertion – second-stage surgery (healing abutment) – single-crown restoration (porcelain fused to metal crown supported by CeraOne abutment) Second group: – implant insertion – second-stage surgery (healing abutment) – single-crown restoration (all-ceramic crown supported by Procera® custom-made ceramic abutment: crown cemented onto ceramic abutment = 4 patients; crown fused directly onto ceramic abutment and screw-retained = 5 patients)	Baseline: crown placement Follow-up: – 2 weeks – 1 year	Implant survival = 100% Implant success = 100% (no complications)	Papilla Index (Jemt[39]) on photographs (papillae were denoted as present when given an index score of 2 to 4 and absent when given an index score of 0 or 1) + – MBL in relation to FAJ – distance FAJ – marginal bone level of adjacent tooth – vertical distance FAJ – most apical level of contact point – vertical distance between most coronal bone-implant contact and most apical level of contact point – horizontal distance between implant and adjacent tooth at the level of the FAJ on radiographs + changes on buccal tissue volume on study casts placed in an optical three-dimensional scanner	NR	NR	– Changes of volumes between the different stages of treatment: Wilcoxon signed-rank test – Changes of papilla volume (present or not present): chi-square test ($p < .05$ = significant)

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Fürhauser and colleagues COIR[30]	R-CS	– To assess the reproducibility of a newly developed index, the PES, for evaluating soft tissue around a single-tooth implant crown. – To assess the effect of observer specialization.	NR	30 implants maxilla: 15 central incisors 11 lateral incisors 4 first premolars	Implant-supported single crown in anterior maxilla	15 to 143 months	NR	Newly proposed index: PES (on photographs) – 2 assessments with an interval of 4 weeks – 20 observers (5 surgeons + 5 prosthodontists + 5 orthodontists + 5 dental students)	NR	– Mean PES of first evaluation versus mean PES of second evaluation: differences NSS – Mean PES of orthodontists in first evaluation versus mean PES of other observers: differences SS	– Differences between first and second assessment: chi-square test – Effect of observer specialization: ANOVA and Tukey's test ($p < .05$)
Cornelini and colleagues IJPRD[32]	P-CS	To evaluate the clinical result of transmucosal implants into fresh extraction sockets and their immediate restoration with a temporary crown	22 patients – 15 ♀ – 7 ♂ mean age = 39 years	22 implants 19 in maxilla 3 in mandible – 13 premolars – 6 central incisors – 3 lateral incisors	Implant-supported single crown: immediate implant placement and provisionalization (within 24 hours) in anterior maxilla and mandible	Baseline: implant and provisional crown insertion Follow-up: 12 months	Implant success = 100% (criteria NR)	Papilla Index (Jemt[39]) + – PI – Mucositis score (Bengazi and colleagues[42]) – Probing attachment level – Mucosal margin position (from the implant shoulder) – Gingival level (vs adjacent teeth)	NR	NR	NR

TABLE 6 ***Continued***

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Meijer and colleagues COIR[29]	R-CS	To develop and validate an index for rating the aesthetics of implant-supported single crowns	NR	24 implants	Implant-supported single crown in anterior maxilla	NR	NR	Newly proposed index: Implant Crown Aesthetic Index (on photographs) Two assessments with an interval of 2 weeks Four observers (two maxillofacial surgeons + two prosthodontists)	NR	Intraobserver agreement: – surgeons = 67.1 to 84.7% – prosthodontists = 86.1 to 86.6% Interobserver agreement: – surgeons = 74.1% – prosthodontists = 81.5% Interobserver agreement among each of the examiners = 70.4 to 82.4%	Intraobserver and interobserver agreement: Cohen's k

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Schropp and colleagues JOMI[28]	RCT	To evaluate interproximal papillae and clinical crown height following the placement of single tooth implants according to early versus delayed protocols	39 patients – 21 ♀ – 18 ♂ mean age = 49 years (range = 23–76 years)	39 implants maxilla: – 10 central incisors – 5 lateral incisors – 2 canines – 13 premolars mandible: – 1 central incisor – 1 lateral incisor – 7 premolars	Implant-supported single crown – early protocol (3–15 days following tooth extraction) – delayed protocol (3 months following tooth extraction) In anterior maxilla and mandible	Baseline: 1 week after crown placement Follow-up: 16–18 months after crown placement	NR	– Papilla Index (Jemt[39]) on photographs randomly mixed (baseline and follow-up, early and delayed protocol) + – clinical crown height: – too long – too short – appropriate One observer (prosthodontist)	Questionnaire survey: "patients highly satisfied" No other data	Intraobserver agreement between first and second assessment: – 81% mesial papilla – 87% distal papilla – 88% clinical crown	Papilla (Papilla Index; Jemt[39]): – early versus delayed protocol (Mann-Whitney test) – baseline versus follow-up (Wilcoxon's test) Papilla (dichotomized data) using two thresholds: 0 versus all other scores = no papilla 2 versus all other scores = presence of papilla – early versus delayed (chi-square test) – baseline versus follow-up (McNemar's test) Clinical crown height (dichotomized data) 1 and 2 = too long/too short 3 = appropriate – early versus delayed (chi-square test) – baseline versus follow-up (McNemar's)

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Ryser and colleagues JOMFS[31]	P-CS	To evaluate the relationships between papilla dimensions at single-crown implant and: – contact point – vertical and horizontal bone level – one-stage protocol (immediate provisionalization) vs two-stage protocol	41 patients age range = 21 to 65 years First group (two-stage protocol): 25 patients – 14 ♀ – 11 ♂ Second group (one-stage protocol): 16 patients – 14 ♀ – 2 ♂	First group: 25 implants (incisors or canines in maxilla) Second group: Four incisors or canines (maxilla) Two premolars or molars (maxilla) Ten premolars (mandible)	First group: Implant-supported single crown with two-stage protocol Second group: Implant-supported single crown with one-stage protocol and immediate provisionalization	Baseline: final restoration insertion Follow-up: 1 year 2 years	NR	Modified Papilla Index (Jemt[39]): – Score 1 = no papilla – Score 2 = less than 50% filling – Score 3 = over 50% filling – Score 4 = papilla fills the entire interdental space	NR	NR	Relationships between papilla class and vertical/horizontal bone level: – generalized estimating equation (GEE1) Relationships between horizontal and vertical measurements: – frequency, means, univariate procedures for descriptive statistics $p < .05$ = SS*
Cardaropoli and colleagues COIR[26]	P-CS	To evaluate dimensional alterations of the peri-implant tissue at single tooth restorations	11 patients – 1 ♀ – 10 ♂ mean age = 26 years (SD = 6.7 years; range = 18–36 years)	11 implants maxillary incisor tooth region	Implant-supported single crown in anterior maxilla Inclusion criteria: – not restorative treatment of the adjacent teeth – not augmentation procedures	Baseline: crown placement Follow-up 1 year later	NR	Papilla Index (Jemt[39]) + – mucosa thickness (assessed with calibrated ultrasonic device) – soft tissue height (PD) – soft tissue level from occlusal stent to buccal soft tissue margin – mucositis score (Bengazi and colleagues[42]) – height of keratinized mucosa One examiner trained to accuracy and reproducibility	NR	NR	Differences in recorded variables = paired sign test

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Cordaro et al. COIR[27]	R-CS	– To evaluate clinical results of mandibular replacement with narrow-neck implants – To describe hard- and soft tissue response – To report patient's and professional's evaluation of the treatment outcome – To compare three groups of treatment	31 patients First group – 19 patients Second group – 4 patients Third group – 8 patients	44 implants (mandibular incisors) – 20 single crowns supported by single implants – 8 single crowns supported by adjacent implants – 8 fixed prostheses supported by 16 nonadjacent implants	Mandibular incisors replacement with narrow-neck implants First group: single crown Second group: adjacent implants that support single crowns Third group: three- or four-unit fixed prostheses supported by two nonadjacent implants	Baseline: NR Follow-up: mean = 23 months range = 18 to 42 months	Implant survival: 100% Implant success: 94% (by Albrektsson and colleagues[6])	Papilla Index (Jemt[39]) One evaluation Three observers Clinical assessment + Further variables: mPI, BOP, PPD + Two VASs: 1. Aesthetic outcome 2. Possibility to perform good oral hygiene	Seven VASs VAS No. 4: "I am pleased with the aesthetic result" (0–10)	NR	To compare mean values among treatment groups: *t*-test ($p < .05$ = statistically significant) For nominal values (mPI, PI, BOP) to report the distributions of the outcomes in the different groups: cross-tabulations and Pearson's chi-square test ($p < .05$ = significant)

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Zarone et al. COIR[24]	P-CS	To evaluate MBL and peri-implant soft tissues around narrow-neck (ITI®, Straumann AG, Waldenburg, Switzerland) implants in the treatment of agenesis of maxillary lateral incisors	30 patients – 19 ♀ – 11 ♂ Age = 21 to 65 years 26 patients: monolateral agenesis 4 patients: bilateral agenesis	34 narrow-neck implants with conventional implant-prosthetic protocol	Implant-supported single crown to replace agenetic lateral incisors	– 1 month (34 implants) – 6 months (34 implants) – 12 months (33 implants) – 24 months (33 implants) – last follow-up between 24 and 39 months	At the 39-month follow-up: implant survival = 97.6% Implant success: 94.12% (success criteria: MBL, PD, no pain and mobility, peri-implant soft tissue conditions)	– Papilla Index (Jemt[39]) – mean buccal recession Gingival index, PI (Löe[43]) BOP (Esposito and colleagues[44])	NR	NR	To verify the normality of data distribution: Kolmogorov-Smirnov test To evaluate differences in MBL and PD over time: Repeated-measures ANOVA To reveal differences among the different aspects of each implant over time: ANOVA and Tukey's post hoc test The level of significance was set at $p = .05$ for all the statistical tests

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Oh and colleagues J Periodontol[25]	RCT	To examine the soft tissue profile changes of single-tooth implants in the premaxillary region after flapless implant surgery, comparing immediate loading to delayed loading	24 patients 14 ♀ 10 ♂ mean age = 45 years (range = 25–72 years)	24 implants Maxilla: – 18 premolars – 6 incisors	Implant-supported single crowns in anterior maxilla with flapless surgery comparing: 1. immediate loading versus 2. delayed loading (4 months)	Baseline: occlusal loading Follow-up: – 2 months – 4 months – 6 months	Cumulative implant survival: 87.5% – group 1: 75% – group 2: 100% At 6 months follow-up	Papilla Index (Jemt[39]) + Other clinical soft tissue measurements: – ML – PD – mBI – mPI – WKM One calibrated blind examiner	Patient's satisfaction data were collected with regard to: – comfort level – appearance – function by means of four scales: 1 = excellent 2 = good 3 = fair 4 = poor	NR	For nonparametric clinical parameters (e.g., mPI, mBI, and PI): – to analyze differences between groups at a given time point = Mann-Whitney *U* test – to compare a time point with baseline = Wilcoxon's signed-rank test For parametric data (e.g., PD, ML, and WKM): – to compare group 1 with group 2 at a given time point = Student's *t*-test – for comparison between different time points – ANOVA Statistical significance was set at $\alpha = 0.05$

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Hall and colleagues Int J Prosthodont[22]	RCT	To evaluate clinical outcomes of conventional and immediately loaded single implants in the anterior maxilla	28 patients Mean age = 43.25 years (range = 23–71 years) randomly assigned to: test ($n = 14$) control ($n = 14$) Dropout: two control patients and one test patient	28 implants Test group ($n = 14$) (immediate loading) Control group ($n = 14$) (conventional loading)	Implant-supported, screw-retained single crown: 14 (test) immediate loading within 4 hours 14 (control) provisional functional crown at second-stage surgery, after 26-week healing period	Baseline: definitive crown insertion Follow-up: – 4 weeks – 1 year (mean: 54 weeks; range = 45–62 weeks)	Cumulative implant survival: 96.43% – test: 93% – control: 86% Cumulative implant success: 50% test: 57% control: 43% Dropout calculated as not survival, not success	Papilla Index (Jemt[39]) + – peri-implant mucosal response (by Belser and colleagues[45]) + – surgical and prosthodontic outcomes (by Walton[46]) + – MBL	NR	NR	To compare the groups: – paired- and independent-samples *t*-tests – nonparametric tests (e.g., Mann-Whitney *U* test where appropriate) To compare mean plaque indices for each site and combined mean plaque indices at implant, patient, and group levels: – ANOVA To compare categorical measures: – Chi-square test For all the statistical tests the level of significance was set at $p < .05$

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Lindeboom and colleagues JOMS[23]	RCT	To evaluate the clinical outcome of immediately loaded versus immediately provisionalized but nonloaded implants (TPS Biocomp) in the anterior and premolar region of the maxilla	48 patients 31 ♀ 17 ♂ mean age = 42.3 years (SD = 13.1 years, range = 19–78 years) Randomly assigned to: 1. Test group (24 patients) 2. Control group (24 patients)	50 implants Test group (immediate loading) – 14 anterior teeth – 11 premolars Control group (immediate nonloaded provisionalization) – 16 anterior teeth – 9 premolars	Implant-supported single crown in anterior maxilla: Test = immediate restoration Control = nonimmediately loaded restoration 16/25 sites of each group had received buccal bone graft harvested from the mandible 3 months before implant insertion	Baseline: implant and provisional restoration insertion (within 24 hours) Follow-up: 6 months (Implant Stability Quotient assessment as primary outcome) – 12 months MBL as primary outcome; implant success, midbuccal gingival level, papilla level as secondary outcomes	Implant cumulative survival = 90% – test group = 92% – control group = 88% Implant success (by Smith and Zarb[8]) = NR	Papilla Index (Jemt[39]) + – midbuccal gingival level versus outline of adjacent teeth, with differences: – 0 to 1 mm – 1 to 2 mm – 2 to 3 mm – >3 mm	NR	NR	NR

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Meijndert and colleagues COIR[21]	RCT	1. To evaluate the aesthetics of implant-supported single-tooth replacements using different bone-augmentation procedures 2. To compare the patient's opinion with the professional's opinion	93 patients 2 failures Thus, 91 patients to evaluate	93 implants Maxilla: – 62 central incisors – 24 lateral incisors – 2 canines – 5 premolars Three-stage surgery: 1. augmentation procedure 2. implant insertion (3–6 months later) 3. implant exposure (6 months later)	Implant-supported single crown in anterior maxilla after bone-augmentation technique: – chin bone – chin bone + Bio-Gide® (Geistlich Söhne AG, Wolhusen, Switzerland) – Bio-Oss® (Geistlich Söhne AG) + Bio-Gide® Patients randomly allocated to three treatment modality groups that were balanced with regard to age, gender, and position of the missing tooth	12 months	NR	Implant Crown Aesthetic Index (Meijer and colleagues[29])	1 year after placement of the porcelain crown, patient questionnaire of subjective appreciation: – overall satisfaction score (VAS 0–10) – crown score (0–1) – mucosa score (0–1)	The index was validated by the same study group[29] with regard to intraobserver and interobserver agreement Correlation between the professional's index score and the patient's subjective assessment was statistically significant, with $p < .001$ for mucosa score; not statistically significant for overall and crown score	Correlations between results of the Implant Crown Aesthetic Index and the satisfaction questionnaire: Spearman's rank correlation test and linear regression analysis (significant for $p < .05$)

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Palmer and colleagues J Clin Periodontol[20]	R-CS	1. To evaluate patient satisfaction with single-tooth implant restoration 2. To compare the patient's evaluation of the clinician's rating with regard to restoration, soft tissue profile, and radiographic data	66 patients 33 ♀ 33 ♂ age range = 18 to 74 years	66 single implants The authors did not report the position of each missing tooth	Implant-supported single crown in anterior maxilla	Follow-up: At least 12 months after restoration	Implant survival: 100% (criteria NR) Implant success: 100% Success criteria: – in function – free of complications	Papilla Index (Jemt[39]) + Further evaluations (by means of photographs) concerning: – gingival color and contour – crown shade and contour Using the same scale used by the two examiners (clinicians) Two examiners, on photographs	Satisfaction questionnaire concerning: – gingival color and contour – crown shade and contour Using the same scale used by the two examiners (clinicians)	Comparison between clinician's evaluation and patient's satisfaction: differences statistically significant with $p < .001$	Within-subject comparisons: – paired *t*-test/ Wilcoxon's matched-pairs signed-rank test Between-subject comparisons: – two-group *t*-Test/ Mann-Whitney *U* test Statistical significance set at $p < .05$
Steigmann and colleagues IJPRD[17]	P-CS	To describe a new technique that uses the patient's own natural tooth for the provisional implant restoration to manage the soft tissue profile following extraction and immediate implant placement	10 patients mean age = 47.1 years (SD = 10.8 years, range = 35–61 years) 4 ♀ 6 ♂	10 single implants maxilla: – 7 central incisors – 2 lateral incisors – 1 premolar	Immediate implant placement and provisionalization with the patient's own natural tooth in the anterior maxilla	Baseline: implant and provisional restoration insertion Follow-up: – 6 months – 12 months – 24 months	NR	Papilla classification by Nordland and Tarnow[47] + – PPD + – RBL	Satisfaction questionnaire of the overall treatment, with five response choices: 1. very unhappy 2. not happy 3. neutral 4. happy 5. extremely happy	NR	NR

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Juodzbalys and Wang COIR[19]	P-CS	To evaluate clinically and radiographically the success and aesthetic result of immediate implant placement into an extraction socket using simultaneous GBR	12 patients	14 implants maxilla: – 8 central incisors – 6 lateral incisors	Immediate implant placement at the time of extraction in anterior maxilla with simultaneous GBR ± connective tissue grafting	Baseline = implant insertion: – evaluation of distance between implant shoulder and first bone to implant contact First follow-up = implant exposure (after 6 months): same evaluation Second follow-up = prosthesis placement: health and stability of soft tissues: – mPI, mBI (Mombelli and colleagues[48]), PD – stability of hard tissues: DIB m, d; DIP m, d Third follow-up = 1 year after prosthesis placement: same evaluation. + PI and PES	Implant survival: 100% Implant success: 100% (by Albrektsson and colleagues[6]) – stability of soft tissues: mPI, mBI; peri-implant PD – stability of hard tissues: DIB m, d; DIP m, d – Papilla Index (Jemt[39]) – PES (Fürhauser and colleagues[30])	Clinical examination: 1. PES (Fürhauser and colleagues[30]) 2. Papilla Index (Jemt[39]) 3. KMW (assessed in millimeters)	NR	NR	To detect differences between diagnostic (implant placement) and reentry (implant exposure) measurements: Wilcoxon's matched-pairs signed-rank test ($p = .05$)

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Noelken and colleagues IJPRD[18]	P-CS	To evaluate clinical and aesthetic results of the scalloped NobelPerfect (Nobel Biocare AG, Zürich, Switzerland) implant in a one-stage procedure	20 patients – 10 ♀ – 10 ♂ Mean age = 44.9 years (range = 29–69 years) 1 dropout at 3 months	31 implants maxilla: 24 implants (incisors, canines, premolars) mandible: 7 implants (incisors)	Implant-supported single-tooth or multiple-tooth restorations in anterior maxilla and mandible – 21 implants immediate after extraction – 7 implants in healed sites – 3 implants after extended augmentation procedures – 18 implant sites received additional simultaneous bone-grafting procedures (2 GBR, 3 sinus lift, 13 buccal onlay graft, 4 connective tissue graft)	Baseline: implant placement + immediate nonfunctional restoration insertion Follow-up: at least 6 months later Primary outcome variables: – implant success – MBL – PES	Implant success: 96.8 (by Smith and Zarb[8])	PES (Fürhauser and colleagues[30]) One observer not involved in the clinical treatment and blinded to the radiological data and to the initial aesthetic status of the patients	NR	NR	Comparison between subpopulations (single-tooth vs multiple-tooth replacement): – nonparametric *U* test according to Wilcoxon, Mann-Whitney Relationship between MBL and PES: Spearman rank-based correlations

TABLE 6 ***Continued***

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Jemt and colleagues Int J Prosthodont[16]	R-CS	To focus on prevalence and magnitude of tooth movements adjacent to single-implant crowns and relate these changes to cephalometric measurements of the reference group	Study group: 25 patients – 7 ♀ – 18 ♂ mean age = 25.4 years (SD = 10.0) reference group: 134 dental students	Study group: 28 conventional (two-stage surgery) single implants in the anterior maxilla	Study group: single implant crown in the anterior maxilla reference group: cephalometric measurements and study casts	Study group baseline: crown placement follow-up (mean): 15.9 years (SD = 0.74) reference group baseline: first registration (cephalograms and study casts) follow-up: – 10 years (cephalograms and study casts) – 20 years (61 subjects, study casts)	NR	Study group (25 patients) newly proposed index: Vertical Implant Infraposition Index + buccal/palatal tooth movements on photographs + study casts (22 patients) reference group (134 subjects): cephalograms and study casts	NR	Each implant site was evaluated by three of the authors individually; scores not similar (=three cases) consensus carried out by means of discussion	Distributions of vertical score index between genders: – chi-square tests with Yates correction for small samples differences in the cephalometric variables between male and female subjects: – unpaired *t*-test changes of cephalometric data between the two registrations – paired *t*-test for relationships between different cephalometric and study cast parameters, the coefficient of correlation (r) was calculated ($p = .05$)

TABLE 6 ***Continued***

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Evans and Chen COIR[15]	R-CS	To review the aesthetic outcomes of single-tooth immediate implant placement	42 patients – 25 ♀ – 17 ♂ Mean age = 47.9 years (SD = 12.8 years)	42 single-tooth implants maxilla: – 23 central incisors – 9 lateral incisors – 5 canines – 4 premolars mandible: – 1 premolar	Implant-supported single crown in anterior maxilla and mandible; placement of implants at the time of tooth extraction; 3 to 4 months of integration before provisional restoration	Baseline: restoration placement Follow-up: 3 months 6 months 12 months Last follow-up – mean = 18.9 months – range = 6 to 50 months Outcome variables: – implant survival – RBL – aesthetic result	Implant survival: 100% (by Buser and colleagues[50]) – Implant success: NR	– Papilla Index (Jemt[39]) + Newly proposed index Subjective Esthetic Score: – vertical change in the mucosal margin position – labial tissue contour and harmony – buccolingual implant position (Buser and colleagues[50]) – tissue biotype (Muller and colleagues[51]) Clinical assessment and evaluation on photographs and study casts	39 patients expressed satisfaction with the aesthetic outcome No further data	NR	To test differences in means between crown height change and: – implant type – tissue biotype – implant position = descriptive statistics, *t*-test, ANOVA models

TABLE 6 ***Continued***

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Palattella and colleagues COIR[12]	RCT	To compare immediate restoration of implants placed immediately after tooth extraction or 8 weeks later (immediate replacement vs immediate restoration)	16 patients – 10 ♀ – 6 ♂ mean age = 35 years (range = 21–49 years) Test group: 8 patients 6 ♀, 2 ♂ Control group: 8 patients 4 ♀, 4 ♂	18 implants maxilla: – 14 central incisors – 2 lateral incisors – 2 canines Test group (9 implants): 7 central incisors 2 canines Control group (9 implants): 7 central incisors 2 lateral incisors	Implant-supported single crown in anterior maxilla Test group: immediate implant placement and immediate nonfunctional restoration (within 48 hours) Control group: implant placement 8 weeks after extraction and immediate nonfunctional restoration (within 48 hours)	Baseline: provisional crown insertion Follow-up: 2 years Outcome variables: – implant survival – MBL (most coronal bone-implant contact to implant shoulder) – aesthetic result – ISQ at implant placement – ISQ at final restoration	Cumulative implant survival: 100% (at 2 years follow-up for both test and control) Implant success: NR	Papilla Index (Jemt[39]) + Mucosal margin position (most apical gingival margin to implant shoulder) Direct clinical assessment at baseline and follow-up by the same observer	NR	NR	Normal distribution of numeric data (e.g., mean bone resorption and mean change in soft tissue position) = Kolmogorov-Smirnov test To compare means: – Student's *t*-test To compare results between test and control group: – nonparametric Mann-Whitney test For nominal values (eg, PI) = crosstabulations of frequency of distribution and investigation of statistical significance with Pearson chi-square test. Statistical significance set at $p < .05$

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Degidi and colleagues J Periodontol[13]	P-CS	1. To evaluate bone and soft tissue levels in immediately restored single implants in the anterior maxilla and mandible, comparing group 1 with group 2 of treatment 2. To compare clinical results in relation to: – maxilla or mandible – implant position, diameter, length, protocol – patient's smoking status 3. To evaluate the relationship between Papilla Index and the distance between the bone peak and the contact point	45 patients – 35 ♀ – 10 ♂ mean age = 41 years (range = 18–70 years)	52 single implants in anterior maxilla and mandible	Implant-supported single tooth with immediate nonfunctional restoration 1. 37 implants in extraction sockets 2. 15 implants in healed sites	Baseline: implant and immediate restoration placement Follow-ups: – first: 6 months – second: 12 months (definitive functional restoration) – third: 2 years – fourth: 3 years – fifth: 4 to 6 years	NR	– Papilla Index (Jemt[39]) – on photographs – one examiner blind to treatment	NR	NR	Differences between the groups at each follow-up: Student's *t*-test Statistical significance set at $p < .05$

TABLE 6 *Continued*

Reference	Study Design	Study Aim as Described by Authors	Patients	Implants	Treatments	Observation Period	Reported Treatment Outcomes	Aesthetic Evaluation (Index)	Patient's Satisfaction	Index Reliability	Statistical Analysis
Lai and colleagues COIR[14]	P-CS	To evaluate soft tissues around single-tooth implant in anterior maxilla at crown placement and 6 months postloading	29 patients – 16 ♀ – 13 ♂ Mean age = 31 years (range = 17–65 years)	29 implants – 20 central incisors – 6 lateral incisors – 3 canines	Implant-supported single crown in anterior maxilla – conventional implant placement – at least 3 months after extraction – nonsubmerged – no augmentation procedures – nonrestored adjacent teeth	Baseline: 1 hour after crown insertion Follow-up: 6 to 8 months postloading	Implant survival: 100% (Albrektsson and colleagues[6]) Two double-blind observers (orthodontists) Two evaluations (baseline and follow-up) Direct clinical assessment	PES (Fürhauser and colleagues[30]) Two double-blind observers (orthodontists) Two evaluations (baseline and follow-up) Direct clinical assessment	NR	O^1 versus O^2 at baseline = NSS ($p = .217$) O^1 versus O^2 at follow-up = NSS ($p = .778$) $O^1 + O^2$ 2 (mean) At baseline versus follow-up = SS* differences in all single variables and total score except for the alveolar process	O^1 versus O^2 At baseline and follow-up: NSS but statistical test is not reported $O^1 + O^2$ 2 (mean) At baseline versus follow-up: – Wilcoxon's rank-sum test for paired data Statistical significance set at $p = .05$

♀ = male; ♂ = female; ANOVA = analysis of variance; BOP = bleeding on probing; CIDRR = *Clinical Implant Dentistry and Related Research*; COIR = *Clinical Oral Implant Research*; DIB m, d = distance implant – bone mesial, distal; DIP m, d = distance implant – peak mesial, distal; FAJ = fixture/abutment junction; GBR = guided-bone regeneration; IJPRD = *International Journal of Periodontics and Restorative Dentistry*; ISQ = Implant Stability Quotient; JOMFS = *Journal of Oral and Maxillofacial Surgery*; JOMI = *International Journal of Oral and Maxillofacial Implants*; mBI = modified bleeding index; MBL = marginal bone loss; mPI = modified plaque index; NR = not reported; NSS = not statistically significant; O^1 = observer 1; O^2 = observer 2; P-CCT = prospective controlled clinical trial; P–CS = prospective case series; PD = probing depth; PES = Pink Esthetic Score; PI = plaque index; PPD = probing pocket depth; RBL = radiographic bone level; R-CCT = retrospective controlled clinical trial; R-CS = retrospective case series; RCT = randomized controlled clinical trial; SS = statistically significant; VAS = visual analogue scale WKM = width of keratinized mucosa.

TABLE 7 The Papilla Index of Jemt[39]

Index score 0	– no papilla is present – there is no curvature of the soft tissue contour adjacent to the single implant restoration
Index score 1	– less than half of the height of the papilla is present – slight curvature of the soft tissue contour
Index score 2	– atleast half of the height of the papilla is present, but not all – soft tissue contour fairly harmonious
Index score 3	– papilla fills up the entire proximal space – papilla is in good harmony with adjacent soft tissue contour
Index score 4	– papilla is hyperplastic and covers too much of the restoration/adjacent tooth – the soft tissue contour is more or less irregular

of aesthetic analysis should be sensitive to, and specific for, other aesthetical defects based on the evaluation of more variables, each of which could be assessed objectively and quantified.

Attempts have been made by some authors to realize a standardized system of aesthetic evaluation by presenting and testing several new indices. For instance, Chang and colleagues[38] reexamined atleast 6 months after the prosthetic restoration 20 patients treated with an implant-supported single crown in the anterior maxilla. The authors compared the prosthetic element with the restored contralateral tooth and considered numerous parameters concerning the form of the crown, its relationships with the adjacent elements, and the dimensions of the soft tissues (Table 8).

These parameters have been integrated with the recording of the clinical conditions, such as the plaque index, bleeding on probing, and probing pocket depth, and with the subjective evaluation of patient and professional satisfaction, which was recorded on a visual analogue scale (VAS; 0–100% on a 10 cm line).

For example, when compared with the homologous, contralateral, nonrestored tooth, the implant crown may be longer apicocoronally, thinner buccolingually, have thicker buccal tissues into the bottom of the pocket, shorter papillae in the apicocoronal direction, and exhibit a greater degree of gingival inflammation. The aesthetic problems thus noted by the authors were partly attributable to the apical contraction of the soft tissues and its consequences. Interestingly, the subjective evaluation of the patients was more positive (mean value of 96% on the VAS) than that of the professionals and the index had a repeatability of 90% at the second observation, which was carried out 1 month after the first.

TABLE 8 Aesthetic Index of Chang and colleagues[38]

Crown Form		Soft Tissue Dimension	
Clinical crown length	Distance between the soft tissue margin and the incisal edge	Width of keratinized mucosa	Distance between the soft tissue margin and the mucogingival junction
Width of the crown	Widest mesiodistal dimension (±0.5 mm)	Thickness of mucosa	Assessed with an ultrasonic device at the bottom of the pocket (double recordings and mean value)
Faciolingual crown dimension	Distance between facial and lingual aspect of the crown at the soft tissue margin (±0.1 mm)	Soft tissue margin level	Distance between the most apical point of the soft tissue margin at the facial aspect and a line connecting midfacial level of the soft tissue margin at the adjacent teeth
Contact point position	The apical extension of the contact point from the incisal edge (percentage value of the clinical crown length)	Papilla height	Distance between the top of mesial and distal papilla to a line connecting midfacial level of the soft tissue margin of the two adjacent teeth

TABLE 9 Pink Esthetic Score (Fürhauser and colleagues[30])

Variable		Score 0	Score 1	Score 2
Mesial papilla	Shape versus reference tooth	Absent	Incomplete	Complete
Distal papilla	Shape versus reference tooth	Absent	Incomplete	Complete
Level of soft tissue margin	Level versus reference tooth	Major discrepancy (>2 mm)	Minor discrepancy (1–2 mm)	No discrepancy (<1 mm)
Soft tissue contour	Natural matching reference tooth	Unnatural	Fairly natural	Natural
Alveolar process	Alveolar process deficiency	Obvious	Slight	None
Soft tissue colour	Color versus reference tooth	Obvious difference	Moderate difference	No difference
Soft tissue texture	Texture versus reference tooth	Obvious difference	Moderate difference	No difference

Slightly different is the Pink Esthetic Score, which takes into account only the soft tissues and has been used by Fürhauser and colleagues[30] to analyze the aesthetics of 30 implant-supported single crowns in the anterior maxilla. This index not only considers the height of the interproximal papilla, but also the margin and the contour of the soft tissues, their color, the surface, and the convexity of the corresponding alveolar process (Table 9).

Fürhauser and colleagues[30] assessed the reproducibility of the Pink Esthetic Score and examined the impact of the observer's speciality on the judgment. To this end, the aesthetic evaluation was performed on photographs by five orthodontists, five oral surgeons, five prosthodontists, and five students who were asked to compare the implant-supported crown with the adjoining element for the anterior teeth and with the homologous contralateral for the premolars. A score of 0, 1, or 2 could be assigned to each parameter, where 2 represents the most satisfactory situation. The four groups of observers were invited to express their judgment twice, reversing the order of observation on the second occasion. The findings demonstrated the objectivity of this evaluation, because within a homogeneous group of observers (i.e., those with the same speciality), the evaluations were sufficiently uniform; they noticed higher SDs only where the score was "1," and that could be ascribed to the observer's individual sensitivity. The lack of statistically significant differences among the average scores in the first and second observations also demonstrated the reproducibility of the index. However, there were some differences in the evaluations between groups of examiners: the orthodontists were greater critics, while the judgment of the other three groups tended to be similar. Thus, although the index produced highly reproducible results, it was not possible to completely eliminate the influence of the individual, and, in particular, that of the observer's technical and cultural background.

Even more complex and articulated is the "Implant Crown Aesthetic Index" introduced by Meijer and colleagues,[29] which takes into account some of the features of the crown, such as diameter, position of the incisal edge, labial convexity, color, translucency, and surface characteristics, as well as some soft tissue features, such as labial margin position, interdental embrasure filling, labial mucosa contour, color, and surface (Table 10).

The reliability of this index has been tested by examining the degree of intraobserver and interobserver agreement among four professionals (two maxillofacial surgeons and two prosthodontists) who were asked to evaluate the aesthetic result of 24 implant-supported single crowns in the anterior maxilla, with the aid of photographs. The prosthodontists were found to be more reliable and objective observers in comparison with the surgeons because they showed greater interobserver (between the first and second evaluations) and intraobserver agreement (one professional compared with the other). It is likely that the relative competence of these professionals in their daily practice has conferred upon them some superiority with regard to the objectivity and reproducibility of their evaluations. In other words, it is possible to develop a technical ability to make realistic and reproducible aesthetic judgments, learning how to observe and what parameters to focus their attention on.

Meijer and colleagues[29] showed the Implant Crown Aesthetic Index to have a considerable degree of

TABLE 10 Implant Crown Aesthetic Index (Meijer and colleagues[29])

		Penalty = 0	Penalty = 1	Penalty = 5
Crown variables	Mesiodistal dimension	No deviation	Slightly overcontoured/ undercontoured	Grossly overcontoured/ undercontoured
	Incisal edge position	No deviation	Slightly overcontoured/ undercontoured	Grossly overcontoured/ undercontoured
	Labial convexity	No deviation	Slightly overcontoured/ undercontoured	Grossly overcontoured/ undercontoured
	Color and translucency	No mismatch	Slight mismatch	Gross mismatch
	Labial surface characteristics	No mismatch	Slight mismatch	Gross mismatch
Soft tissue variables	Labial margin position	No deviation	Deviation less than 1.5 mm	Deviation of 1.5 mm or more
	Interdental embrasure filling	No deviation	Deviation less than 1.5 mm	Deviation of 1.5 mm or more
	Labial surface contour	No deviation	Slightly overcontoured/ undercontoured	Grossly overcontoured/ undercontoured
	Labial mucosa colour and surface	No mismatch	Slight mismatch	Gross mismatch

0 penalty points = excellent; 1 to 2 penalty points = satisfactory; 3 to 4 penalty points = moderate; 5 or more penalty points = poor.

reliability and suggested that it could be used as a guide to determine a professional's awareness and ability to make coherent judgments. However, it should be noted that with such a structured evaluation, a large discrepancy from the ideal situation for only one particular variable can bring about a negative judgment of "non-satisfactory aesthetics," even when there is a positive judgment as regards the other variables, while small discrepancies, which may add penalty points to the final total, allow the attainment of a satisfactory to moderate aesthetic judgment.

In spite of the risk of severe, uncompromising evaluations, even where there is only one altered variable, the Implant Crown Aesthetic Index shows a good sensitivity, and it is without doubt well structured and complete with regard to the parameters that are taken into consideration.

Jemt and colleagues[16] evaluate on photographs and study casts the tooth movements adjacent to single-implant crown in anterior maxilla during a 15-year follow-up in a study group of 25 patients; they furthermore relate these changes to cephalometric measurements of a reference group of 134 dental students during a 10 to 20-year follow-up.

The aim of the authors was to analyze, in a long-term study, a possible relationship between infraposition of the single-implant restoration and adjacent tooth movements in a palatal/buccal direction in the study group patients and changes of cephalometric parameters – such as increase of anterior face height and posterior rotation of mandible – in the reference group.

The index score is established like the following:

1. *Score A*: no obvious clinical vertical infraposition in relation to marginal edges of the adjacent teeth
2. *Score B*: small, insignificant clinical vertical infraposition less than half a millimeter (<0.5 mm) in relation to the adjacent teeth
3. *Score C*: obvious clinical vertical infraposition, assessed not to exceed 1 mm (≤1 mm) in relation to the adjacent teeth
4. *Score D*: clinically significant vertical implant infraposition, more than 1 mm in relation to the adjacent teeth

Moreover, on photographs and study casts, the authors evaluate the buccal/palatal tooth movements:

1. Adjacent teeth palatal to the implant crown = "P"
2. Adjacent teeth buccal to the implant crown = "B"
3. Stable situation = "S"

This index is different from all the others because it rates an aspect that, although not depending on clinician's therapeutic procedures, is a property that cannot be disregarded to obtain a good, long-term aesthetic result: the correct three-dimensional position of single-implant restoration in relation to adjacent teeth.

The method of judgment used by Evans and Chen[15] to appraise 42 single crowns supported by immediate postextractive implants in the anterior maxillary and

TABLE 11 Variables Conditioning the Reproducibility and the Objectivity of the Observation

Observation Method	Bias	Why
Direct	Objectivity (interobserver) reproducibility (intraobserver)	Influence of the general aesthetic appearance of the face Memory of the previously given opinions
Indirect	Objectivity (interobserver) reproducibility (intraobserver)	Not possible to observe images: – rapidly following one another – randomly mixed – to the same enlargement – from the same angle
Direct Photographs	Objectivity (interobserver)	Observer's technical and cultural background
Direct Photographs (each time repeated)	Reproducibility (intraobserver)	Too much time between observations = possibility of tissues maturation
Direct Photographs	Reproducibility (intraobserver)	Progressive increase in judgment awareness and critical sense

mandibular sectors uses a variety of indices introduced by other authors, such as the Papilla Index of Jemt for the papilla,[39] the index of Buser and colleagues[50] for the buccolingual position of the implant, and the indications given by Müller and colleagues[51] for the tissue biotype; they integrate them with further measurements concerning the crown and soft tissue dimensions – initial crown height, change in crown height, contralateral crown height, distal papilla height, mesial papilla height – and with the "Subjective Esthetic Score" that rates the vertical change in the mucosal margin position and tissue fullness like the following: I = vertical buccal change of 0.5 mm or less and labial tissue fullness in harmony with the adjacent teeth; II = vertical buccal change of between 0.5 and 1 mm, and labial tissue fullness in harmony; III = vertical buccal change of between 1 and 1.5 mm or labial tissue deficient in contour; and IV = vertical buccal change greater than 1.5 mm and deficiency in labial tissue contour.

This method of aesthetics analysis not only appears confusing and fragmentary, comprising a series of different, apparently unconnected evaluation systems, but it is also performed on photographs by one or more nonspecified observers; the authors do not query the reliability of the system.

It has become evident from our examination of the different methods of evaluating aesthetic results presented in the literature that, at present, there is no commonly approved reliable index. Most authors adopt the Papilla Index of Jemt,[39] often integrating it with other measurements, or else they propose new methods that are, in their opinion, more complete, objective, and reproducible.

Fürhauser and colleagues[30] and Meijer and colleagues[29] attempt to objectify their aesthetic judgment, creating a system that achieves reproducibility and lacks, as far as possible, the direct influence of the particular characteristics of each observer. Indeed, when observers do not confine themselves to giving simple measurements,[38] but express an assessment of value on every single variable, the reliability of the index must be subordinate to the reproducibility and objectivity of the judgment. The first must be verified by statistical analysis of the degree of intraobserver agreement, with repeated blind observations, and the second must be validated by statistical elaboration of the degree of interobserver agreement. However, it is necessary to take into account the possible distortion of the assessment because of the observer's technical and cultural background.[30,29]

Nevertheless, the reproducibility of the aesthetic judgment is conditioned by some variables proper of the direct observation, of the observation on photographs, and of both the observation method, that must be considered as possible bias (Table 11).

It appears that the evaluation of photographs, even if it removes some risks specific to direct observation, is inadequate for those variables that require three-dimensional observation, such as the degree of labial convexity, or those that may be influenced by brightness,

contrast, and neatness of the image, such as the superficial appearance and the color of the soft tissues in comparison with the surrounding mucosa.

These latter data cannot be integrated even by the analysis of study casts. However, these are parameters that are particularly prone to observer subjectivity because they are intrinsically not quantifiable, being more a quality, as evidenced by the large SDs recorded on this subject by Fürhauser and colleagues,[30] especially in cases of results that are not distinctively either good or poor.

CONCLUSIONS

It is possible to draw some conclusions from the international literature review performed in this study. The aesthetic result is still not systematically included among the implant therapy success criteria, although a tendency to do so is developing in more recently published articles and especially in those that appraise the implant-supported prosthetic rehabilitations of the maxillary and mandibular anterior sectors.

It has not been possible to identify an aesthetic evaluation index that is commonly approved by clinicians and researchers because the parameters considered are often different between study groups or they are used in various combinations. A common index would be useful not only to assess the success of the therapy as a whole, but also as a valid tool of longitudinal observation of the progressive maturation of the peri-implant soft tissues.[23] It would then be possible to appraise the aesthetics not only in terms of purely descriptive dimensional measurements, but also in terms of a progressive matching of the implant-supported prosthetic restoration with the surrounding tissues.[12–14] The lack of an encoded index that has been approved by the international scientific community represents a spur to search for a method with which to evaluate the aesthetic result that is as far as possible complete, objective, reproducible, reliable, and free from methodological errors (bias).

Finally, there is a need to integrate the professional's "objective" evaluation and the "subjective" evaluation of the patient, the latter harvested by means of satisfaction questionnaires whose answers are quantified on VASs. This would not only establish the degree of agreement or disagreement between the two points of view but would also make the clinician aware of the parameters that would render the implant-supported rehabilitation more aesthetically pleasing in the eyes of the patient.[22]

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