Comparison of Classifications and Indexes for Extraction Socket and Implant Supported Restoration in the Aesthetic Zone: a Systematic Review

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ABSTRACT

Objectives: The primary objective of the present systematic review is to test the hypothesis - the revision of the complexity of the extraction sockets morphology classifications will reveal the most important parameters for implant aesthetic and functional success in case of immediate dental implant placement in aesthetic zone. The secondary objective is to revise the most important parameters of aesthetic indexes created for implant-supported restoration in aesthetic zone.

Material and Methods: MEDLINE (PubMed) and Cochrane Library search in combination with hand-search of relevant journals was conducted including human studies published in English between 1 January 2005 and 1 February 2022. After evaluation of the titles and abstracts in accordance with the PRISMA guidelines, risk-of-bias assessment was evaluated and data was extracted from the full papers.

Results: Electronic and hand searching resulted in 477 entries. Five systematic reviews, research syntheses and 7 prospective studies met the inclusion criteria and were included in the final data synthesis. Selected articles reported the different classifications complexity of the extraction sockets morphology and aesthetic indexes for implant supported restoration in aesthetic zone.

Conclusions: The most important parameters for implant aesthetics and functional success, incorporated in classifications of extraction sockets are facial soft tissue level and quality, gingival biotype, keratinized gingival, mesial and distal papillae appearance, buccal bone level and thickness, labial and buccal bone plates damage and bone lesions. The most important aesthetic indexes parameters are soft tissue contour position, including colour and texture, interdental papilla, mesial and distal interproximal bone height, gingival biotype.

Keywords: bone loss; classification; dental esthetics; dental implant; review literature; tooth socket.

INTRODUCTION

During the initial weeks following tooth extraction, a physiological process of disuse atrophy occurs, marked by an extensive erosion of the alveolar bone and partial invagination of the mucosa. Although the extent and severity of the tissue repair process varies according to unique local and systemic variables, it often results in some level of horizontal and vertical alveolar ridge decrease, primarily in the bucco-coronal region [1]. Traditional implant placement techniques need a period of several months or more for the proper bone regeneration after tooth extraction prior to replacing a dental implant [2]. Recently, the old approach has been progressively supplanted by a quicker protocol that involves immediate placing an implant in a fresh extraction socket and rapidly restoring it. Provisional restorations on a single implant in the aesthetic zone have been advised for achieving a satisfactory soft tissue shape and hard tissue stability [3]. Furthermore, this technique has been associated with a number of potential advantages, including decreased treatment time, fewer surgical operations, less traumatic surgery, and increased patient satisfaction [4].

Nowadays tooth replacement with a single implant-supported restoration is a predictable and successful treatment. However, a strict patient selection and operation planning is necessary [5]. The complex aesthetic region evaluation is critical for the successful outcome and patient's satisfaction regarding the implant-supported restoration in the aesthetic zone. Clinicians must take into account a variety of elements that affect the aesthetic outcome, including tooth position, neighbouring tooth root position, periodontal biotype, tooth form, smile line, implant site anatomy, and implant location. Additionally, the criteria's such as the anatomical confines of the implant site, periodontal health, and occlusal parameters must be evaluated prior to determining the aesthetic aspects of such artificial repair [6-7].

In order to simplify the assessment of the most important soft and hard tissue parameters, several classifications of extraction sockets morphology have been developed. Additionally it can collaborate and acquire information using a global summary of the extraction socket classification system [7]. Bonnet et al. [8] evaluated the effectiveness of immediate implant placement technique in terms of soft tissue contours in aesthetic areas with the use of the pink aesthetic score (PES). The soft tissue around the tooth to be extracted was scored according to the PES before the surgery and at least 1 year after the final prosthesis placement. It is important to note that this index was created for the single implant-supported restoration aesthetic outcome assessment. Consequently, the classification of extraction sockets and aesthetic indexes for the single implant-supported restoration can be a useful tool for successful outcomes and patient satisfaction.

The primary objective of the present systematic review is to test the hypothesis - the revision of the complexity of the extraction sockets morphology classifications will reveal the most important parameters for implant aesthetic and functional success in case of immediate dental implant placement in aesthetic zone. The secondary objective is to revise the most important parameters of aesthetic indexes created for implant-supported restoration in aesthetic zone.

MATERIAL AND METHODS
Protocol and registration

The current systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement for reporting systematic reviews [9].

The local bioethics committee granted approval (No. BCE-OF-90) by the Department of Bioethics, Medical Academy Lithuanian University of Health Sciences, Lithuania.

Focus question

The focus question was developed according to the Patient, Intervention, Comparison, Outcome and Study Design (PICOS) framework as described in Table 1.

The focus question: The revision of the extraction sockets morphology classifications and aesthetic indexes created for implant-supported restoration in aesthetic zone, will reveal the most important parameters for implant aesthetic and functional success and patient satisfaction.

Information sources

Search was undertaken in MEDLINE (PubMed) and Cochrane Library in combination with hand-search of relevant journals was conducted. Due to the desire to discover more socket classifications and aesthetic indexes for comparison, filters were applied ensure that the studies to be included were published between January 2005 to February 2022, and the information sources were in English. Additional related publications were found by manually searching the reference list of the selected articles.

Table 1. PICOS framework of the framed clinical question

Component	Description
Population (P)	Patient undergo immediate dental implant placement and aesthetic outcomes evaluation following an implant-supported restoration in the aesthetic zone
Intervention (I)	Dental implant in the aesthetic zone, with or without extraction socket morphology evaluation before treatment and aesthetic result evaluation after treatment – comparison between the classifications' and indexes' parameters. The most important parameters identification
Comparison (C)	Implant aesthetic and functional failure\success
Outcome (O)	Implant aesthetic and functional success and patient satisfaction
Study design	Systematic reviews, research syntheses and prospective clinical studies

Search

A thorough electronic search was carried out according to the PRISMA guidelines to determine the relevant studies [9]. The primary search inquiries used were: ["Dental Implant" OR "Implant failure" OR "immediate implant"] AND ["Implant esthetic" OR "Esthetic zone" OR "Esthetic region" OR "Esthetic indexes"] AND ["extraction socket" OR "socket classification"].

Selection of studies

The titles of the identified reports were independently screened by two reviewers (R.S. and P.D.) based on the inclusion criteria. A third reviewer (G.J.) checked mistyping. The abstract was assessed when the title indicated that the study was relevant. Full-text analysis was obtained for those with obvious relevance. The reviewers compared results and resolved differences through discussion, consulting senior researcher (G.J.) when consensus could not be reached. Reviewers were calibrated and inter-rater reliability Cohen's kappa coefficient (κ) values were calculated for title-abstract screening.

Types of publication

Human studies published in the English language were considered in the review. Letters, editorials, PhD theses, and abstracts were excluded.

Types of studies

The review included all human systematic reviews and research syntheses and prospective cohort studies published between 1 January 2005 and 1 February 2022 that reported on patient's extraction socket morphology evaluation before immediate implantation, as well as aesthetic indexes for implant-supported restoration evaluation, in the aesthetic zone.

Type of population

Patients undergo immediate dental implant placement and aesthetic outcomes evaluation following an implant-supported restoration in the aesthetic zone.

Inclusion criteria

Articles were selected according to the following inclusion criteria:
- Systematic reviews and research syntheses, and controlled prospective clinical studies, retrospective clinical studies.
- Studies published between 1 January 2005 and 1 February 2022.
- Only articles in English language.
- Only human studies.
- Explored extraction socket morphology before immediate dental implant placement operation.
- Investigated aesthetic and functional outcomes evaluation following an implant-supported restoration in the aesthetic zone.

Exclusion criteria

Articles were selected according to the consequent exclusion criteria:
- Publications in languages other than English because the data availability and interpretation was compromised.
- Irrelevant data on the selected topic.
- Studies performed on animals.

Sequential search strategy

Following the preliminary literature search, all article titles were screened to eliminate irrelevant publications. Afterward, studies were excluded based on data obtained from the abstracts. The final stage of screening included reading the full text articles to authorize articles eligibility.

Data extraction

The data was extracted independently from studies in the form of variables, in accordance with the present review's aims and themes that are described below. If the essential data was missing, the corresponding authors were contacted by electronic mail.

Data items

Following items were collected and arranged in the following fields:

- "Authors" and "Year of publication" - revealed the author and the publication year.
- "Type of articles" - describes the design of the study.
- "Soft tissue parameters" - describes soft tissue related to extraction sockets and aesthetic indexes.
- "Hard tissue parameters" - describes the hard tissue related to extraction sockets and aesthetic indexes.
- "Tissue health parameters" - describes the tissue health related to extraction sockets.
- "Prosthetic restoration parameters" - describes the prosthetic restoration related to aesthetic indexes.
- "Prognostic value parameters" - describes the prognostic value related to aesthetic indexes.

Assessment of methodological quality

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Systematic Reviews and Research Syntheses [10] (Table 2) and the JBI Critical Appraisal Checklist for cohort studies [11] (Table 3) were used to assess the procedural quality of the studies that

fulfilled the inclusion criteria.
Methodological quality was categorized as follows: "high risk of bias", when the study scored up to 49% of positive answers; "moderate risk of bias", when study scored between 50 and 69% of positive answers; "low risk of bias", when study reached more than 70% of favourable answers.

Statistical analysis

Zotero 5.0 reference management software (www.zotero.org) was used for articles management. Meta-analysis was not performed due to heterogenic parameters and lack of data for meta-analysis. The level of agreement between the two raters in selecting abstracts and studies were measured using Cohen's kappa coefficient (κ).

RESULTS
Study selection

The database search yielded one paper in the electronic Journal of Oral and Maxillofacial Research that was discovered through a manual search, 107 articles in Cochrane Library and 369 publications in MEDLINE (PubMed) databases. There were selected 10% of publications for Kappa calculation, based on title-abstract analysis. Inter-rater reliability Kappa of 0.84 was achieved. Figure 1 illustrates a summary of the article selection process using the PRISMA flow chart.
There were 44 articles remaining after 433 duplicates were removed. Seventeen articles were excluded due to not relevant titles and abstracts.

Table 2. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Systematic Reviews and Research Syntheses

Q1	Is the review question clearly and explicitly stated?
Q2	Were the inclusion criteria appropriate for the review question?
Q3	Was the search strategy appropriate?
Q4	Were the sources and resources used to search for studies adequate?
Q5	Were the criteria for appraising studies appropriate?
Q6	Was critical appraisal conducted by two or more reviewers independently?
Q7	Were there methods to minimize errors in data extraction?
Q8	Were the methods used to combine studies appropriate?
Q9	Was the likelihood of publication bias assessed?
Q10	Were recommendations for policy and/or practice supported by the reported data?
Q11	Were the specific directives for new research appropriate?

Table 3. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Cohort Studies

| Q1	Were the two groups similar and recruited from the same population?
Q2	Were the exposures measured similarly to assign people to both exposed and unexposed groups?
Q3	Was the exposure measured in a valid and reliable way?
Q4	Were confounding factors identified?
Q5	Were strategies to deal with confounding factors stated?
Q6	Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?
Q7	Were the outcomes measured in a valid and reliable way?
Q8	Was the follow up time reported and sufficient to be long enough for outcomes to occur?
Q9	Was follow up complete, and if not, were the reasons to loss to follow up described and explored?
Q10	Were strategies to address incomplete follow up utilized?
Q11	Was appropriate statistical analysis used?
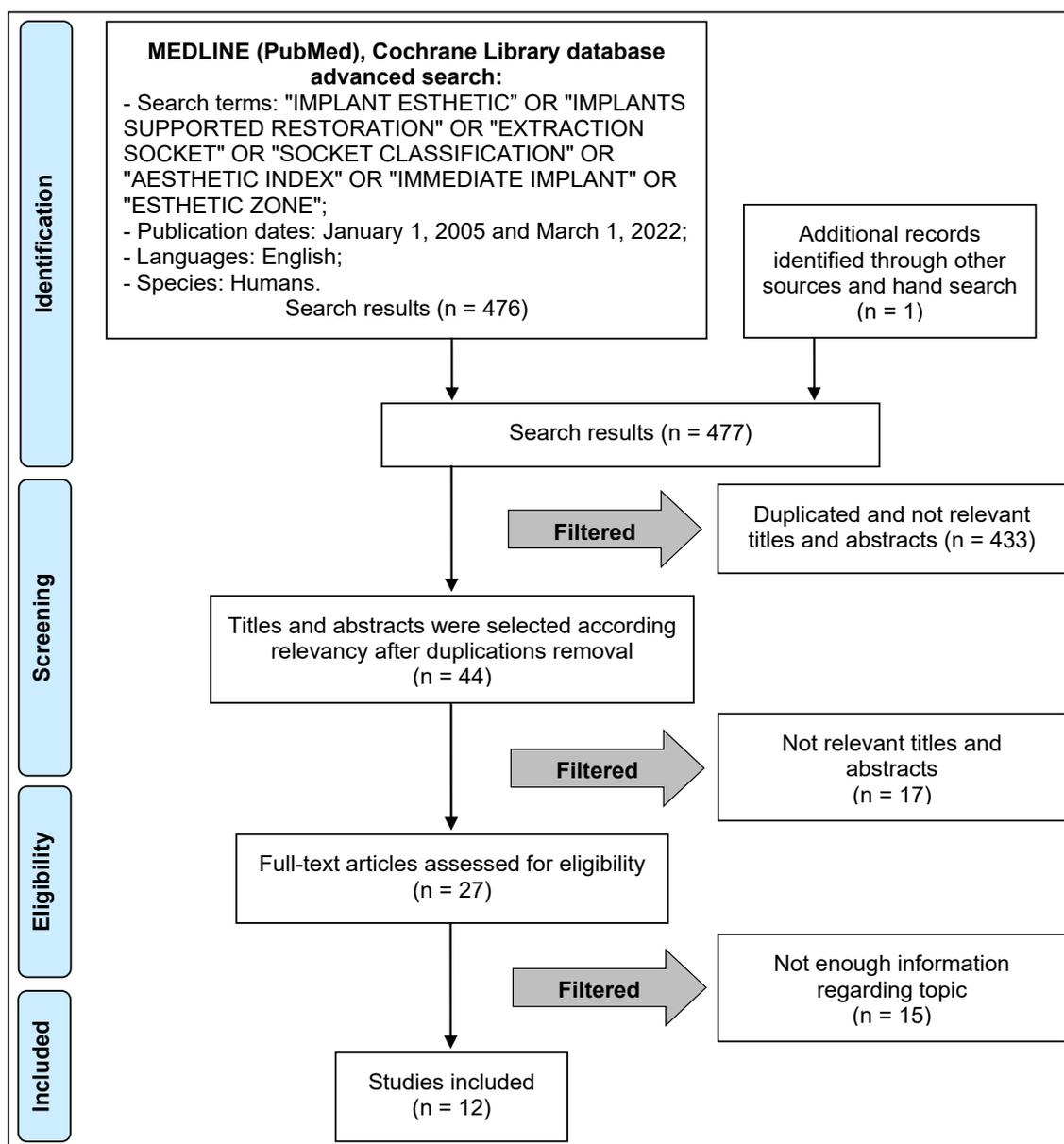
Figure 1. Flow diagram of studies selection according PRISMA guidelines.

Next 15 full-text articles [1-6,12-20] were excluded because they did not fulfil the inclusion requirements. Therefore, this scientific literature review evaluated 12 articles (Figure 1).

Risk of bias assessment

The JBI Critical Appraisal Checklist for systematic reviews and research syntheses [10] and the JBI Critical Appraisal Checklist for cohort studies [11] were used to assess the procedural quality of the studies that fulfilled the inclusion criteria.
The results on risk of bias assessment of systematic reviews and research syntheses are summarized in Tables 2 and 4. The results on risk of bias assessment of cohort studies are summarised in Tables 3 and 5. All of the systematic reviews, research syntheses,

and prospective studies in this systematic review have high quality and a low probability of bias, with methods that do not include addressing incomplete follow-up.

Characteristics of the studies included

The studies included in this review compared the extraction socket classifications and aesthetic indexes for implant-supported restoration in the aesthetic zone. Five systematic reviews and research syntheses [21-25] and seven prospective studies [7,26-31] were included for the final review. The analysis included 537 patients in all prospective studies. All studies included in this review were published during the last 17 years, written in the English language and performed only on humans.

Table 4. Results of systematic reviews and research syntheses from The JBI Critical Appraisal Checklist

Study	Year of publication	Study design	Checklist											Total (% score yes)	Methodological quality
			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11		
Caplanis et al. [21]	2005	Review	+	+	+	+	+	+	+	+	+	+	+	100	High
Elian et al. [22]	2007	Review	+	+	+	+	+	+	?	+	+	+	+	90	High
Chu et al. [23]	2015	Review	+	+	+	+	+	+	+	+	+	+	+	100	High
El Chaar et al. [24]	2016	Review	+	+	+	+	+	+	+	+	+	+	+	100	High
Steigmann et al. [25]	2022	Review	+	+	+	+	+	+	+	+	+	+	+	100	High

? = unclear; + = yes; - = no.

Table 5. Results of cohort studies from The JBI Critical Appraisal Checklist

Study	Year of publication	Study design	Checklist											Total (% score yes)	Methodological quality
			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11		
Juodzbalys and Wang [2]	2010	Prospective	+	+	+	+	+	+	+	+	+	-	+	90	High
Juodzbalys et al. [26]	2008	Prospective	+	+	+	+	+	+	+	+	+	-	+	90	High
Kim et al. [27]	2021	Prospective	+	+	+	+	+	+	+	+	+	-	+	90	High
Meijer et al. [28]	2005	Prospective	+	+	+	+	+	+	+	+	+	+	+	100	High
Belser et al. [29]	2009	Prospective	+	+	+	+	+	+	+	+	+	-	+	90	High
Hosseini and Gotfredsen. [30]	2011	Prospective	+	+	+	+	+	+	+	+	+	-	+	90	High
Tettamanti et al. [31]	2015	Prospective	+	+	+	+	+	+	+	+	+	-	+	90	High

? = unclear; + = yes; - = no.

Synthesis of results

Tables 6 and 7 presents systematization of data of included studies. Table 6 represents the classifications of extraction sockets based on soft and hard tissue parameters in the aesthetic zone. By this study, all the classifications are referring to soft and hard tissues parameters but only two [26,27] are referring to tissue health as well.

DISCUSSION

Present systematic literature review hypothesizes that the revision of the complexity of the extraction sockets morphology classifications and aesthetic indexes created for implant-supported restoration in the aesthetic zone evaluation, will reveal the most important parameters for implant aesthetic and functional success.

Extraction socket classifications

All extraction socket classifications are designed for the evaluation of soft and hard tissues immediately after tooth extraction, as bone or soft tissue damage may occur during the surgical procedure. Clinical visual evaluation and the use of a periodontal probe can provide an objective evaluation of the tissues of the extraction socket. The presence and location of bony structures have an effect on the soft-tissue shapes. On the other hand, new evidence suggests that peri-implant soft tissues are essential for maintaining peri-implant health [32].

Soft tissue

One of the most important parameters of soft tissue is the facial soft tissue and its variations. All authors of the extraction socket classifications [21-24,26,27] except of Steigmann et al. [25] distinguished this parameter. Some socket classifications describe soft tissue variations as "soft tissue level" [22], "buccal soft tissue deficiency" [23], "vertical soft tissue deficiency" [26] or "soft tissue damage" [27]. In general vertical soft tissue deficiency is vertical distance between the socket and adjacent teeth's buccal mucosa tissues margin [26]. For defects bigger than 2 mm, Kazor et al. [33] is recommending soft tissue augmentation prior to implant insertion.

Juodzbalys et al. [26] distinguishes in his classification more detailed soft tissue parameters, such as soft tissue contour, the keratinized gingival width, mesial and distal papillae appearance and soft tissue quality. Soft tissue contour variations are characterized as vertical distance between the socket and adjacent teeth's buccal gingival scallop margin.

Table 6. Characteristics of included studies – extraction sockets morphology and health

Study	Soft tissue parameters	Hard tissue parameters	Tissue health parameters
Caplanis et al. [21]	Periodontal biotype	Affected socket walls, amount of bone loss, distance between alveolar crest and dentino-enamel junction	None
Elian et al. [22]	Facial soft tissue level	Buccal bone level	None
Chu et al. [23]	Buccal soft tissue deficiency	Buccal bone plate level	None
El Chaar et al. [24]	Soft tissue biotype	Buccal plate loss, periapical bone topography, interproximal bone level	None
Steigmann et al. [25]	None	-Buccal bone intact thickness; -Buccal bone fenestration; -Buccal bone dehiscence compared with dehiscence height	None
Juodzbalys et al. [26]	-Soft tissue contour; -Vertical soft tissue deficiency; -Keratinized gingival; -Mesial and distal papillae; -Gingival biotype; -Soft tissue quality - colour, consistency, and contour	-Alveolar process height; -Labial plate vertical position; -Facial bone thickness; -Intra dental bone peak height; -Adjacent teeth mesio-distal distance; -Palatal angulation; -Available bone beyond the apex of extraction socket	Bone lesions
Kim et al. [27]	Soft tissue damage	-Bony walls resorption; -Buccal plate or the palatal/lingual plate; -Buccal and palatal/lingual walls; -Hard tissue damage	Bone defect configuration and pathology

Table 7. Characteristics of included studies - aesthetic indexes

Study	Soft tissue parameters	Hard tissue parameters	Prosthetic restoration parameters	Prognostic value parameters
Juodzbalys and Wang [2]	**CEI: S index:** -Soft tissue contour variations; -Soft tissue vertical deficiency; -Soft tissue colour and texture variations; -Mesial papillae appearance; -Distal papillae appearance	None	**R index:** -Colour and translucency; -Labial convexity in the abutment/ implant junction; -Implant/crown incisal edge position; -Crown width/length ratio; -Surface roughness and ridges	**P index:** -Mesial interproximal bone height; -Distal interproximal bone height; -Gingival tissue biotype; -Implant apico-coronal position; -Horizontal contour deficiency
Meijer et al. [28]	-Labial margin; -Papillae; -Contour of the labial surface; -Colour and surface	None	-Width; -Length; -Labial convexity; -Colour/translucency; -Surface; -Mesio-distal dimension; -Position of the incisal edge	None
Belser et al. [29]	**PES:** -Mesial papilla; -Distal papilla; -Alveolar process; -Soft-tissue texture; -Contour; -Colour; -Level of the soft tissue margin	None	**WES:** -General tooth form; -Outline of the clinical crown; -Volume of the clinical crown; -Colour and translucency; -Texture; -Characterization	None
Hosseini and Gotfredsen [30]	**CIS:** -Mucosal discoloration; -Mesial papilla; -Distal papilla	None	-Crown morphology; -Crown colour match; -Symmetry/harmony	None
Tettamanti et al. [31]	**PICI:** -Papillae; -Zenith; -Root convexity	None	-Shape; -Colour; -Characterization	None

S = soft-tissue index; PES = pink aesthetic score; CEI = complex aesthetic index; PICI = peri-implant and crown index; WES = white aesthetic score; R index = restoration index; P index = predictive index.

The soft tissue contour closely mimics that of adjacent natural teeth and is critical in achieving a final aesthetic restoration [33]. Juodzbalys et al. [26] indicated a defect threshold of 2 mm when soft tissue plastic is already recommended. The keratinized gingival width on the mid-buccal side of the socket helps close-fitting tissue adaptation and provides a connective tissue circumferential fibre system that resists mechanical stress [34]. A mean KG width ≥ 2 mm is optimal for an aesthetic restoration [26]. Mesial and distal papillae appearance is the most challenging aspect of getting an excellent aesthetic outcome is maintaining a soft-tissue shape with intact papillae [12]. Maintaining a space of no more than 6 mm between the contact point and the alveolar crest next to the implant has been proved to be required for obtaining an unbroken papilla [35]. Treatments for a missing papilla caused by a lack of vertical bone are extremely difficult to conduct. Soft tissue quality: pink colour and firm consistency with a normal contour Juodzbalys et al. [26] classified as adequate quality for optimal aesthetic result achievement.

Another important soft tissue parameter included in most socket classifications is the gingival biotype [21,24,26]. It is evident that thick and thin tissues respond to regenerative procedures or inflammation is different [36]. Juodzbalys et al. [26] gingival tissue biotype characterized by fibrotic gingival thickness as thick (≥ 2 mm), moderate (≥ 1 to < 2 mm), or thin (< 1 mm). Numerous clinical studies have shown that a thick biotype allows for better aesthetic and functional results [37-39].

A broad biotype is seen as advantageous, particularly in terms of gingival recession, the most prevalent cosmetic issue linked with dental implants. A thin biotype with decreased tissue density and ragged gingival structure is the least appealing. This biotype may necessitate gingival biotype improvement, such as connective tissue transplant [12].

For everlasting harmonious gingival borders, the elevation and density of facial bone are critical. Thus, before placing an implant, the quality and amount of facial bone should be examined. Gingival recession occurs when an implant is placed in an area with a facial bone deficiency.

Hard tissue

When assessing the condition of hard tissue, all classifications distinguish one essential parameter - "buccal bone plate level" or "labial plate vertical position" [21-27]. This parameter can be characterized as the distance between the tip of the extraction socket labial plate and the cementoenamel junction of the adjacent teeth. The more distant the position of the alveolus bony margin to the soft tissues, the greater the risk for gingival recession [40]. The significant or complete loss of the buccal bone plate could be one of the contraindications for placing the implant immediately after tooth extraction [41]. If the distance between the tip of the extraction socket labial plate and the cementoenamel junction of the adjacent teeth is > 3 to < 7 mm, a guided bone regeneration procedure often is required [26].

Facial bone thickness is the next important parameter included in most socket classifications [25,26,27]. To maintain the implant soft tissue profile and to ensure implant aesthetics, a minimal labial plate width of 2 mm is needed. A thinner labial plate increases the risk of bone resorption during the healing period [42]. It suggests the importance of CBCT acquisition before any immediate implant placement. Alveolar buccal plates were also found to be thinner than lingual plates in many cases, and this was likewise linked to greater resorption in immediate implantation. Therefore, the resorption pattern showed that always the buccal portion of the alveolar process will be resorbed first and the axis of alveolar process is changing the angle [17,18].

Two authors highlighted buccal bone "defects" [25] or "lesions" [26]. Juodzbalys et al. [26] mentioned that periodontal and traumatic bone lesions often jeopardize the success of immediate implant procedures. In implant sites, hard-tissue defects include intra-alveolar, dehiscence, fenestration, horizontal ridge, and vertical ridge flaws. If patient lose a tooth or have an infection in the root canal or a fracture in the bone in the area where the sinus floor meets maxilla prior to getting an implant, clinician need to address these issues before getting an implant. A compromised extraction socket buccal angulation is defined as 5° to 30° [26]. When deciding where to place implants in the past, it was generally based on the amount of bone accessible. To ensure that the dental implant is placed in the correct position following a thorough prosthetic planning, bone augmentation techniques are employed nowadays. Because of advances in the production of bone replacements and more information regarding guided tissue regeneration treatments, implant placement has become prosthetically driven. Advanced reconstructive surgery, on the other hand, raises the possibility of problems and a loss of aesthetic appeal. As a result, attempts have been undertaken to perform non-invasive treatment of bone abnormalities in order to avoid complicated treatments [12].

Reduced alveolar bone breadth and iatrogenic fracture of the alveolus, which may occur before or during

tooth extraction, are further causes of additional bone resorption. Pathology resulting from any infective process, including as periodontal and endodontic abscesses, cysts, and tumours, are further local issues to consider. The growth of fibrous tissue in the injured regions may increase the rate and type of resorption, preventing normal healing and osseous regeneration [5].

Prognostic value

Dentists have come to believe that endosseous osseointegrated dental implants are a benign and regular method of replacing missing teeth. Implant dentistry's early focus was on osseointegration, and that focus remains the most important criteria of success in the field today. As a result, new criteria are increasingly being employed to evaluate implant success due to patient and clinician needs and the improved confidence of osseointegration. Peri-implant soft-tissue level, prosthesis level, and patient subjective judgments are examples of these criteria. Implant dentistry's success or failure should be evaluated using these characteristics. Modern patients expect not just better function but also a normal look from their medical treatments. It is critical for implants placed in the aesthetic zone to consider aesthetics while planning their location [12].

Juodzbalys and Wang [7] explained that because all of these elements affect their long-term aesthetic stability, it is obvious that clinicians should study all soft and hard tissue characteristics and prosthetic components when considering aesthetics. The parameters included in aesthetic index proposed by Juodzbalys and Wang [7] are as follows: mesial and distal interproximal bone height, gingival tissue biotype, implant apico-coronal position and horizontal contour deficiency. It is important the relationship between bone level and interproximal bone height and aesthetics of peri-implant soft tissue. It is obvious that the bone should support soft tissue papillae. While the thick tissue biotype exhibited less peri-implant soft tissue recession, Chen et al. [19] found that there was a significant difference between the two. Additionally, buccal shoulder implants location had three times the amount of recession as implants with the same position in the lingual/palatal region [7].

Aesthetic indexes

All aesthetic indexes parameters are evaluated after dental implant osseointegration, soft tissue maturation and final prosthetic treatment. Although some parameters of periimplant tissues are similar to

the evaluation parameters of the extraction socket, they cannot be interpreted in the same way. Soft tissue parameters in both cases can be evaluated visually and using periodontal probe. In contrast, for bone dimensions assessment X-ray methods are used to assess implant treatment outcome [7].

There should be a harmonious relationship between the peri-implant soft tissues and the neighbouring tooth mucosa, and a well-integrated crown on the implant. A number of researchers have proposed objective measures for peri-implant aesthetic outcome. The most important parameters included in all aesthetic indexes covering only aspects of mucosal appearance, are the length of the interdental papillae and the soft tissue contour variations and appearance [7,28-31]. Although superstructure is as important as mucosa in determining the quality of prosthesis repair, it should also be considered in terms of mucosal appearance [15].

An aesthetic index that is often used is the pink and white score. The PES was developed by Belser et al. [29] to assess seven soft tissue features surrounding single-tooth implant crowns. The suggested index white aesthetic score (WES) encompassed the overall tooth shape, contour and size of the clinical crown, colour, and translucency [29].

Restoring a lost tooth with implants has become a common and reliable procedure. Modern implant dentistry uses implant rehabilitation to help patients regain lost phonetic and masticatory function as well as to improve their smile structural and aesthetic appeal. Restorations supported by dental implants are designed to resemble natural teeth as closely as possible. Implant-supported restorations also need to match the neighbouring teeth symmetrically. For implant rehabilitation to be successful, the following are regarded essential: appropriate bone volume, good implant positioning, stable and healthy peri-implant soft tissues, and an aesthetically pleasing soft tissue shape. Implant dentistry has just recently begun to develop quantitative methods for evaluating aesthetic outcomes [7].

For example, Meijer et al. [28] proposed aesthetic index rating soft tissue labial margin, papillae, contour of the labial surface, colour and surface. The rate of the prosthetic crown by: width, length, labial convexity, colour/translucency, surface, mesio-distal dimension and position of the incisal edge. Belser et al. [29] proposed the PES snd WES score that was described before. Juodzbalys and Wang [7] in order to rate the appearance of anterior maxillary implant-supported restorations and the soft and hard tissues around them, introduced the complex aesthetic index (CEI) for these restorations. The three factors of this aesthetic index

are: the soft tissue index (S), predictive index (P), and implant-supported restoration index (R). Variations in soft tissue shape, vertical deficit, colour and texture, and the presence of mesial and distal papillae are all examples of soft tissue features. Primary components examined by the P include: interproximal bone height in the mesial and distal regions, gingival tissue biotype, implant apico-coronal location, and lack of horizontal contour. R components include: an evaluation of implant-supported restoration colour and transparency, labial convexity at the abutment/implant junction, the implant/crown incisal edge position, the crown width/length ratio, the surface roughness and ridges in relation to the neighbouring and contralateral teeth [7]. The results demonstrated that the CEI could accurately predict eventual implant aesthetic values by including both soft and hard tissue assessments. For complicated and prognostic evaluation, the CEI index is the best choice. Hosseini and Gotfredsen [30] proposed the Copenhagen index score (CIS) index scoring 6 parameters: distal papilla, mesial papilla, mucosal discoloration, colour match, crown morphology and symmetry/harmony. Recently Tettamanti et al. [31] proposed the peri-implant and crown index (PICI) based on: papillae, zenith, root convexity, shape, colour and characterization.

CONCLUSIONS

1. The existing classifications of extraction sockets in the aesthetic zone are based on different number of soft and hard tissue parameters assessment. In addition, only two classifications [26,27] assess tissue health.

2. The existing aesthetic indexes developed for implant supported restoration in aesthetic zone are evaluating wide range of implant supported single-tooth implant crown and adjacent soft and hard tissues parameters. Only one aesthetic index [7] displays the prognostic value of long-term stability of aesthetics.

3. The most important parameters for implant aesthetics and functional success, incorporated in classifications of extraction sockets are facial soft tissue level and quality, gingival biotype, keratinized gingival, mesial and distal papillae appearance, buccal bone level and thickness, labial and buccal bone plates damage and bone lesions. The most important aesthetic indexes parameters are soft tissue contour position, including colour and texture, interdental papilla, mesial and distal interproximal bone height, gingival biotype.

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REFERENCES

1. Avila-Ortiz G, Chambrone L, Vignoletti F. Effect of alveolar ridge preservation interventions following tooth extraction: A systematic review and meta-analysis. J Clin Periodontol. 2019 Jun;46 Suppl 21:195-223. [Medline: 30623987] [doi: 10.1111/jcpe.13057]

2. Blanco J, Carral C, Argibay O, Liñares A. Implant placement in fresh extraction sockets. Periodontol 2000. 2019 Feb;79(1):151-167. [Medline: 30892772] [doi: 10.1111/prd.12253]

3. Weigl P, Strangio A. The impact of immediately placed and restored single-tooth implants on hard and soft tissues in the anterior maxilla. Eur J Oral Implantol. 2016;9 Suppl 1:S89-106. [Medline: 27314114]

4. Meng HW, Chien EY, Chien HH. Immediate Implant Placement and Provisionalization in the Esthetic Zone: A 6.5-Year Follow-Up and Literature Review. Case Rep Dent. 2021 Sep 15;2021:4290193. [Medline: 34567810] [PMC free article: 8457954] [doi: 10.1155/2021/4290193]

5. Juodzbalys G, Stumbras A, Goyushov S, Duruel O, Tözüm TF. Morphological Classification of Extraction Sockets and Clinical Decision Tree for Socket Preservation/Augmentation after Tooth Extraction: a Systematic Review. J Oral Maxillofac Res. 2019 Sep 5;10(3):e3. [Medline: 31620265] [PMC free article: 6788426] [doi: 10.5037/jomr.2019.10303]

6. Juodzbalys G, Wang HL. Soft and hard tissue assessment of immediate implant placement: a case series. Clin Oral Implants Res. 2007 Apr;18(2):237-43. [Medline: 17348889] [doi: 10.1111/j.1600-0501.2006.01312.x]

7. Juodzbalys G, Wang HL. Esthetic index for anterior maxillary implant-supported restorations. J Periodontol. 2010 Jan;81(1):34-42. [Medline: 20059415] [doi: 10.1902/jop.2009.090385]

8. Bonnet F, Karouni M, Antoun H. Esthetic evaluation of periimplant soft tissue of immediate single-implant placement and provisionalization in the anterior maxilla. Int J Esthet Dent. 2018;13(3):378-392. [Medline: 30073219]

9. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009 Jul 21;6(7):e1000097. [Medline: 19621072] [PMC free article: 2707599] [doi: 10.1371/journal.pmed.1000097]

10. Aromataris E, Fernandez R, Godfrey C, Holly C, Khalil H, Tungpunkom P. Chapter 10: Umbrella Reviews. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis. JBI, 2020. [doi: 10.46658/JBIMES-20-01]

11. Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Lisy K, Qureshi R, Mattis P, Mu P. Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis. JBI, 2020. [doi: 10.46658/JBIMES-20-01]

12. Fuentealba R, Jofré J. Esthetic failure in implant dentistry. Dent Clin North Am. 2015 Jan;59(1):227-46. [Medline: 25434568] [doi: 10.1016/j.cden.2014.08.006]

13. Nordland WP, Tarnow DP. A classification system for loss of papillary height. J Periodontol. 1998 Oct;69(10):1124-6. [Medline: 9802711] [doi: 10.1902/jop.1998.69.10.1124]

14. Délben JA, Goiato MC, Gennari-Filho H, Gonçalves Assunção W, Dos Santos DM. Esthetics in implant-supported prostheses: a literature review. J Oral Implantol. 2012 Dec;38(6):718-22. [Medline: 22066512] [doi: 10.1563/AAID-JOI-D-11-00086]

15. Stefanini M, Felice P, Mazzotti C, Mounssif I, Marzadori M, Zucchelli G. Esthetic evaluation and patient-centered outcomes in single-tooth implant rehabilitation in the esthetic area. Periodontol 2000. 2018 Jun;77(1):150-164. [Medline: 29493024] [doi: 10.1111/prd.12215]

16. Hämmerle CHF, Tarnow D. The etiology of hard- and soft-tissue deficiencies at dental implants: A narrative review. J Periodontol. 2018 Jun;89 Suppl 1:S291-S303. [Medline: 29926950] [doi: 10.1002/JPER.16-0810]

17. Araújo MG, Wennström JL, Lindhe J. Modeling of the buccal and lingual bone walls of fresh extraction sites following implant installation. Clin Oral Implants Res. 2006 Dec;17(6):606-14. [Medline: 17092217] [doi: 10.1111/j.1600-0501.2006.01315.x]

18. Araújo MG, Sukekava F, Wennström JL, Lindhe J. Tissue modeling following implant placement in fresh extraction sockets. Clin Oral Implants Res. 2006 Dec;17(6):615-24. [Medline: 17092218] [doi: 10.1111/j.1600-0501.2006.01317.x]

19. Chen ST, Darby IB, Reynolds EC. A prospective clinical study of non-submerged immediate implants: clinical outcomes and esthetic results. Clin Oral Implants Res. 2007 Oct;18(5):552-62. [Medline: 17608739] [doi: 10.1111/j.1600-0501.2007.01388.x]

20. Fürhauser R, Florescu D, Benesch T, Haas R, Mailath G, Watzek G. Evaluation of soft tissue around single-tooth implant crowns: the pink esthetic score. Clin Oral Implants Res. 2005 Dec;16(6):639-44. [Medline: 16307569] [doi: 10.1111/j.1600-0501.2005.01193.x]

21. Caplanis N, Lozada JL, Kan JY. Extraction defect assessment, classification, and management. J Calif Dent Assoc. 2005 Nov;33(11):853-63. [Medline: 16463907]

22. Elian N, Cho SC, Froum S, Smith RB, Tarnow DP. A simplified socket classification and repair technique. Pract Proced Aesthet Dent. 2007 Mar;19(2):99-104; quiz 106. [Medline: 17491484]

23. Chu SJ, Sarnachiaro GO, Hochman MN, Tarnow DP. Subclassification and Clinical Management of Extraction Sockets with Labial Dentoalveolar Dehiscence Defects. Compend Contin Educ Dent. 2015 Jul-Aug;36(7):516, 518-20, 522 passim. [Medline: 26247445]

24. El Chaar E, Oshman S, Fallah Abed P. Single-Rooted Extraction Sockets: Classification and Treatment Protocol. Compend Contin Educ Dent. 2016 Sep;37(8):537-541;quiz542. [Medline: 27608197]

25. Steigmann L, Di Gianfilippo R, Steigmann M, Wang HL. Classification Based on Extraction Socket Buccal Bone Morphology and Related Treatment Decision Tree. Materials (Basel). 2022 Jan 19;15(3):733. [Medline: 35160679] [PMC free article: 8836467] [doi: 10.3390/ma15030733]

26. Juodzbalys G, Sakavicius D, Wang HL. Classification of extraction sockets based upon soft and hard tissue components. J Periodontol. 2008 Mar;79(3):413-24. [Medline: 18315423] [doi: 10.1902/jop.2008.070397]

27. Kim JJ, Ben Amara H, Chung I, Koo KT. Compromised extraction sockets: a new classification and prevalence involving both soft and hard tissue loss. J Periodontal Implant Sci. 2021 Apr;51(2):100-113. [Medline: 33913633] [PMC free article: 8090797] [doi: 10.5051/jpis.2005120256]

28. Meijer HJ, Stellingsma K, Meijndert L, Raghoebar GM. A new index for rating aesthetics of implant-supported single crowns and adjacent soft tissues--the Implant Crown Aesthetic Index. Clin Oral Implants Res. 2005 Dec;16(6):645-9. [Medline: 16307570] [doi: 10.1111/j.1600-0501.2005.01128.x]

29. Belser UC, Grütter L, Vailati F, Bornstein MM, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: a cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores. J Periodontol. 2009 Jan;80(1):140-51. [Medline: 19228100] [doi: 10.1902/jop.2009.080435]

30. Hosseini M, Gotfredsen K. A feasible, aesthetic quality evaluation of implant-supported single crowns: an analysis of validity and reliability. Clin Oral Implants Res. 2012 Apr;23(4):453-8. [Medline: 21443589] [doi: 10.1111/j.1600-0501.2011.02162.x]

31. Tettamanti S, Millen C, Gavric J, Buser D, Belser UC, Brägger U, Wittneben JG. Esthetic Evaluation of Implant Crowns and Peri-Implant Soft Tissue in the Anterior Maxilla: Comparison and Reproducibility of Three Different Indices. Clin Implant Dent Relat Res. 2016 Jun;18(3):517-26. [Medline: 25727214] [doi: 10.1111/cid.12306]

32. Brito C, Tenenbaum HC, Wong BK, Schmitt C, Nogueira-Filho G. Is keratinized mucosa indispensable to maintain peri-implant health? A systematic review of the literature. J Biomed Mater Res B Appl Biomater. 2014 Apr;102(3):643-50. [Medline: 24124021] [doi: 10.1002/jbm.b.33042]

33. Kazor CE, Al-Shammari K, Sarment DP, Misch CE, Wang HL. Implant plastic surgery: a review and rationale. J Oral Implantol. 2004;30(4):240-54. [Medline: 15453224] [doi: 10.1563/0.637.1]

34. Noelken R, Moergel M, Pausch T, Kunkel M, Wagner W. Clinical and esthetic outcome with immediate insertion and provisionalization with or without connective tissue grafting in presence of mucogingival recessions: A retrospective analysis with follow-up between 1 and 8 years. Clin Implant Dent Relat Res. 2018 Jun;20(3):285-293. [Medline: 29575589] [doi: 10.1111/cid.12595]

35. Nordland WP, Tarnow DP. A classification system for loss of papillary height. J Periodontol. 1998 Oct;69(10):1124-6. [Medline: 9802711] [doi: 10.1902/jop.1998.69.10.1124]

36. Seyssens L, De Lat L, Cosyn J. Immediate implant placement with or without connective tissue graft: A systematic review and meta-analysis. J Clin Periodontol. 2021 Feb;48(2):284-301. [Medline: 33125754] [doi: 10.1111/jcpe.13397]

37. Fu JH, Lee A, Wang HL. Influence of tissue biotype on implant esthetics. Int J Oral Maxillofac Implants. 2011 May-Jun;26(3):499-508. [Medline: 21691596]

38. Weigl P, Strangio A. The impact of immediately placed and restored single-tooth implants on hard and soft tissues in the anterior maxilla. Eur J Oral Implantol. 2016;9 Suppl 1:S89-106. [Medline: 27314114]

39. Forna N, Agop-Forna D. Esthetic aspects in implant-prosthetic rehabilitation. Med Pharm Rep. 2019 Dec; 92(Suppl No 3):S6-S13. [Medline: 31989103] [PMC free article: 6978930] [doi: 10.15386/mpr-1515]

40. 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 Apr;17(2):165-71. [Medline: 16584412] [doi: 10.1111/j.1600-0501.2005.01210.x]

41. Garber DA, Salama MA, Salama H. Immediate total tooth replacement. Compend Contin Educ Dent. 2001 Mar;22(3): 210-6, 218. [Medline: 11913258]

42. Cho YB, Moon SJ, Chung CH, Kim HJ. Resorption of labial bone in maxillary anterior implant. J Adv Prosthodont. 2011 Jun;3(2):85-9. [Medline: 21814617] [PMC free article: 3141124] [doi: 10.4047/jap.2011.3.2.85]