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VISEU

IMMEDIATE IMPLANT PLACEMENT IN DAMAGED EXTRACTION SOCKETS: A SYSTEMATIC REVIEW AND META-ANALYSIS OF THE LITERATURE

Por:

Marco Campi

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Orientador: Tiago Gonçalves Ferreira Borges

Coorientador: Bruno Leitão de Almeida

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QUOTE

"Dream on, dream until your dreams come true."

Steven Tyler (Aerosmith).

Acknowledgments

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Abstract

Background: The purpose of this systematic review and meta-analysis was to observe whether the immediate dental implants placement into damaged sockets is a successful modality for the treatment of hopeless teeth.

Materials and Methods: A manual and electronic search was conducted through various databases, (Pubmed, Web Of Science, Scopus and ScienceDirect) to identify various exclusively RCT studies from the last 10 years. This systematic review has been registered on the PROSPERO platform, and the articles identified during the search were selected based on the eligibility criteria. The risk of bias was evaluated using the Cochrane risk-of-bias tool for randomized trials (RoB2).

Results: A total of 626 articles were found, where 5 studies with 135 patients and 138 implants were finally included. In general, the meta-analysis showed homogeneity between the studies, where gender was in balance in the studies, showing more women in the total. The Buccal/Facial Bone thickness showed good results for the experimental group, as did the Pink Esthetic Score (PES) where it also showed favouritism for the Test Group and without statistical significance.

Conclusion: Research suggests that immediate implant placement (IIP), in the presence of buccal bone defects, can offer comparable to traditional methods. Bone regeneration surgery is essential to achieve optimal results.

Keywords: immediate implant placement; fresh sockets; buccal bone defect; compromised extraction sockets

Resumo

Introdução: A finalidade desta revisão sistemática e meta-análise é observar se a colocação de implantes dentários imediatos em alvéolos danificados é uma modalidade de sucesso para o tratamento de dentes sem esperança.

Materiais e Método: Foi realizada uma pesquisa manual e eletrónica através de diferentes bases de dados (Pubmed, Web Of Science, Scopus e ScienceDirect) para identificar vários estudos exclusivamente RCT dos últimos 10 anos, a fim de compreender se a colocação imediata de implantes em alvéolos dentários danificados é um tratamento bem-sucedido. Esta revisão sistemática foi registada na plataforma PROSPERO, e os artigos identificados durante a pesquisa foram seleccionados com base nos critérios de elegibilidade. O risco de viés foi avaliado utilizando a ferramenta Cochrane risk-of-bias para ensaios aleatórios (RoB2).

Resultados: Foi encontrado um total de 626 artigos, onde 5 estudos com 135 pacientes e 138 implantes foram finalmente incluídos. Em geral, a meta-análise mostrou homogeneidade entre os estudos, onde o género estava em equilíbrio nos estudos, mostrando mais mulheres no total. O local do implante teve uma prevalência Incisal com equilíbrio entre os grupos nos vários estudos e a idade tendeu a ser menor no Grupo de Teste. A espessura óssea Buco-facial mostrou favoritismo para o Grupo de Teste, sem significância estatística, assim como o Pink Esthetic Score (PES) onde também mostrou favoritismo para o Grupo de Teste e sem significância estatística.

Conclusão: A investigação sugere que a colocação imediata de implantes (IIP), na presença de defeitos ósseos vestibulares, pode oferecer resultados clínicos e radiológicos comparáveis aos dos métodos tradicionais. A cirurgia de regeneração óssea é essencial para obter resultados óptimos.

Palavras-chave: colocação imediata de implantes; alvéolos frescos; defeito ósseo vestibular; alvéolos de extração comprometidos.

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List of abbreviations and acronyms

IIP: Immediate Implant Placement

CTG: Connective Tissue Grafting

CBCT: Cone-Beam Computer Tomography

ARP: Alveolar Ridge Preservation

GTR: Guided Tissue Regeneration

GBR: Guided Bone Regeneration

MBL: Marginal Bone Loss

BBT: Buccal Bone Thickness

DBBM: Deproteinized Bovine Bone Mineral

IDR: Dento-Alveolar Reconstruction

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCT: Randomized Controlled Trial

PICO: Population, Intervention, Comparison, Outcome

PES: Pink Esthetic Score

SST: Socket Shield Technique

VST: Vestibular Socket Technique

VAS: Visual Analogue Scale

OHIP: Oral Health Impact Profile

1. INTRODUCTION

I. Introduction

I.1. Advancements in Dental Implantology

In the initial twenty-five years following the advent of modern osseointegration-based dental implantology, it was a common practice, to place implants exclusively in long-term edentulous patients, with healed sites. The main objective was to improve the masticatory function and quality of life of these patients. However, in the 1980s, dental implants began to be used even in partially edentulous patients, with positive results published in promising studies. This represented an important step forward in implantology, allowing more patients to benefit from this innovative technique.(1)

In the last years, the number of partially edentulous patients receiving implant treatments has significantly increased. Today, these indications are widely used in daily clinical practice, particularly in the case of replacing a single missing tooth. This development has allowed an ever-increasing number of patients to benefit from this innovative technique, improving their masticatory function and overall quality of life.(1)

To obtain excellent aesthetic results and predictable and innovative implant therapies, it is essential to have an in-depth knowledge of the biological processes underlying the healing of bones and soft tissues after tooth extraction. Previously, studies have concentrated on comprehending the process of osseointegration. Accordingly, a detailed analysis of the topography and surface chemistry of the implant was made to improve its performance. These innovations have led to a significant reduction in healing times, allowing excellent results to be achieved.(2)

Currently, the preferred choice for replacing missing teeth is dental rehabilitation using dental implants, due to their high success rate and excellent long-term prognosis. (3,4) In 1965, Brånemark succeded in placing the first endosteal titanium implant. (3,5,6) In the 1980s, Brånemark provided the first protocol for implant therapy, which required a 5–6 month post-extraction healing period before the implant could be inserted into the alveolar ridge. The main idea of the conventional protocol was that only complete

healing of the hard and soft tissues could ensure optimal osseointegration. The concept of IIP in a fresh socket was first introduced in 1976, followed by the insertion of the first immediate implant in 1989 by Lazzara. (3,5) Presently, the literature describes four different methods for placing implants in edentulous sites (1,7):

- Immediate implant placement (IIP) in fresh extraction sockets(1,8), involves inserting the implant directly after tooth extraction. (1,9)
- Early implant placement , where the implant is placed 1 to 2 months post-extraction. (1,9)
- Delayed implant placement, where the implant is inserted 3-4 months after the tooth has been removed. (1,9)
- Late implant placement, in which the implant is inserted after more than 4 months following tooth extraction. (1,9)

When the treatment choice is IIP, most of the literature suggests that the tooth extraction should take place atraumatically, without elevation of the buccal flap. (10,11) The flapless approach is typically related with a decrease of the volumetric bone changes that occur after tooth extraction and implant insertion. (10) Achieving aesthetically pleasing and predictable outcomes is possible with flapless implant placement in the maxillary anterior region through guided surgery, assuming that the implant positions planned in advance are accurately replicated during surgery. (11) To ensure ideal functionality and aesthetics, implant placement in the dental arch must be biologically accepted and prosthetically guided. (12) Nevertheless, not only the surgical extraction procedure produces an effect on the outcomes of IIP procedures. The previous local anatomic conditions as well as the chosen regenerative procedure to maintain the buccal bone volume, are important features related with the final result of this treatment modality. Based on the topography of the hard and soft tissues, fresh extraction sockets can be divided into several categories:

- **Type I**: The bone socket is undamaged and the shape of the soft tissues is unaltered. (13)
- **Type II**: The coronal portion of the bone socket is intact, whereas the apical region shows a fenestration. The soft tissues are unaffected and unalterated. (13)

- **Type III**: Bone decrease is observed in the coronal portion of the socket, while the soft tissues remain unaffected and unaltered. (13)
- **Type IV**: Bone defects associated with soft tissue deformities are found. In many cases, the severity of this defect prevents the insertion of an implant. (13)

Following tooth extraction, it has been verified that the alveolar bone goes through a remodeling process that occurs horizontally (2,14) and mainly in the vestibular area of the dental crest followed by the emergence of a vertical defect, which has a limited reduction. (2,14) It is generally expected that there will be a reduction of up to 50 percent in the original width of the bone crest. (14,15) Bone resorption is likely to be more pronounced at the vestibular level compared to the lingual/palatal level, and the alveolar bone in the molar regions is expected to undergo a greater reduction. (14) These changes can affect and modify the aesthetic appearance, with the possibility of a vertical recession in the mid-facial or interdental area, a loss of buccal contours in the horizontal dimension, or a difference in color and texture of the surrounding tissues. These modifications in the surrounding hard and soft tissues can be particularly difficult to manage in the anterior part of the jaw, where adequate outcomes are required. Although the literature suggests that placing a dental implant after tooth extraction can partially reduce alveolar bone shrinkage, recent clinical evidence indicates that buccal bone resorption continues to occur both vertically and horizontally.(16)

I.2. Enhancing Dental Implant Success: Factors and Surgical Techniques

According to various studies, there are several factors that can influence the resorption of alveolar bone after IIP. These factors include buccal bone wall thickness, gingival thickness and biotype, the surgical technique used (flap or flapless), the gap between the implant platform and the crestal bone, the coating or surface design of the implant and the size of the space between the implant and the alveolar wall sockets.(16)

Nevertheless, to obtain a reduction in the recession of the mid-facial mucosa and the use of a connective tissue graft has been described at the literature, which can be removed from the region of the tuberosity or from the palate, placing it submucosally in the vestibular area of the implant. Two RCT studies, **Migliorati et al. (2015)** and **Yoshino et al. (2014)**, (17–19) concluded that, by placing a connective tissue graft, there was less vertical loss of the midfacial mucosa after one year, with more stable peri-implant mucosal levels, although these studies provided a limited number of patients.(17)

It is therefore known that the way in which a tooth is extracted affects the amount of alveolar bone loss. (20,21) Conventional methods for extracting teeth, which involve instruments such as luxators and forceps, tend to expand the socket. This can cause fractures or deformities of the interproximal bone, making it difficult in preserving the socket's integrity and harming the surrounding soft tissues, including the interdental papillae. This in turn can affect the correct positioning of the implant and future prosthetic replacement. Furthermore, extracting roots or fractured teeth with the margin benheat the gingival level can be challenging and highlights the importance of safeguarding the surrounding soft tissues during the procedure. Minimizing trauma during the removal of a non-salvageable tooth is essential to preserve the surrounding tissues, which notable influences on the planning of treatments, prognosis and results.(21)

In the scientific field, various atraumatic tooth extraction methods have been cerated to safeguard the integrity of the alveolar bone and surrounding gingival tissues. This allows the dental implant to be positioned appropriately, using instruments such as periotomes, piezotomes, piezoelectric surgery which demonstrated multiple benefits over traditional tooth extraction techniques and implant bed preparation using rotating instruments, (22) and vertical extraction systems. The main objective of these techniques is to minimize trauma during tooth extraction, thus preserving the surrounding tissues. This greatly influences treatment planning, the results achieved, and the long-term prognosis.(21)

Another well described technique is the Socket Shield Technique (SST) which stipulates that the tooth designated for extraction first undergoes a decoronation,

followed by the separation of its root portion along the mesio-distal axis into two sections: one buccal and one palatine. The palatine segment is then removed, preserving only the vestibular portion with the coronal part positioned at or slightly above the height of the vestibular bone ridge, up to a maximum of 1 mm. The vestibular portion is shaped to a concave format, reducing its thickness to 1.5 mm or half of its original vestibular root volume. The implant is subsequently positioned within the residual vestibular root portion or a space is left between the two. Post-operative treatment varies depending on the surgical protocol adopted: the space can be bone grafted or left to heal naturally. (23)

Different implant positioning could then significantly affect the outcome, with immediately positioned implants tending to move frontally compared to the initial drill trajectory. Implants positioned buccally exhibit mucosal recession that is three times greater than that of implants placed in the standard position. (4,24) A slight palatal position is recommended. (4) Tissue phenotype may be associated with the extent of recession after implant placement, with patients with thin mucosal tissue having a greater risk of aesthetic failure after immediate implant placement. (24) To overcome recession, surgical modifications such as connective tissue grafting and flapless surgery have been proposed. The thickness of the buccal plate and the presence of a buccal bone of at least 2 mm thickness are important for the stability of the overlying soft tissues. (4,24) Unpredictable bone remodeling after immediate implantation, especially in cases of buccal wall defect, may contribute to mid-facial soft tissue recession.(24)

To reduce bone resorption following tooth extraction, it is advisable to place the implant a minimum 2 mm palatally to the inner buccal wall of the extraction socket and fill the gap between the implant and the socket with graft material. (25) Regenerative procedures are essential for IIP, and soft tissue stability is closely connected to bone volume support and vascularisation. (26) The bone graft may be positioned within the gap between the implant and the alveolar wall, as well as at the junction of the implant and abutment, to ensure soft tissue support and volume. (26) To minimize recession and volume loss of the mid-buccal mucosa, it is advisable to augment the soft tissues surrounding the implant through connective tissue grafting in conjunction with implant placement, besides filling the space between the implant and the socket. However, as reported in the article of **Fernandes et al. (2023)**, the placement of a connective tissue

graft (CTG) could not completely preserve the original architecture of the peri-implant tissue, although in phenotypes with thin bone, smaller dimensional changes are expected with the use of a CTG. (27) Some studies have shown that connective tissue grafting (CTG) during immediate implantation can lead to better preservation of the mid-buccal mucosa, with a greater increase in mucosal thickness. However, it is important to note that measurement of mid-buccal mucosal volume may not not accurately reflect variations on changes in underlying buccal bone thickness (BBT). (25)

Also, observing the alveolar ridge preservation (ARP) techniques, we can see how they have become increasingly important in the dental field, evolving as a clinically important protocol, given that with their execution, better tissue healing is promoted, thus also decreasing the dimensional change of bone and soft tissues. (15,28) Minimal tissue loss affects the need for any alveolar ridge augmentation during implant placement and simplifies subsequent implant surgical procedures.(28) The ARP therefore, through the use of a bone grafting material, reduces the dimensional alterations that normally and physiologically occur after tooth extraction. (15)

In recent years, numerous methods and grafting materials have emerged for the Alveolar Ridge Preservation (ARP). These include the application of collagen-deproteinized bovine bone mineral (DBBM-C), which has demonstrated efficacy in mitigating alveolar ridge atrophy in damaged and intact extraction sites. (29)

Guided tissue regeneration (GTR) and guided bone regeneration (GBR) therapy have been developed for teeth and dental implants. The researchers have experimented with different surgical techniques and biomaterials, initially focusing on the use of regenerative membranes. Nonetheless, research into bone grafts in periodontal defects prompted researchers to examine how useful membranes combined with bone grafts. (30) Including bone grafting in the buccal space during immediate implant placement is essential for averting vertical bone loss, particularly in cases where the buccal bone wall thickness measures 1 mm or less. (4) Throughout a patient's lifetime, there's a gradual reduction in both the height and width of the alveolar bone, with an estimated yearly resorption rate ranging from 0.5% to 1%. Hence, augmenting bone mass becomes imperative to facilitate dental implant placement in this region and guarantee enduring tissue stability. (20) GBR is now commonly performed as a

combined procedure using membranes and supporting bone substitutes. Demineralized allografts, malleable, rapidly resorbing, and apparently osteoinductive, and mineralized grafts, stiffer, minimally resorbing, and apparently osteoconductive, have been employed by several investigators. (30) Currently, there are several biomaterial options for GBR, including demineralized and mineralized bone grafts, and membranes that vary in their stiffness and degradation properties. Two discordant GBR approaches include the use of cross-linked collagen membranes, with more rigidity and durability, in combination with demineralized grafts, and also the use of non-cross-linked collagen membranes, with more flexibility and durability, in combination with mineralized grafts. A multicenter randomized study was conducted to compare these two techniques in ridge preservation of extraction sockets with significant buccal dehiscences. (30)

It has been proposed to use autologous bone harvested from the tuberosity for its simplicity of acquisition, compared to other sources of autogenous bone, and for its biological characteristics. Distinct from alternative autologous techniques, the Immediate Dento-Alveolar Reconstruction (IDR) technique entails extracting a cortical block from the tuberosity and placing it into the vestibular defect of the implant, where it serves as a bone shield. (31) Described benefits of using autogenous bone grafts are their biological properties which provide a substantial reservoir of cells for bone formation. These grafts are regarded as the prime option in different regenerative dentistry procedures due to their reduced cost and the ability to acquire the graft in an appropriately sized block format, making it easier to reconstruct the alveolar volume and convexity. (31)

However, there are disagreements over this method since the literature suggests using slowly absorbing grafts to mitigate dimensional alterations. For instance, one publication highlights the application of deproteinized bovine bone mineral (DBBM) (31,32) with a collagen barrier was proposed for buccal bone defect regeneration, at the same time as the installation of immediate implants. DBBM has been recognized as one of the primary options for bone reconstruction in various circumstances related to dental implantology. (31,32)

I.3. Immediate Implant Placement: Benefits and Features

Immediate implant placement (IIP) represents a therapeutic methodology introduced in 1976 as an alternative to the traditional delayed implant placement described by Branemark. This innovative approach in the field of dental implants provides several benefits, such as: (33)

- shortened duration of treatment and fewer surgical procedures: IIP makes it possible to shorten the overall treatment time, reducing patient discomfort related to long waits and multiple interventions. (33)
- Increased patient satisfaction: by reducing treatment time and interventions, IIP contributes to increased overall patient satisfaction. (33)
- Immediate implant insertion and immediate restoration are aimed at preserving the peri-implant bone and soft tissue, promoting future osseointegration. This approach is combined with the restoration of a natural peri-implant mucosa, thus ensuring a satisfactory aesthetic result. (34)

The IIP is a viable technique that allows aesthetic recovery in a short time and at the same time decreases the surgery time, greatly shortening the period required for dental restoration. (35)

In addition, IIP has demonstrated that the survival and success rates of implants are comparable to those of implants installed in healed edentulous ridges, confirming the effectiveness of this treatment method. (33)

Amid et al. (2021) also reported that the IIP in freshly extracted sockets is as effective as implants placed in healed ridges, achieving long-term survival rates of approximately 94%. (36)

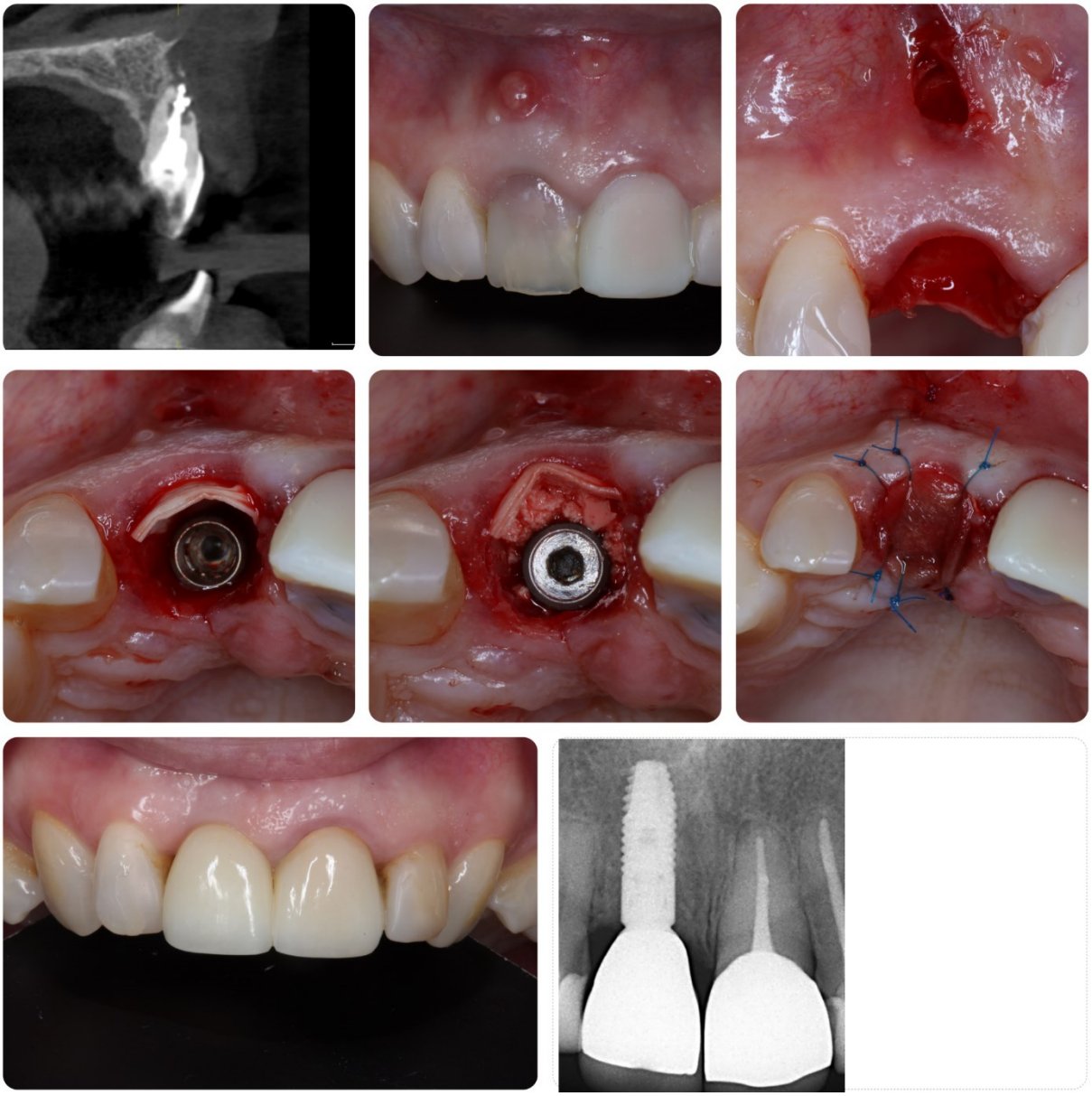
Although hard and soft tissue grafting with delayed implant placement is often recommended after a tooth extraction with a large bone defect, there are several studies that report a favourable aesthetic result from placing immediate implants in post-extraction sockets with bone deficiencies. (37) However, Immediate implant placement can achieve satisfactory soft tissue aesthetic results. (4)

As stated by **Meijer et al. (2018)**, in patients where large bone defects are present in a failed tooth, It was feasible to recreate a buccal bone layer around the implant, which then remained stable after one year of follow-up and, he adds, that there are no notable variations in buccal bone thickness were found between 1 month and 1 year and in individuals with small bone defects or no defects. (37)

A recent solution when IIP to ensure that the contour of the original soft tissue is preserved as much as possible is the customized healing abutments. (32) According to the article by **Fernandes et al. (2021)**, the alterations in peri-implant tissues between the use of xenogenic collagen matrices with customised healing abutments made of PMMA, are compared as a sealing option for a socket. All this during the placement of immediate implants using a flapless approach. The results showed that there was no statistical significance with regard to the dimensional changes of the peri-implant tissue in both groups, so both are predictable solutions for sealing the socket, although tissue volume contraction over time could not be avoided. (32)

However, immediate implant placement continues to be a appealing treatment choice in the aesthetic maxillary area. This approach offers numerous advantages, including a shorter duration of treatment with fewer surgical procedures involved and a high survival rate with superior aesthetic results. Recently, an innovative therapy called vestibular socket therapy (VST) has recently been introduced for immediate implant placement in compromised extraction sockets in the aesthetic zone. This therapy involves augmentation of the socket through a minimally invasive vestibular access tunnel. Finally, VST achieved favorable results on soft and hard tissues.(38)

Illustrative photos for IIP



Photos courtesy of Prof Dr Tiago

I.4. Objective

The objective of this systematic review and meta-analysis, was intended observe whether the immediate dental implant placement into damaged sockets is a effective method for the treatment of hopeless teeth. Also, it was our goal to understand weather the biomaterials used in addition with IIP, are a crucial component for the treatment success.

2. MATERIALS AND METHODS

II. Materials and Methods

II.1. Study and recording protocol:

The systematic review's reporting adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). This systematic review was registered at the Prospero platform under the number CRD42023485453

II.2. PICO question:

The study was conducted utilizing the PICO strategy as its research paradigm. The subsequent research question was developed in conformity with the problem, intervention, comparison, and outcome (PICO) framework:

FOCUS QUESTION: Is the immediate dental implant placement in damaged sockets an effective method for the replacement of hopeless teeth?

Table 1: *The PICO framework.*

Definition	Description
Patient (P)	Patient with a lost tooth with an indication for implant treatment
Intervention (I)	Immediate implant placement
Comparison (C)	A test group with damaged sockets and a control group with undamaged sockets or healed sites
Outcome (O)	Survival rate, Marginal bone level, Buccal bone thickness, Pink Esthetic score (PES), Soft Tissue Assessment.

II.3. Elegibility Criteria

The criteria for inclusion and exclusion defined for this review were as follows:

Inclusion criteria

- Patients over 18 years old.
- Randomized Clinical Trials.
- Need for immediate post-extraction implant.
- Damaged sockets (bone defects, fenestration of buccal bone plate, apical lesion).
- If the extraction sockets were categorized as being damaged.
- Minimum 12 month follow-up considered.
- Assessed using one of the outcomes.

Exclusion criteria

The following criteria were used to exclude studies:

- Case-series, retrospective studies, case-control studies, clinical cases and cohort studies.
- Non-English articles.
- Animal and *in-vitro* studies.
- Studies lacking mention of socket morphology.
- Studies with unclear methodology descriptions.

II.4. Source of information and search strategy

An extensive and in-depth search was carried out by two independent researchers, TB and MC, who conducted a digital search via Google as a search engine, using various electronic databases, namely Pubmed, Web Of Science, Scopus and ScienceDirect. (Table 2)

- **Pubmed:** (immediate implant placement OR fresh sockets OR buccal bone defect OR compromised extraction sockets).
  Restrictions on the search: Publication date: from 2013 to 2023; Article language: English; Text Availability: Free full text, Full text; Article type: Randomized controlled Trial; Species: Humans;

- **Web Of Science:** (ALL=(immediate implant placement OR fresh sockets OR buccal bone defect OR compromised extraction sockets)) AND ALL=(Randomized Controlled Trial).
  Restrictions on the search: Publication date: from 2013 to 2023; Document types: Article; Web of Science Categories: Dentistry Oral Surgery Medicine; Languages: English;

- **Scopus:** (immediate AND implant AND placement OR fresh AND sockets OR buccal AND bone AND defect OR compromised AND extraction AND sockets) AND (randomized AND controlled AND trials).
  Restrictions on the search: Publication date: from 2013 to 2023; Subject area: Limited to Dentistry; Document type: Limited to Article; Keyword: Limited to Human; Language: Limited to English;

- **ScienceDirect:** ((ALL=(immediate implant placement OR fresh sockets OR buccal bone defect OR compromised extraction sockets)) AND ALL=(RCT)) AND ALL=(Randomized Controlled Trial).
  Restrictions on the search: Publication date: from 2013 to 2023; Article type: Research articles; Subject areas: Medicine and Dentistry

KEYWORDS: immediate implant placement; fresh sockets; buccal bone defect; compromised extraction sockets.

Table 2: *Databases and search terms.*

Databases	Keywords and Restrictions
Pubmed	(immediate implant placement OR fresh sockets OR buccal bone defect OR compromised extraction sockets). Restrictions on the search: Publication date: from 2013 to 2023; Article language: English; Text Availability: Free full text, Full text; Article type: Randomized controlled Trial; Species: Humans;
Web Of Science	(ALL=(immediate implant placement OR fresh sockets OR buccal bone defect OR compromised extraction sockets)) AND ALL=(Randomized Controlled Trial). Restrictions on the search: Publication date: from 2013 to 2023; Document types: Article; Web of Science Categories: Dentistry Oral Surgery Medicine; Languages: English;
Scopus	(immediate AND implant AND placement OR fresh AND sockets OR buccal AND bone AND defect OR compromised AND extraction AND sockets) AND (randomized AND controlled AND trials). Restrictions on the search: Publication date: from 2013 to 2023; Subject area: Limited to Dentistry; Document type: Limited to Article; Keyword: Limited to Human; Language: Limited to English;
ScienceDirect	((ALL=(immediate implant placement OR fresh sockets OR buccal bone defect OR compromised extraction sockets)) AND ALL=(RCT)) AND ALL=(Randomized Controlled Trial). Restrictions on the search: Publication date: from 2013 to 2023; Article type: Research articles; Subject areas: Medicine and Dentistry

II.5. Quality assessment

Two reviewers, T.B. and M.C., independently assessed the study's quality. The risk of bias in randomized controlled trials (RCTs) was appraised using the updated Cochrane risk-of-bias tool for randomized trials (RoB2). (39) This tool evaluates several domains: the randomization process, deviation from intended interventions, missing outcome data, outcome measure, and selection of reported outcomes. The color indicates the evaluator’s assessment of the potential

for bias in each analysis. Red signifies a substantial likelihood of bias, yellow denotes an indeterminate likelihood of bias, and green signals a minimal likelihood of bias.

II.6. Meta-analysis

Our objective is to assess the outcomes through a meta-analysis of average differences. In particular, we intend to examine the effects of different variables and compare them across study groups. We will use advanced statistical methods to aggregate data from different studies and obtain an overall effect estimate. All statistical analyses were carried out using Review Manager 5.4 software.

3. RESULTS

III. Results

III.1. Study selection process, PRISMA

Two reviewers, T.B. and M.C., independently conducted the screening. A preliminary electronic search across four databases (PubMed, Web of Science, Scopus, ScienceDirect) revealed the presence of 685 articles. Duplicates and triplicates were removed prior to screening (59). The titles and abstracts of the articles potentially suitable for the study concerning immediate implant placement in damaged extraction sockets were thoroughly examined for eligibility, 610 publications were excluded, resulting in 16 articles, after reading the title and abstract, some also because they did not belong to the area of dentistry. Ultimately, a comprehensive evaluation of the full texts was conducted for the remaining 16 articles. Eleven (11) of these were excluded for the following reasons: (1) incompatibility with the eligibility criteria, (2) not having differentiated the various groups with bone loss, (3) not having specified the tipe of study. Finally, 5 articles were selected for inclusion in the article.

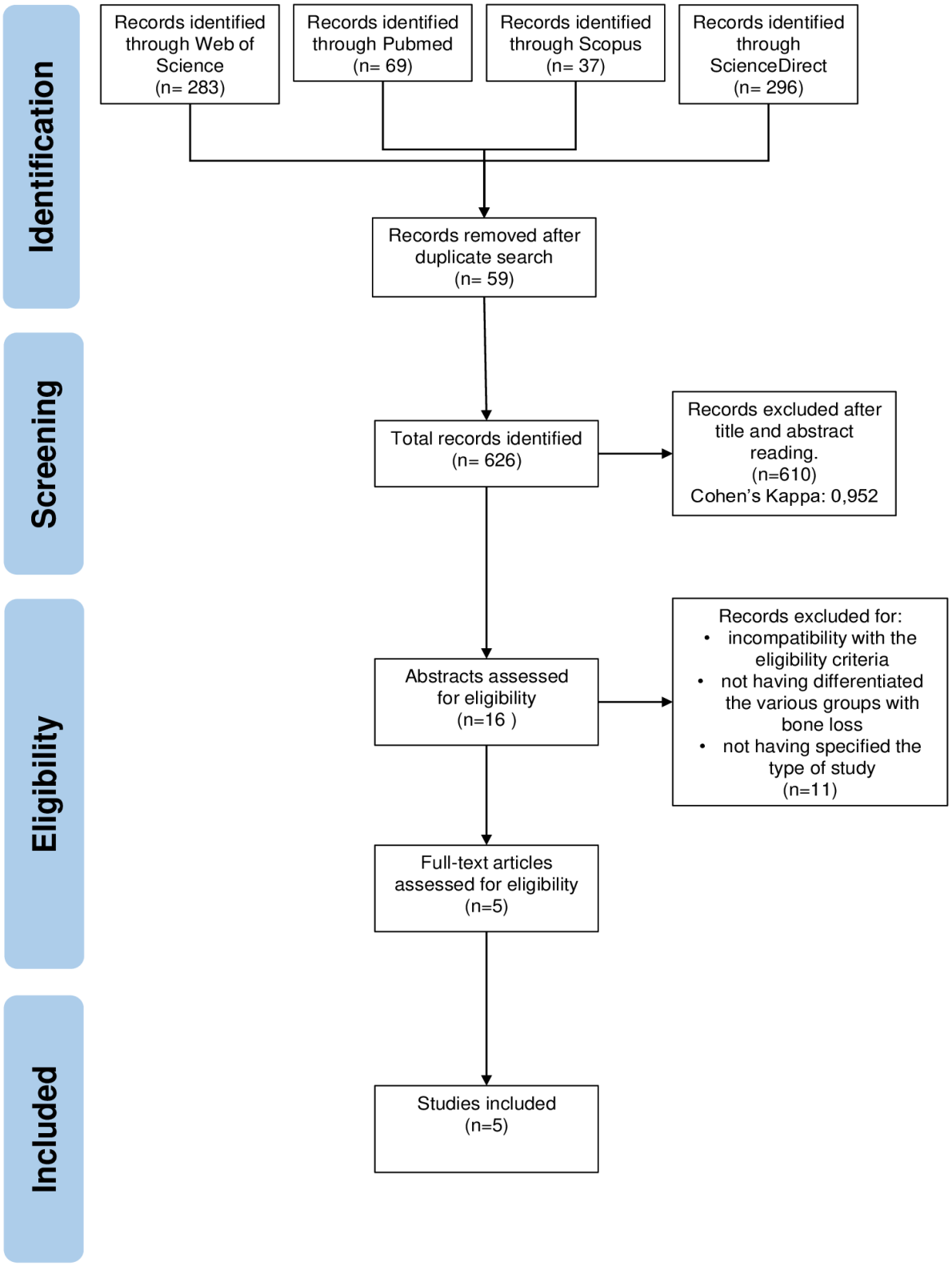


Figure 1: *PRISMA flow diagram for the selection process (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).*

III.2. Data collection and outcome variables

The data was independently extracted by two reviewers (TB and MC) from the selected publications that were in accordance with the inclusion criteria. This process focused at the main characteristics of the studies, details about the populations, and immediate implant placement in damaged extraction sockets. Any disparities were resolved through discussion and collaboration.

The extracted data was organized into tables, encompassing the following categories:

- General information: study design, publication year, patient count, and patient details.
- Informations regarding socket grafting materials, no. of fixtures, time of implant placement, implant type and loading protocol.
- Information concerning the surgical protocol.
- Information regarding the studies outcome's variables.
- Main outcomes: Survival rate, Marginal bone level, Buccal bone thickness, Pink Esthetic score (PES), Soft Tissue Assessment.
- Secondary outcomes: Bleeding on probing (Bop), Plaque Index.

III.3. Study characteristics

The tables (1-7) provide information about the studies included. A total of 135 patients and 138 implants from randomized clinical trials were analyzed, which we categorized into different groups: A Test Group with regenerative treatment having a buccal bone cortical defect in post-extraction alveoli, a Test Group without regenerative treatment and a Control Group with Delayed implant placement or without regenerative treatment.

III.3.1. Gender distribution

As far as gender is concerned, the total of the 5 articles, presented a population of 44 males and 90 females.

III.3.2. Implant location distribution

Dental implants were inserted in the aesthetic areas in the studies by **K. W. Slagter et al. (2016)** (37 in the incisors and 3 in the canines) and (**2021)**, **ElAskary et al. (2022)** (29 in the incisors, 4 in the canines and 6 in the premolars) and **M. M. Hamed et al. (2023).** Upper anterior region (between second premolars) in the study by **G. S. Borgia et al. (2022)** (23 in central incisors, 3 in canines and 5 in premolars).

III.3.3. Smoking habits

In the studies written by **K. W. Slagter et Al. (2016 and 2021)**, people with a smoking habit were excluded. In the study written by **ElAskary et al. (2022)**, smokers and ex-smokers were excluded. In the study written by **G. S. Borgia et al. (2022)**, people who smoked more than 10 cigarettes per day were excluded, just as in the study written by **M. M. Hamed et al. (2023)**, heavy smokers were excluded.

III.3.4. Periodontal status

According to the investigation leaded by **Slagter et al. (2016) and (2021)**, persons with periodontal disease were excluded. In the remaining studies, preventive periodontal therapy measures were implemented prior to surgical procedures.

III.3.5. Alveolar bone condition

The condition of the alveolar bone, as described in the inclusion criteria, had to be damaged sockets with the possibility of bone defects, fenestration of buccal bone plate or apical lesion.

Table 3: *Demographic Information.*

AUTHOR	YEAR	STUDY DESIGN	FOLLOW UP	PATIENTS NUMBER	AGE (Mean value in years)	GENDER (MALE/ FEMALE)
K. W. Slagter et Al.	**2016**	**RCT**	1 year	40 **Test group**: 20 **Control group**: 20	>18 **Test group**: 18-63, 43.7 ±13.9 **Control group**: 20-72, 48.6 ±16.4	18/22 **Test group**: 11/9 **Control group**: 7/13
K. W. Slagter et Al.	**2021**	**RCT**	5 years	40 **Test group**: 20 **Control group**: 20	**Test group**: 44 ± 14 **Control group**: 49 ± 16	NR
A. ElAskary et Al.	**2022**	**RCT**	1 year	40 **Test group**: 20 **Control group**: 20	>18 **Test group**: 36.26 (7.47) **Control group**: 35.60 (9.00)	9/30 **Test group**: 4/15 **Control group**: 5/15
G. S. Borgia et Al.	**2022**	**RCT**	1 year	31 **Test group**: 16 **Control group**: 15	35–65 **Test group**: 55.6 ± 11.8 **Control group**: 51.1 ± 8.0	10/21 **Test group**: 6/10 **Control group**: 4/11
M. M. Hamed et Al.	**2023**	**RCT**	1 year	24 **Test group I**: 8 **Test group II**: 8 **Control group**: 8	>18 **Test group I**: 40.50 **Test group II**: 37.00 **Control group**: 47.00	7/17

RCT = randomized clinical trial; NR = not reported;

Table 4: *Socket regeneration procedures and implant characteristics.*

AUTHOR	Socket grafting materials	Control group	No. of implants	Time of implant placement	Implant type	Loading protocol
K. W. Slagter et Al. 2016	Tuberosity bone graft + A mixture of autologous bone and Bio-Oss®¶ spongiosa granules + soft tissue graft (from tuberosity region)	Delayed implant placement. The identical procedure as described for the immediate group.	40 (20 Test and 20 Control)	Immediate And Delayed	NR	NR
K. W. Slagter et Al. 2021	Tuberosity bone graft and mixture of tuberosity bone and deproteinized bovine bone substitute	Delayed implant placement, The identical procedure as described for the immediate group	40 (20 Test and 20 Control)	Immediate and Delayed	NR	NR
A. ElAskary et Al. 2022	Particulate bone mixture, composed of 50% autogenous bone chips harvested from the local surgical site using a sharp bone scraper (Stoma, Storz am Mark GmbH, Emmingen-Liptingen, Germany), with 50% of deproteinized bovine bone mineral (DBBM) (MinerOss X, Biohorizons, Birmingham, Al, USA) + flexible cortical membrane of 0.6 mm thickness (OsteoBiol® Lamina®, Tecnoss®, Giaveno, Torino, Italy)	Collagen plug (BioPlug, Biohorizons Birmingham, Al, USA) + after implant placement, layer of autogenous bone and layer of DBBM + Double-layer of noncross-linked collagen membrane (Bio-guide, Geistlich Pharma, Wolhusen, Switzerland)	40 (20 Test and 20 Control)	Immediate	Biohorizons Implant Systems, Birmingham, Al, USA	NR
G. S. Borgia et Al. 2022	Collagen membrane (Bio-Guide, Geistlich, Zurich, Switzerland) between the buccal soft tissue and bone defect, and an inorganic bovine bone graft imbedded in a collagen matrix (Bio-Oss collagen, Geistlich, Zurich, Switzerland) was inserted	Corticocancellous bone graft, Cancellous bone from the tuberosity	34 (17 Test and 17 Control)	Immediate	Conical implants with internal connection (Osseotite Certain prevail, Biomet 3i, Palm Beach Gardens, USA)	Torque ≥ 35 Ncm Immediate provisionalization with an acrylic facet Torque < 35 Ncm Individualized healing cap, adhesive provisional crown. After 6 months, a definite cemented ceramic crown was installed
M. M. Hamed et Al. 2023	Group (II) used a Demineralized Bone Matrix (DBM) Grafton, and Group (III) used a particulate bone graft composed of two-thirds autogenous cortical chips harvested from the surgical site and one-third deproteinized bovine bone minerals (DBBM) MinerOss X (Biohorizons, Birmingham, Al, USA + Flexible equine cortical membrane shield of 1 mm thicknes (OsteoBiol® Lamina®, Technoss®, GiavenoTorino, Italy)	Group (I) used a Collagen plug + Flexible equine cortical membrane shield of 1 mm thicknes (OsteoBiol® Lamina®, T echnoss®, Giaveno, Torino, Italy)	24 (8 Test I, 8 Test II and 8 Control)	Immediate	Tapered pro implant platform switched design (Biohorizons, Birmingham, Al, USA)	After 2 months

Table 5: *Surgical Protocol.*

AUTHOR	YEAR	SURGICAL PROTOCOL
K. W. Slagter et Al.	**2016**	Surgical interventions The removal of compromised teeth was carried out under local anesthesia by the same skilled surgeon (GMR) with: Sulcular incision, detachment of the periodontal ligament and use of periotomes. Meticulous cleaning of the alveolus after tooth removal. Alveolar debridement with sterile gauze. Extraction of bone grafts from the maxillary tuberosity. Closure of the bone graft wound in the tuberosity region: 4-0 acrylic sutures.
K. W. Slagter et Al.	**2021**	Same surgical procedure described in K. W. Slagter et al. (2026)
A. ElAskary et Al.	**2022**	Patients underwent the following treatments: **Vestibular Socket Therapy**: Initial cone beam computed tomography (CBCT). Post-extraction socket assessment. Vestibular access creation and flap reflection. Placement of bone graft material. Membrane insertion and fixation with tacks. Implant examination after healing. **Contour Augmentation Technique**: Initial cone beam computed tomography (CBCT). Post-extraction socket assessment. Insertion of collagen plugs. Second-stage procedure involving implant placement and bone graft insertion. Double collagen membrane insertion.
G. S. Borgia et Al.	**2022**	All patients received immediate implants using a flapless approach. Prior to tooth extraction, the periodontal phenotype was assessed dichotomously. The chosen tooth was extracted with minimal invasiveness, ensuring the papillae and alveolar walls remained undamaged. Following this, the defect was analyzed and measured with a periodontal probe in the mesiodistal and apex-coronal directions. The surgical guide was then positioned. Internal connection conical fixtures, (Osseotite Certain Prevail), were placed. Notably, the provisional restoration or healing cap was installed after graft placement for each group as described: corticocancellous bone graft, cancellous bone from the tuberosity, and inorganic bovine bone graft embedded in a collagen matrix. For the test and control groups, collagen was placed between the buccal soft tissue and the bone defect, followed by the insertion of an inorganic bovine bone graft embedded in a collagen matrix.
M. M. Hamed et Al.	**2023**	A horizontal incision was made at the base of the vestibule at the socket site using a 15-c blade, extending to the adjacent teeth. The tooth was extracted atraumatically, followed by lavage and curettage of the socket. The implant was placed using a prefabricated surgical guide, positioning the implant shoulder 2 mm apical to the zenith of the labial gingival margin and slightly palatal. The graft was carefully condensed to fill the gaps between the implant and the extraction socket. A 1-mm-thick flexible cortical equine membrane of heterologous origin was trimmed and secured through the vestibular incision, extending 1.0 mm below the gingival margin.

Table 6: *Clinical Outcome.*

AUTHOR & YEAR	Buccal bone thickness	Pink Esthetic Score (PES)	Marginal bone level (MBL)	Vertical Soft Tissue
K. W. Slagter et Al. 2016	**Buccal of implant (mean ±sd):** **T1:** **Immediate group:** 1.01±0.55 **Delayed group:** 0.79±0.46 **T12:** **Immediate group:** 1.00±0.47 **Delayed group:** 0.71±0.28	**Tpre: Immediate group:** 7.0±2.1 **Delayed group:** 6.9±1.3 **T1:** **Immediate group:** 7.8±1.7 **Delayed group:** 7.4±1.6 **T12:** **Immediate group:** 7.5±1.6 **Delayed group:** 7.4±1.5	**Mesial of implant (mean ±sd):** **T1:** **Immediate group:** 0.49±0.46 **Delayed group:** 0.45±0.41 **T12:** **Immediate group:** 0.56±0.39 **Delayed group:** 0.51±0.43 **Distal of implant (mean ±sd)** **T1:** **Immediate group:** 0.71±0.51 **Delayed group:** 0.48±0.47 **T12:** **Immediate group:** 0.74±0.51 **Delayed group:** 0.54±0.45	**Not reported**
K. W. Slagter et Al. 2021	**Median** (interquartile range) **in mm** **Pre-extraction:** **Immediate group: M0** (at neck) 0.00 **M1** 0.00 **M2** 0.00 **M3** 0.00 **M4** 0.00 [0.00;0.49], **M5** 0.00 [0.00;1.44] **Delayed group: M0** (at neck) 0.00, **M1** 0.00, **M2** 0.00, **M3** 0.00, **M4** 0.00, **M5** 0.00 [0.00;0.74], **1 Month:** **Immediate group: M0** (at neck) 0.91 [0.76;1.22], **M1** 1.16 [0.70;1.81], **M2** 1.14 [0.69;1.58], **M3** 1.25 [0.77;1.73], **M4** 1.04 [0.74;1.73], **M5** 0.89 [0.57;1.64], **Delayed group: M0** (at neck) 0.64 [0.54;0.74], **M1** 0.56 [0.46;1.13], **M2** 0.65 [0.48;1.36], **M3** 0.64 [0.45;1.43], **M4** 0.60 [0.28;1.31], **M5** 0.51 [0.26;1.22], **5 Years:** **Immediate group: M0** (at neck) 1.58 [1.02;1.64], **M1** 1.23 [0.83;1.49], **M2** 1.45 [1.25;2.19], **M3** 1.49 [1.15;2.02], **M4** 1.49 [1.05;1.84], **M5** 1.36 [1.03;1.89], **Delayed group: M0** (at neck) 1.23 [0.83;1.49], **M1** 1.06 [1.00;1.39], **M2** 1.38 [1.18;1.63], **M3** 1.15 [1.05;2.09], **M4** 1.05 [0.95;1.89], **M5** 1.44 [0.96;1.60]	**Tpre: Immediate group:** 7.00(2.05) **Delayed group:** 6.90(1.32) **T1:** **Immediate group:** 7.80(1.66) **Delayed group:** 7.40(1.59) **T60:** **Immediate group:** 7.44(1.85) **Delayed group:** 7.53(1.33)	**Marginal bone level changes in mm (± SD):** **Mesial of implant** **T1:** **Immediate group:** −0.49 (0.46) **Delayed group:** −0.45 (0.41) **T60:** **Immediate group:** −0.64 (0.38) **Delayed group:** −0.50 (0.45) **Distal of implant:** **T1:** **Immediate group:** −0.71 (0.51) **Delayed group:** −0.48 (0.47) **T60:** **Immediate group:** −0.77 (0.43) **Delayed group:** −0.58 (0.41) **Mesial and distal side:** **T1:** **Immediate group:** −0.59 (0.34) **Delayed group:** −0.47 (0.41) **T60:** **Immediate group:** −0.71 (0.35) **Delayed group:** −0.54 (0.41)	**Not reported**

A. ElAskary et Al. 2022	**Test group:** Coronal level 12 months (mm): 1.97 (0.82) **Control group:** Coronal level 12 months (mm): 1.95 (0.77)	**Not reported**	**Not reported**	**Mesial (mm)** **Test group:** −0.64 (0.95) **Control group:** −1.20 (0.81) **Mid-facial (mm)** **Test group:** − 0.53 (1.17) **Control group:** − 1.87 (0.69) **Distal (mm)** **Test group:** − 0.56 (1.17) **Control group:** −1.26 (0.63)
G. S. Borgia et Al. 2022	**Not reported**	**Overall PES:** **DBBM group:** 11.5 ± 1.7 **Autologous group:** 10.8 ± 1.9	**Not reported**	**Not reported**
M. M. Hamed et Al. 2023	**Pre:** **Collagen plug group:** -Min.–Max. 0.08–0.67 -Median 0.21 **Grafton group:** -Min.–Max. 0.00-0.67 -Median 0.27 **MinerOss X group: :** -Min.–Max. 0.00-0.67 -Median 0.35 **6 Months:** **Collagen plug group:** -Min.–Max. 0.92–1.70 -Median 1.03 **Grafton group:** -Min.–Max. 0.72–1.33 -Median 1.06 **MinerOss X group: :** -Min.–Max. 0.20–1.47 -Median 1.19 **12 Months:** **Collagen plug group:** -Min.–Max. 0.91–1.62 -Median 1.01 **Grafton group:** -Min.–Max. 0.70–1.70 -Median 1.11 **MinerOss X group: :** -Min.–Max. 0.23–1.83 -Median 1.44	**6 Months:** **Collagen plug group:** -Min.–Max. 9.00–13.00 -Median 11.50 **Grafton group:** -Min.–Max. 9.00–13.00 -Median 11.50 **MinerOss X group: :** - Min.–Max. 11.00–14.00 -Median 12.00 **12 Months:** **Collagen plug group:** -Min.–Max. 9.00–14.00 -Median 12.00 **Grafton group:** -Min.–Max. 9.00–14.00 -Median 11.00 **MinerOss X group: :** - Min.–Max. 12.00–14.00 -Median 13.00	**Not reported**	**Soft Tissue Difference in Vertical Height** **6 Months:** **Collagen plug group:** -Min.–Max. 0.52–0.87 -Median 0.55 **Grafton group:** -Min.–Max. 0.41–0.63 -Median 0.58 **MinerOss X group: :** - Min.–Max. 0.30–0.69 -Median 0.57 **12 Months:** **Collagen plug group:** -Min.–Max. 0.52–0.87 -Median 0.55 **Grafton group:** -Min.–Max. 0.41–0.63 -Median 0.58 **MinerOss X group: :** - Min.–Max. 0.30–0.69 -Median 0.57

III.4. Characteristics and Results of Interventions

***K. W. Slagter et Al. 2016*:** In this study, the authors aimed to evaluate if the 1-year treatment results, in terms of changes in MBL, of immediate implant placement with delayed provisionalization are not inferior to those of delayed implant placement with delayed provisionalization in fresh extraction sites (40) with labial bone defects of approximately ±5 mm

in the esthetic zone, with Tuberosity bone graft + A mixture of autologous bone and Bio-Oss®¶ spongiosa granules + soft tissue graft (from tuberosity region). (40)

One year after definitive crown placement, the immediate placement group experienced a Margin Bone Loss (MBL) of 0.56 – 0.39 mm mesially and 0.74 – 0.51 mm distally. In the delayed placement group, the MBL was 0.51 – 0.43 mm mesially and 0.54 – 0.45 mm distally (not significant). (40) Regarding mean differences, non-inferiority was demonstrated after 1 year (difference in mean for immediate versus delayed: mesially 0.04 mm [95% confidence interval (CI) = -0.22 to 0.30 mm, P = 0.40]; distally 0.21 mm [95% CI = -0.10 to 0.51 mm, P = 0.58]). No important differences in the other outcome variables were observe. (40)

***K. W. Slagter et Al.* 2021:** The authors of this 5-year randomized controlled trial aimed to compare the outcomes of immediate implant placement in post-extraction sockets with buccal bone defects of ≥ 5 mm to delayed implant placement after ridge preservation in the esthetic zone. (41) Specifically, they examined changes in bone level, buccal bone thickness, mucosa level, esthetic evaluations by professionals, and patient-reported satisfaction. (41)

The average change in marginal bone level after 5 years was −0.71 ± 0.35 mm for the Immediate group and −0.54 ± 0.41 mm for the Delayed group (P = 0.202). This difference, along with variations in other factors, was not statistically significant.. (41)

A. ElAskary et Al. 2022: The authors of this study to compare the VST technique (test group) with the contour augmentation technique (control group) for implant placement in compromised extraction sockets within the maxillary esthetic zone. (38)

All implants achieved successful osseointegration with exception for one fixture in the test group. The VST technique exhibited significantly less mid-facial soft tissue changes of -0.53 ± 1.17 mm compared to -1.87 ± 0.69 mm in the control group ($p < 0.001$). In the same way, the changes in mesial papilla (test = -0.64 ± 0.95 mm, control = -1.20 ± 0.81 mm) and distal papilla (test = -0.56 ± 1.17 mm, control = 1.26 ± 0.63 mm), as well as horizontal soft-tissue (test = -0.82 ± 0.95 mm, control = -1.84 ± 0.88 mm; $p < 0.05$) were significantly less in VST. (38) Intra-group comparisons showed a significant increase in buccal bone thickness, with no differences between groups. Regression analysis indicated a significant correspondence between VST as well as augmented coronal bone thickness with the reduction in mid-facial soft-tissue changes. (38)

***G. S. Borgia et Al. 2022*:** In this study, the authors wanted to evaluate the use of autologous bone grafts from the tuberosity versus a xenogenic material for reconstructing labial bone defects in IIP. (31) The comparison focused on changes in the alveolar ridge, peri-implant clinical outcomes, and patient satisfaction. (31)

The success rate of the implants was 100% in both groups. The changes in FPT were 0.05. No significant differences were noticed between the groups regarding patients' satisfaction and aesthetics, pain index, and quality of life measurement. The PES score for DBBM and TUBER groups was 11.5±1.7 and 10.8±1.9, respectively (p=0.37). (31)

***M. M. Hamed et Al. 2023*:** In this investigation, the authors objective was to evaluate and compare the outcomes and predictability of three grafting materials: VST with collagen plug, VST with Demineralized Bone Matrix (DBM – Grafton), VST with autogenous cortical chips harvested from the surgical site and Deproteinized bovine bone minerals (DBBM MinerOss X), in addressing osseous defects in the maxillary anterior esthetic zone. (42)

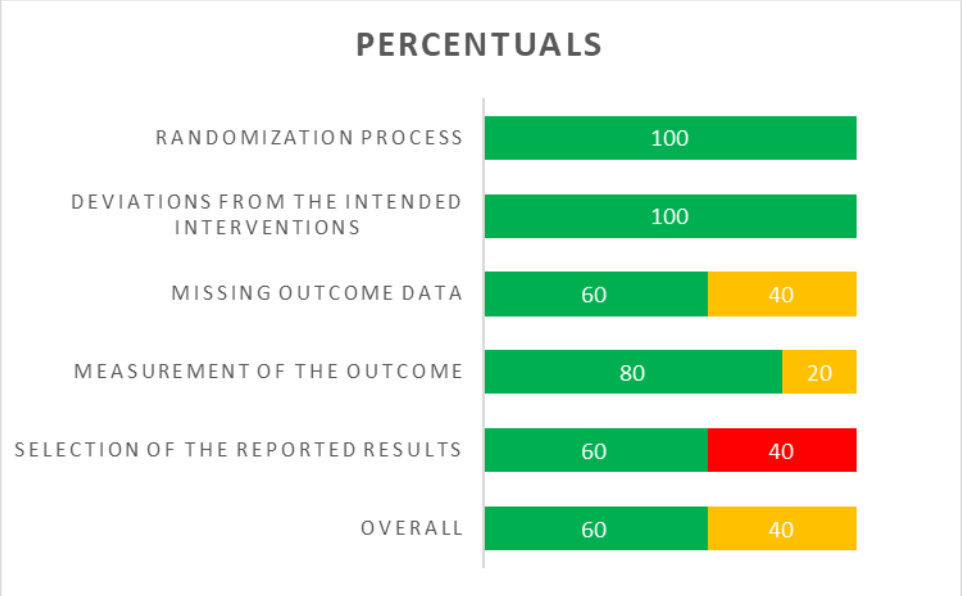
Out of 22 cases, 91.6% achieved a total PES score of >10, with no significant difference observed among the groups. (42) Significant improvements in vertical height of soft tissue were noted in the Collagen plug and Grafton groups at 6 and 12 months, while the MinerOss X group showed no significant changes at these intervals compared to baseline. Radiographic analysis revealed that FBT, initially recorded at 0.72±0.20, 0.44±0.12, and 0.95±0.37, significantly augmented to 1.61±0.88, 1.48±1.20, and 2.31±0.86 at 12 months for the respective groups. (42)

III.5. Quality Assessment

Table 7: *The Cochrane Risk of Bias 2 tool (RoB 2) for the overall risk of bias assessment.*

REFERENCES	Randomization process	Deviations from the intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported results	Overall
K. W. Slagter et Al. 2016	✓	✓	✓	✓	✓	✓
K. W. Slagter et Al. 2021	✓	✓	✓	✓	✓	✓
A. ElAskary et Al. 2022	✓	✓	!	✓	✓	✓
G. S. Borgia et Al. 2022	✓	✓	!	✓	✗	!
M. M. Hamed et Al. 2023	✓	✓	✓	!	✗	!

Table 8: *Percentages Overall Risk of bias.*



III.6. Clinical outcomes

III.6.1. Pink Esthetic Score (PES)

Pink Esthetic Score (PES) was computed in the studies of **Slagter et al. (2016 e 2021)**, **Borgia et al. (2022)** and **Hamed et al. (2023)**.

In the articles by **Slagter et al. (2016 and 2021)**, no significant differences were noticed between the two groups. We can particularly observe that in **Slagter et al. (2016),** the measurements detected after 12 months were 7.5 ± 1.6 in the Test Group and 7.4 ± 1.5 in the Control Group. In **Slagter et al. (2021)**, the measurements detected after 60 months were 7.44 ± 1.85 and 7.53 ± 1.33 for the Test and Control group, respectively.

Regarding **Borgia et al. (2022)**, we can note that the overall PES scores for the DBBM and autologous block groups were 11.5 and 10.8 ($p = 0.37$), respectively. There were no notable distinctions observed among the two groups compare to the overall PES score and for all the 7 evaluated items. (31) The groups did not show significant variations in the distribution of the highest PES scores. (31)

Hamed et al. (2023), reported that among the three groups, there was no statistical significance. The mean ± S.D. measured after 12 months of follow-up were: 11.75 ± 1.75 for the Grafton group (Test Group I) and 12.87 ± 0.83 for the MinerOss X group (Test Group II) and 12.12 ± 1.88 for the Collagen plug group (Control Group). (42)

III.6.2. Soft Tissue Changes

Two studies specifically measured the soft tissue changes, **ElAskary et al. (2022)** and **Hamed et al. (2023)**.

ElAskary et al. (2022), reported that the test group experienced reduced soft tissue loss at the 1-year evaluation. Soft tissue changes were measured on digital intraoral scans.(38) Midfacial changes in the test group averaged -0.53 ± 1.17 mm, whereas the control group averaged -1.87 ± 0.69 mm ($p < 0.001$). (38) On the mesial margin, changes were 0.64 ± 0.95 mm for the test group and -1.20 ± 0.81 mm for the control group ($p = 0.023$). Analogously, distal changes values were -0.56 ± 1.17 mm and -1.26 ± 0.63 mm in the test and the control group, respectively ($p = 0.001$). (38) Both

groups showed a significant reduction in horizontal soft tissue between baseline and 12 months, but the test group exhibited a smaller mean change of -0.82 ± 0.95 mm compared to -1.84 ± 0.88 mm in the control group (p = 0.001). (38)

Hamed et al. (2023), declared that there was no significant difference among the three studied groups. (42) The mean ± S.D. measured after 12 months of follow-up were: 0.57 ± 0.05 for the Grafton group (Test Group I) and 0.51 ± 0.09 for the MinerOss X group (Test Group II) and 0.63 ± 0.07 for the Collagen plug group (Control Group). (42)

III.6.3. Patient Satisfaction

Patient Satisfaction was computed according to the articles of **Slagter et al. (2016 e 2021)** and **Borgia et al. (2022**).

In **Slagter et al. (2016)**, OHIP-14 scores showed no significant differences between the groups (P >0.05). One year after crown insertion, overall satisfaction scores were 8.4 ± 1.4 for the immediate group and 8.1 ± 1.3 for the delayed group.(40)

Moreover, **Slagter et al. (2021)** reported elevated and comparable overall patient satisfaction between the groups during follow-up (P = 0.389). (41) Overall patient satisfaction was measured using a Visual Analogue Scale (VAS). The results obtained, with a score of 0-100, were 77.7 ± 17.2 for the Immediate group (Test Group) and 82.4 ± 14.3 for the Deleyed group (Control Group). (41)

In **Borgia et al. (2022)**, all patients in both groups showed VAS scores identical to 100 for esthetic and functional satisfaction. (31) No significant differences were computed between the groups' baseline OHIP scores (p = 0.14), with median and interquartile values of 10 (4–18) for the DBBM group and 16 (8–25) for the autologous block group. (31) Both groups experienced a substantial reduction in OHIP scores, with median values falling to 0 (interquartile range 0-2) after the follow-up period, with no relevant differences among the groups at the end of the study (p = 0.68). (31)

III.6.4. Facial-palatal ridge thickness (FPT)

The Facial-palatal ridge thickness was determined in the study of **Borgia et al. (2022).** Results indicated no significant differences in FPT at the implant site between groups

both at baseline and after 12 months (Table 2). Initially, FPT at the gingival margin (0 mm) was 7.4 mm in both groups (p = 0.99) and 7.3 mm after 12 months (p = 0.95). (31) Similarly, no notable differences in FPT were found among groups at the contralateral control teeth. In general, ridge thickness was consistently lower at the implant site compared to the contralateral tooth. (31) This decrease averaged -1% in the DBBM group and -0.6% in the autologous graft group at the gingival margin (0 mm) (p = 0.80). At a height of 6 mm, the autologous block group experienced a reduction of nearly 5%, in comparison with a 2% reduction of the DBBM group (p = 0.08). (31)

III.7. Data from the radiographics outcomes

III.7.1. Hard Tissue Assessment – Facial/Buccal Bone Thickness (FBT)

Three studies have calculated the Facial/Buccal Bone Thickness (FBT/BBT), and they are: **Slagter et al. (2016 e 2021)** and **Hamed et al. (2023).**

In **Slagter et al. (2016),** the results obtained after 12 months of follow-up were 1.00 ± 0.47 for the Immediate Group (Test Group) and 0.71 ± 0.28 for the Delayed Group (Control Group). BBT did not change after 12 months. (40)

In **Slagter et al. (2021),** his 5-year evaluation revealed no significant differences in BBT across all six positions among the groups. At T60, the Immediate Group (Test Group) had a minimum buccal bone thickness at the implant neck of 0.44 mm and a maximum thickness of 2.04 mm. (41) Meanwhile, in the Delayed Group (Control Group), the buccal bone thickness at the implant neck ranged from 0.43 mm to 1.74 mm during the same period. (41)

In **Hamed et al. (2023),** the median radiographic facial bone thickness for the Collagen plug group (Control Group) was 0.21, which considerably increased to 1.03 and 1.01 at 6 and 12 months, respectively (p=.008). (42) Similar increases were observed to Grafton (Test Group I) and MinorOss X (Test Group II) groups. (42) The initial FBT was 0.27 mm for Grafton and 0.35 mm for MinorOss X, which rose considerably in the Grafton group to 1.06 mm at 6 months and 1.11 mm at 12 months (p=.024). (42) In addition, for the Minor Oss group (Test Group II), it increased to 1.19 mm at 6 months and 1.44 mm at 12 months, showing a statistically significant difference from baseline

(p=.027). (42) Nevertheless, there was no statistically significant difference among the three studied groups at six (p=.898) and twelve months (p=.523). (42) Value of mean ± S.D. at 12 months: 1.25 ± 1.65 for the Collagen plug group (Control Group), 1.34 ± 0.26 for the Grafton Group (Test Group I) and 1.28 ± 0.38 for the MinorOss X Group (Test Group II). (42)

ElAskary el al. (2022), documented a statistically significant bone gain in the apical segment of both groups, as determined by CBCT measurements of labial/buccal plate thickness. (38) The test group showed an increase from a baseline thickness of 1.53 ± 1.29 mm to 2.21 ± 0.93 mm (p = 0.007), while the control group exhibited an increase from 1.97 ± 1.69 mm to 2.73 ± 1.35 mm (p = 0.001). (38) Additionally, the middle alveolar bone segment thickness increased for both the test group (from 0.62 ± 0.67 mm at baseline to 2.10 ± 0.68 at 12-months [p < 0.001]) and the control group (from 1.12 ± 1.26 mm at baseline to 2.47 ± 1.08 at 12-months [p < 0.001]). (38) Finally, despite the fact that an increase in bone at the coronal level of 1.97 ± 0.82 and 1.95 ± 0.77 mm was reported in the control and test groups, no significant difference was observed among the two groups (p > 0.05). (38)

III.7.2. Margin Bone Loss (MBL)

In two studies by **Slagter et al. (2016 and 2021)**, the Margin Bone Loss was determined.

In **Slagter et al. (2016),** no inferiority was noted for the change in MBL between the groups, at both 1 month (40) (difference in mean immediate group versus delayed: mesially, 0.04 mm [95% CI = -0.24 to 0.23 mm, P = 0.83]; distally, 0.23 mm [95% CI = -0.84 to 0.54 mm, P = 0.70]) and 1 year (mesially, 0.04 mm [95% CI = -0.22 to 0.30, P = 0.40]; distally, 0.21 mm [95% CI = -0.10 to 0.51 mm, P = 0.58]). (40)

In **Slagter et al. (2021),** the major MBL change occurred between the time of implant placement and the T1 measurement in both groups. After one month with the final restoration only minor changes were noted in both groups, with no significant differences between them (41) (Immediate group: −0.64 ± 0.38 mm mesially and −0.77 ± 0.43 mm distally compared to Delayed group: −0.50 ± 0.45 mm mesially and −0.58 ± 0.41 mm distally; P = 0.336 and P = 0.171 for the mesial and distal sides, respectively). (41) At T60 (5 years), the Immediate group exhibited peri-implant bone changes ranging from a minimum of -0.15 mm to a maximum of -1.45 mm. During the

same period, the Delayed group showed bone changes ranging from 0.00 to -1.38 mm. (41)

4. RESULTS OF META-ANALYSIS

IV. Results of Meta-analysis

The studies included in this meta-analysis were: **K. W. Slagter et Al. (2016), K. W. Slagter et Al. (2021), A. ElAskary et Al. (2022), G. S. Borgia et Al. (2022) and M. M. Hamed et Al. (2023).** According to meta-analyses, the aim of random effects model was to analyse the variables, as this is the most suggested model for generalising outcomes. It supposes that the effect of interest is not the similar for all investigations and considers that the ones being analysed consist in a random example from a hypothetical sample of studies. Heterogeneity was analysed through Cochran's Q test and Higgins' I2 statistic; the presence of heterogeneity is the manifestation of differences among studies in relation to the estimation of effects.
The method used to measure the effect was standardised mean differences.
All statistical analyses were carried out using Review Manager 5.4 software.

IV.1. Gender

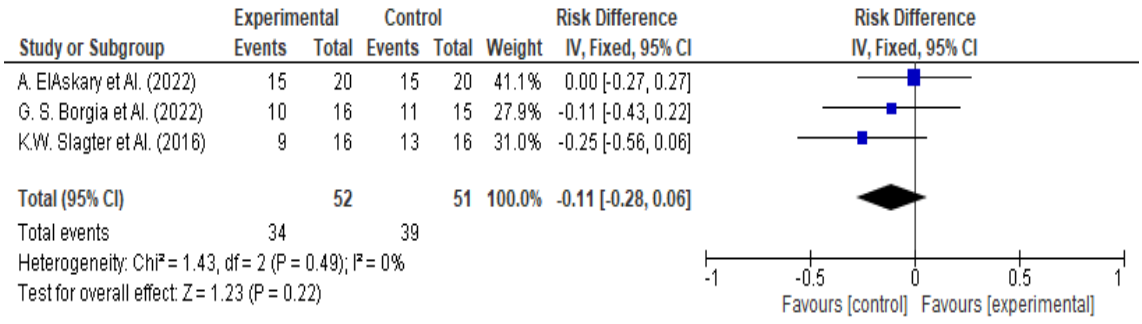


Figure 2: *Results of the meta-analysis for gender.*

Figure 2 shows the results for gender, considering the studies that presented the number of men and women, the number of women over the total was considered. In view of the outcomes in figure 1, Cochran's Q (p=0.49>0.05) and I2=0%, it became clear that the studies were homogeneous as far as regards gender. Observing the forest plot shows that in each both genders are balanced by group (control versus experimental) and that in all studies women prevail.

IV.2. Implant site

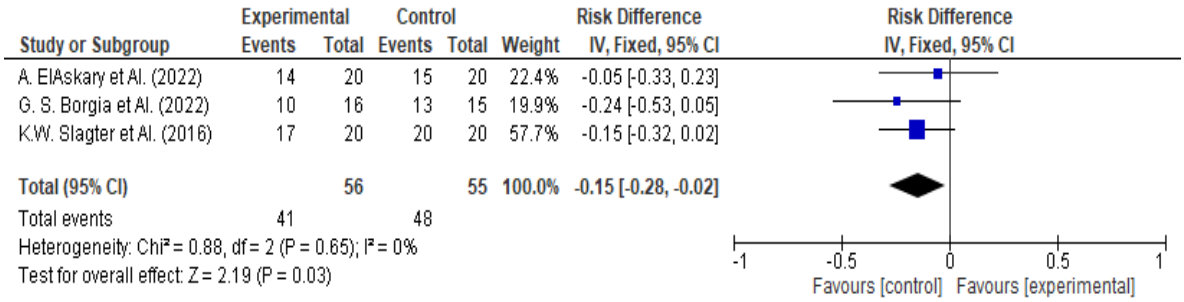


Figure 3: *Meta-analysis results for implant site.*

Figure 3 shows the results for the implant site, taking into account the studies that presented the number of incisor implants and others that considered the number of incisors over the total. Given the results in figure 2, Cochran's Q (p=0.65>0.05) and I2=0%, it was concluded that there was homogeneity between studies with regard to the implant site. Observing the forest plot shows that in each study the implant site is balanced by group (control versus experimental) and that in all studies incisor implants prevail.

IV.3. Age

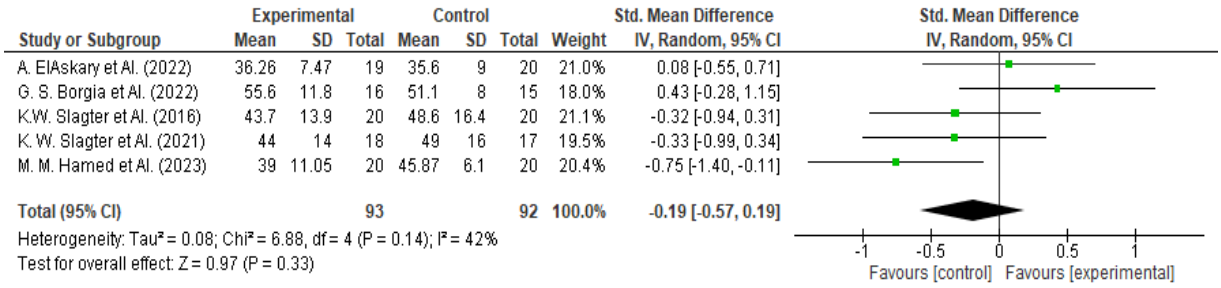


Figure 4: *Meta-analysis results for age.*

Given the results in figure 4, Cochran's Q (p=0.14>0.05) and I2=42%, it was concluded that there was homogeneity between studies regarding age. Looking at the forest plot, there is a tendency for age to be lower in the test group.

IV.4. Buccal/Facial Bone thickness (12 months)

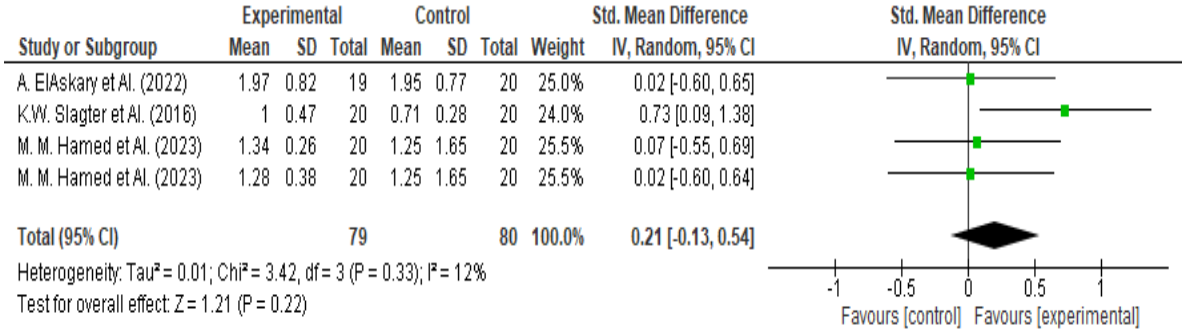


Figure 5: *Meta-analysis results for Buccal/Facial Bone thickness (12 months).*

Considering the results in figure 5, Cochran's Q (p=0.33>0.05) and I2=12%, it was concluded that heterogeneity is not significant between studies regarding Buccal/Facial Bone thickness. Observing the forest plot, it can be seen that the effect of the meta-analysis 0.21 (95%CI [-0.13;0.54]) is not statistically significant (p=0.22).

IV.5. Pink Esthetic Score (12 months)

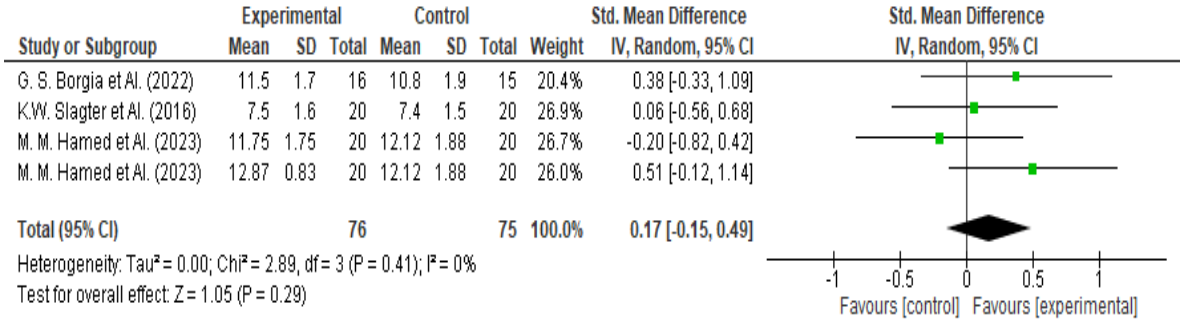


Figure 6: *Meta-analysis results for Pink Esthetic score (12 months).*

Considering the results in figure 6, I2=0%, it was concluded that there was homogeneity between the studies regarding the Pink Esthetic score. Looking at the forest plot, it can be seen that the studies do not show significant differences; the

studies favour the experimental group, with the exception of the first study by M.M Hamed et al. The weights of the studies are identical in this analysis, with G.S. Borgia et al. showing the lowest value, 20.4 per cent, given the samples considered compared to the others. A look at the forest plot shows that the effect of the meta-analysis 0.17 (95%CI [-0.15;0.49]) is not statistically significant (p=0.29).

5. DISCUSSION

V. DISCUSSION

The aim of this systematic review and meta-analysis was to observe whether the immediate dental implants placement into damaged sockets is a successful modality for the treatment of hopeless teeth. Since a large number of sockets have some kind of defect of the alveolar bone plates, it is therefore important to understand how this condition affects the results of this treatment modality.

This study was carried out taking into consideration all RCTs that examined the placement of immediate dental implants, where in at least one group was diagnosed with a alveolar bone plate defect.

IIP is accepted as a very reliable solution for the replacement of unrecoverable teeth, whether for the treatment of a single tooth or for complete rehabilitation of the dental arch. (27,32,43) However, implant installation requires adherence to rigorous criteria in order to ensure functionally satisfactory results, particularly in fresh anterior extraction sockets, where particularly fine aesthetics are required. (1,32) We can observe that a thick gingival biotype, an intact facial bone wall and a three-dimensionally sufficient bone volume are consistently indicated as success factors for an IIP. (1,32)

We can note how the dehiscence of the buccal bone wall can cause a non-optimal aesthetic result after the placement of an IIP, (44) this suggests that the post-extraction insertion to replace a maxillary anterior tooth is a complicated surgical procedure. (45) By virtue of this, immediately after a tooth extraction at the upper-arch anterior area , the buccal bone wall is more susceptible to bone resorption, due to the latter's lesser thickness. (45,46) However, as stated in the study by **Mizuno et al. (2021)**, where they superimposed the CBCT data before and after surgery with an assessment of the morphology of the buccal cortical, including bone dehiscences, and using xenografts (Bio-Oss) and a barrier membrane (Bio-Gide), IIP can be useful in the treatment of preoperative buccal alveolar bone dehiscence. (44)

Considering the results obtained in our meta-analysis, and advancing gradually, we can note that, with regard to gender, that there was homogeneity between the different studies. Looking at the forest plot, we can see that in each investigation there is a

balance of men and women between the control and experimental group. In the total number of studies, women prevailed. This result is in line with the study by **ElAskary et al. (2022)**, because we may observe that in the Test group, we have 4 males and 15 females and in the Control Group we have 5 males and 15 females.

The adoption of the practice of IIP has gained considerable interest and clinical debate recently, with certain premises suggesting the importance of having a buccal bone wall with a minimum thickness of 1 mm. Literature reports some benefits over traditional methods of dental implant placement that involve longer waiting times. Studies, such as the one conducted by **Mello et al.**, have shown that this technique can accelerate the osseointegration process, limit bone loss while maintaining the existing periodontal architecture, and offer particularly advantageous aesthetic results in critical areas such as the anterior teeth. (35,47)

Clinical studies have shown that the correct surgical approach in Immediate Implant Placement (IIP) can effectively reduce the phenomenon of alveolar bone resorption. Several surgical techniques have been suggested and evaluated to counteract morphological changes in the tissues around the implant and ensure excellent aesthetics for immediately inserted implants. These methods include the use of bone grafts (with or without the use of barriers), soft tissue augmentation using connective tissue grafts, the adoption of flapless techniques and implant placement towards the palatal side. (48) Literature suggests that buccal bone thickness (BBT) at the anterior maxillary region is less than 1.0 mm thick and, in half of the cases, 0.5 mm or less. The removal of an upper anterior tooth can cause a significant tissue reduction in within a few weeks after extraction, resulting in an esthetic problem. The palatal position of the implant insertion in IIP, increasing the area among the implant and the buccal bone wall, can prevent such dimensional changes, although the outcomes of this conservative procedure are variable. (49)

Buser et al. (2017) distinguished the main elements that contribute to the risk of soft tissue recession, thus causing aesthetic complications, such as a thin tissue biotype, non-optimal implant placement, and the presence of a reduced or compromised buccal bone wall at the time of tooth extraction. (1) It is precisely for this reason that BBT becomes a relevant variable in determining aesthetic results.

In the maxillary anterior area, the morphology of the buccal bone around implants is crucial in determining the contour of the peri-implant tissues and the aesthetics of the surrounding soft tissues. Consequently, the thickness of the facial bone around implants placed in this area is considered crucial to achieve a favorable result. (50)

We can observe from the results of the meta-analysis that Buccal/Facial Bone thickness had a tendency towards favouring the experimental group. This result is in line with the study by **Slagter et al. (2016)** and **Hamed et al. (2023)**. **ElAskary et al. (2022)**, showed almost at a perfect parity between the two groups, with the test group slightly favoured. We can note that in the investigation conducted by **Slagter et al. (2016)**, the results are fully in favour of the test group compared to the control group. In fact, the group with immediate implant placement (Test Group) in sockets with labial bony defect ≥ 5 mm with bone graft, had a value of 1.00 ± 0.47 compared to the control group that obtained a value of 0.71 ± 0.28 using delayed implant placement with the same conditions and procedures. Therefore, we can conclude that in this study, the test group had better results at 12 months follow-up. (40) This result is also in line with the study of **Hamed et al. (2023)**, where we have the tendency to favour the experimental group. We can observe that through the use of VST, in the collagen plug group (Control Group), there was a considerable decrease in the overall thickness (1.25±1.65) of the labial bone after 12 months follow-up compared to the Grafton (Test Group I) and MinerOss X (Test Group II) groups (1.34±0.26 and 1.28±0.38). (42) With regard to **ElAskary et al. (2022)**, as mentioned previously, considering the BBT values at the coronal level, with a value of 1.97 ± 0.82 and 1.95 ± 0.77 mm after 12 months of follow-up for the test group and control group respectively, there was an increase in bone thickness after treatment, similar in both groups, with a slight tendency towards the experimental group, but no significant difference was noticed among the two groups ($p > 0.05$). (38)

In fact, we can conclude that, in the test groups examined in this systematic review, the materials used as graft in the sockets with bone defect, were mostly autologous bone mixed with a xenograft. **Slagter et al. (2016)** used a tuberosity bone graft plus a mixture of autologous bone and Bio-Oss®¶ spongiosa granules + soft tissue graft (from tuberosity region) (40); **Hamed et al. (2023)** employed a particulate bone graft consisting of two-thirds autogenous cortical chips collected from the surgical site and one-third deproteinized bovine bone minerals (DBBM) MinerOss X (Biohorizons,

Birmingham, Al, USA) supplemented with a 1 mm thick flexible equine cortical membrane shield (OsteoBiol® Lamina®, Technoss®, Giaveno, Torino, Italy) in the experimental group III (42) **ElAskary et al. (2022)** used a particulate bone mixture, divided in half autogenous bone chips collected from the local surgical site utilising a sharp bone scraper (Stoma, Storz am Mark GmbH, Emmingen-Liptingen, Germany), and half of deproteinized bovine bone mineral (DBBM) (MinerOss X, Biohorizons, Birmingham, Al, USA) with a flexible cortical membrane of 0.6 mm thickness (OsteoBiol® Lamina®, Tecnoss®, Giaveno Torino, Italy) (38) and **Borgia et al. (2022)**, used a corticocancellous bone graft, cancellous bone from the tuberosity and Inorganic bovine bone graft imbedded in a collagen matrix (Bio-Oss collagen, Geistlich, Zurich, Switzerland), (31) which on average produced better results. Only in test group I of the article by **Hamed et al (2023)** allograft was used (Demineralized Bone Matrix (DBM) Grafton). (42)

Thus, we can state that the placement of IIP in an alveolus with a bone defect is possible, and is predictable, with the requirement to use a bone graft, preferably autologous bone plus xenograft.

The study by **Tsuda et al. (2011)** demonstrates that, beyond achieving a high success rate for implants and favorable peri-implant tissue response, it is also feasible to maintain the gingival facial level around immediate single-tooth dental implants placed post-extraction by treating the implants with subepithelial connective tissue graft (SCTG), achieving a correct three-dimensional implant location and using a bone graft, with Xenograft, Bio-Oss, Osteohealth material to fill the gap between the implant and the socket. (51)

As reported by **Bakkali et al. (2021)**, a randomized clinical trial conducted by **Chen et al. (2007)**, found that treatment groups using bovine bone mineral (DBBM) to fill the gap showed significantly less horizontal bone reduction compared to control groups where the gap remained unfilled. Similarly, other researchers have advocated for the use of various grafting materials to fill the gap for the same reason. (48,52)

The main interest in areas where aesthetics is crucial has focused on achieving an excellent aesthetic appearance. To achieve this, it is crucial that implants are placed and oriented in the most appropriate manner. This study introduced an innovative aesthetic index, (11,53) called the Pink Esthetic Score (PES). (54) The research

focused on the fidelity and reproducibility of this index and the influence that the specialisation of the observer could have on the evaluation of the aesthetic appearance. (54)

The PES evaluates seven key aspects: the soft-tissue level, the mesial papilla, the distal papilla, their contour, any lack of alveolar process, and the color and consistency of the soft tissues. (54) Each aspect is assigned a score from 2 to 0, where 2 indicates the optimal condition and 0 the least desirable condition. The assessment of the mesial and distal papillae takes into consideration whether they are complete, incomplete, or missing while the other criteria are evaluated by comparing the area of interest with a reference tooth, which can be the correlate one in the anterior area or a neighboring tooth in the premolar area. (54)

The highest score obtainable, 14, underlines a perfect correspondence of the peri-implant soft tissue with that of the reference tooth, testifying to an impeccable aesthetic result. (54)

In addition, various combinations of surgical protocols such as flapless vs. flap surgery, bone grafts and/or connective tissue, and immediate or early/conventional loading protocols were identified for research on immediate implants. (1,55)

Studies have shown that the most consistent outcomes are achieved when a treatment protocol of flapless extraction and implant placement is employed, along with the use of bone grafts, connective tissue grafts, and the application of an immediate temporary crown. (1,55)

As concerns the Pink Esthetic Score (PES), we can notice that this Index tends towards a subjective analysis, since it depends on the observer measurements. Nowadays, we have some available tools that allow the investigator to take the measurements in a digital format, so it reduces some of the subjective variables and make the assessment objective and precise. The same measurements can be repeated several times with greater accuracy (56) and we have less risk of distortion. (57)

We can observe how in a study by **Borges et al. (2020)**, where they examined the placement of immediate implants in post-extraction sockets, verifying the possible reduction of socket contraction, using a digital evaluation method, they were able to

obtain precise and objective results, as well as superimposable results between T0, T1 (1 month follow-up), T2 (4 months follow-up) and T3 (1 year follow-up). (58)

Therefore, the digital data can then be archived and compared over time. This makes it possible to monitor any changes over time and to assess the effectiveness of treatments during a determined observation period.

The PES calculation at the 12-months of follow-up, in this meta-analysis revealed an increased outcome of the experimental group. This outcome coincides with the study of **Borgia et al. (2022)**, because we can note that the mean PES were higher than 10, which denotes good to high overall levels of aesthetics and the mean ± S.D. measured at 12 months follow-up was 11.5 ± 1.7 according the Test Group while according the control group 10.8 ± 1.9. (31)

This outcome is also supported in the article by **Slagter et al. (2016)**, where the PES value was favorable in both groups but slightly higher than the experimental group.(40) The results obtained are also in line with the study by **Hamed et al. (2023)**, although the latter has a contradictory result. We can therefore observe that the overall PES values after 12 months were 12.12±1.88 in the Control Group (collagen plug), while Test Group I (Grafton) demonstrated scores of 11.75±1.75 and Test Group II (MinerOss X) demonstrated scores of 12.87±0.83, which are very good scores. The contradiction was caused by the Grafton group (Test Group I) having lower scores than the Control Group, but in general we can observe that the final results are always skewed towards the Test Group. Outstanding aesthetic results were achieved with the VST due to the preservation of the peri-implant soft tissue. (42)

Amid et al. (2021) stated in their systematic review and meta-analysis that there was no substantial difference observed in the implant survival rate (RR=0.992; 95% CI=0.979 to 1.005; P=.246). However, when taking into account the underlying cause, the highest survival rate was seen in buccal plate defects at 99.22%, whereas sockets with a history of periodontal lesions exhibited the lowest survival rate at 94%. (36)

In this Systematic Review, other variables outside the meta-analysis were analysed. Importantly, it is mentioned about Patient Satisfaction. It was computed in the articles of **Slagter et al. (2016 and 2021)** and **Borgia et al. (2022)**.

Slagter et al. (2016) used the OHIP-14 (Oral Health Impact Profile) score as an evaluation tool, a useful instrument to value the impact of oral health on patients' quality of life. Specifically, it measures oral cavity health, general health status and related quality of life, as these aspects are closely interconnected (59). The result was that no significant differences were found between the two study groups.

In **Slagter et al. (2021)**, moreover, the Visual Analogue Scale (VAS), which is used to estimate pain intensity, was used to measure patient satisfaction. Scores are derived from subjective evaluations of symptoms, documented by means of a single handwritten mark along a 10 cm line. This line representing a relation among the two extremes of the scale: “no pain” at the left end (0 cm) and “maximum pain” at the right end (10 cm). The measurements range from the starting point (left end) of the scale to the patients' signs, expressed in centimeters and interpreted as indications of their interpretation of pain. (60) In this case, a value of 0 indicates total aesthetic dissatisfaction, while a value of 10 represents full satisfaction. (41) The results obtained were, using a scale from 0 to 100, were 77.7 ± 17.2 for the Immediate group (Test Group) and 82.4 ± 14.3 for the Delayed group (Control Group). (41) This suggests a good result in both groups.

In **Borgia et al. (2022)** we can observe that the VAS score, on a score from 0 to 100, resulted in 100 for aesthetic and functional satisfaction. Therefore, all patients had the highest satisfaction. (31) With regard to the OHIP scores, although there was a reduction in the score after the 12-month follow-up, the author points out that there were no significant differences between the two groups. (31)

ElAskary et al. (2022) and **Hamed et al. (2023),** however, examined soft tissue changes. According to **ElAskary et al. (2022)**, who used digital intraoral scans to perform the measurements, the test group showed less soft tissue loss after 12 months, with the test group having a result of -0.82 ± 0.95 mm compared to a mean change of -1.84 ± 0.88 mm in the control group ($p = 0.001$). (38) **Hamed et al. (2023)**, on the other hand, stated that there was no statistically significant difference between the three groups examined. (42)

Our review has several strengths but also some limitations. Among the strengths is certainly the use of a rigorous methodology, following the PRISMA protocol, using different databases and scanning many articles (only from the last 10 years and thus the most recent), and only RCTs, so as to have a high quality of articles. Well-defined

inclusion and exclusion criteria (such as a minimum follow-up of 12 months) were used for the selection of the various studies, thus reducing the risk of bias. We can note that the studies chosen in this systematic review are of good quality on average, as three of the five articles show a low risk of bias and the remaining two show a medium risk of bias. In conclusion, we can deduce exactly how the Risk of Bias is very balanced and has mostly low risk values. The use of a robust meta-analysis method for combining the various data allowed us to obtain precise estimates of the results.

On the other hand, among the limitations of this study, we note that of the myriads of articles scanned, only five were included in this review, which denotes a not very large number of studies, which could indeed be a limitation. To this we can add that it was not possible to add all articles to the meta-analysis, all due to the fact that the variables were not always measured in the same way and the high variability of the variables.

6. CONCLUSION

VI. CONCLUSION

These findings enable us to determine that the IIP after dental extraction in sockets with buccal bone defects, present clinical and radiographic results similar to those observed in conventional techniques. Performing regenerative procedures in these clinical situations is fundamental to achieve favourable results, although it is not clear the outcomes obtained by the use of a specific regenerative material. Nevertheless, it remains clear that further RCT studies and further evidence must be carried out to corroborate the results of this review.

7. BIBLIOGRAPHY

VII. BIBLIOGRAPHY

1. Buser D, Chappuis V, Belser UC, Chen S. Implant placement post extraction in esthetic single tooth sites: when immediate, when early, when late? Periodontol 2000. 2017 Feb;73(1):84-102.

2. Chappuis V, Araújo MG, Buser D. Clinical relevance of dimensional bone and soft tissue alterations post-extraction in esthetic sites. Periodontol 2000. 2017 Feb;73(1):73-83.

3. Saijevan A, Juodzbalys G. Immediate Implant Placement in Non-Infected Sockets versus Infected Sockets: a Systematic Review and Meta-Analysis. J Oral Maxillofac Res. 2020 Jun 30;11(2).

4. Blanco J, Carral C, Argibay O, Liñares A. Implant placement in fresh extraction sockets. Periodontology 2000. 2019 Feb;79(1):151-167.

5. Ebenezer V, Balakrishnan K, Asir RV, Sragunar B. Immediate placement of endosseous implants into the extraction sockets. J Pharm Bioallied Sci. 2015 Apr;7(Suppl 1):S234-7.

6. Higuchi KW, Slack JM. The use of titanium fixtures for intraoral anchorage to facilitate orthodontic tooth movement. Int J Oral Maxillofac Implants. 1991 Fall;6(3):338-44.

7. Hämmerle CH, Araújo MG, Simion M; Osteology Consensus Group 2011. Evidence-based knowledge on the biology and treatment of extraction sockets. Clin Oral Implants Res. 2012 Feb;23 Suppl 5:80-2.

8. Schropp L, Isidor F. Timing of implant placement relative to tooth extraction. J Oral Rehabil. 2008 Jan;35 Suppl 1:33-43.

9. Chatzopoulos GS, Wolff LF. Survival Rates and Factors Affecting the Outcome Following Immediate and Delayed Implant Placement: A Retrospective Study. J Clin Med. 2022 Aug 1;11(15).

10. Mazzocco F, Jimenez D, Barallat L, Paniz G, Del Fabbro M, Nart J. Bone volume changes after immediate implant placement with or without flap elevation. Clin Oral Implants Res. 2017 Apr 1;28(4):495–501.

11. Fürhauser R, Mailath-Pokorny G, Haas R, Busenlechner D, Watzek G, Pommer B. Esthetics of Flapless Single-Tooth Implants in the Anterior Maxilla Using Guided Surgery: Association of Three-Dimensional Accuracy and Pink Esthetic Score. Clin Implant Dent Relat Res. 2015 Oct 1;17:e427–33.

12. Fu JH, Oh TJ, Benavides E, Rudek I, Wang HL. A randomized clinical trial evaluating the efficacy of the sandwich bone augmentation technique in

increasing buccal bone thickness during implant placement surgery: I. Clinical and radiographic parameters. Clin Oral Implants Res. 2014 Apr;25(4):458–67.

13. Evian CI, Waasdorp JA, Ishii M, Mandracchia M, Sanavi F, Rosenberg ES. Evaluating extraction sockets in the esthetic zone for immediate implant placement. Compend Contin Educ Dent. 2011;32(3):e58-65.

14. Araújo MG, Silva CO, Misawa M, Sukekava F. Alveolar socket healing: what can we learn? Periodontol 2000. 2015 Jun;68(1):122-34.

15. Clementini M, Castelluzzo W, Ciaravino V, Agostinelli A, Vignoletti F, Ambrosi A, et al. The effect of immediate implant placement on alveolar ridge preservation compared to spontaneous healing after tooth extraction: Soft tissue findings from a randomized controlled clinical trial. J Clin Periodontol. 2020 Dec 1;47(12):1536–46.

16. Borges T, Fernandes D, Almeida B, Pereira M, Martins D, Azevedo L, et al. Correlation between alveolar bone morphology and volumetric dimensional changes in immediate maxillary implant placement: A 1-year prospective cohort study. J Periodontol. 2020 Sep 1;91(9):1167–76.

17. van Nimwegen WG, Raghoebar GM, Zuiderveld EG, Jung RE, Meijer HJA, Mühlemann S. Immediate placement and provisionalization of implants in the aesthetic zone with or without a connective tissue graft: A 1-year randomized controlled trial and volumetric study. Clin Oral Implants Res. 2018 Jul 1;29(7):671–8.

18. Migliorati M, Amorfini L, Signori A, Biavati AS, Benedicenti S. Clinical and Aesthetic Outcome with Post-Extractive Implants with or without Soft Tissue Augmentation: A 2-Year Randomized Clinical Trial. Clin Implant Dent Relat Res. 2015 Oct 1;17(5):983–95.

19. Yoshino S, Kan JYK, Rungcharassaeng K, Roe P, Lozada JL. Effects of Connective Tissue Grafting on the Facial Gingival Level Following Single Immediate Implant Placement and Provisionalization in the Esthetic Zone: A 1-Year Randomized Controlled Prospective Study. Int J Oral Maxillofac Implants. 2014;29(2):432–40.

20. Deesricharoenkiat N, Jansisyanont P, Chuenchompoonut V, Mattheos N, Thunyakitpisal P. The effect of acemannan in implant placement with simultaneous guided bone regeneration in the aesthetic zone: a randomized controlled trial. Int J Oral Maxillofac Surg. 2022 Apr 1;51(4):535–44.

21. Ghallab NA, Elaskary A, Elsabagh H, Toukhy A El, Abdelrahman H, El-Kimary G. A novel atraumatic extraction technique using vestibular socket therapy for immediate implant placement: a randomized controlled clinical trial. Oral Maxillofac Surg. 2023 Sep 1;27(3):497–505.

22. Blus C, Szmukler-Moncler S. Atraumatic tooth extraction and immediate implant placement with Piezosurgery: evaluation of 40 sites after at least 1 year of loading. Int J Periodontics Restorative Dent. 2010 Aug;30(4):355-63.

23. Atieh MA, Shah M, Abdulkareem M, AlQahtani HA, Alsabeeha NHM. The socket shield technique for immediate implant placement: A systematic review and meta-analysis. J Esthet Restor Dent. 2021 Dec;33(8):1186-1200.

24. Chan HL, George F, Wang IC, Suárez López del Amo F, Kinney J, Wang HL. A randomized controlled trial to compare aesthetic outcomes of immediately placed implants with and without immediate provisionalization. J Clin Periodontol. 2019 Oct 1;46(10):1061–9.

25. Zuiderveld EG, van Nimwegen WG, Meijer HJA, Jung RE, Mühlemann S, Vissink A, et al. Effect of connective tissue grafting on buccal bone changes based on cone beam computed tomography scans in the esthetic zone of single immediate implants: A 1-year randomized controlled trial. J Clin Periodontol. 2021 Apr 1;92(4):553–61.

26. Testori T, Weinstein T, Scutellà F, Wang HL, Zucchelli G. Implant placement in the esthetic area: criteria for positioning single and multiple implants. Periodontol 2000. 2018 Jun;77(1):176-196.

27. Fernandes D, Marques T, Borges T, Montero J. Volumetric analysis on the use of customized healing abutments with or without connective tissue graft at flapless maxillary immediate implant placement: A randomized clinical trial. Clin Oral Implants Res. 2023 Sep 1;34(9):934–46.

28. MacBeth ND, Donos N, Mardas N. Alveolar ridge preservation with guided bone regeneration or socket seal technique. A randomised, single-blind controlled clinical trial. Clin Oral Implants Res. 2022 Jul 1;33(7):681–99.

29. Couso-Queiruga E, Weber HA, Garaicoa-Pazmino C, Barwacz C, Kalleme M, Galindo-Moreno P, et al. Influence of healing time on the outcomes of alveolar ridge preservation using a collagenated bovine bone xenograft: A randomized clinical trial. J Clin Periodontol. 2023 Feb 1;50(2):132–46.

30. Scheyer ET, Heard R, Janakievski J, Mandelaris G, Nevins ML, Pickering SR, et al. A randomized, controlled, multicentre clinical trial of post-extraction alveolar ridge preservation. J Clin Periodontol. 2016 Dec 1;43(12):1188–99.

31. Borgia GS, Pebé P, Barbot R, Haas AN. Immediate implants with buccal defects filled with bone from the tuberosity or a xenograft: 1-year randomized trial. Braz Oral Res. 2022 Jul 11;36:e102.

32. Fernandes D, Nunes S, López-Castro G, Marques T, Montero J, Borges T. Effect of customized healing abutments on the peri-implant linear and

volumetric tissue changes at maxillary immediate implant sites: A 1-year prospective randomized clinical trial. Clin Implant Dent Relat Res. 2021 Oct 1;23(5):745–57.

33. Ragucci GM, Elnayef B, Criado-Cámara E, Del Amo FS, Hernández-Alfaro F. Immediate implant placement in molar extraction sockets: a systematic review and meta-analysis. Int J Implant Dent. 2020 Oct 13;6(1):40.

34. Noelken R, Moergel M, Kunkel M, Wagner W. Immediate and flapless implant insertion and provisionalization using autogenous bone grafts in the esthetic zone: 5-year results. Clin Oral Implants Res. 2018 Mar 1;29(3):320–7.

35. Heimes D, Schiegnitz E, Kuchen R, Kämmerer PW, Al-Nawas B. Buccal Bone Thickness in Anterior and Posterior Teeth-A Systematic Review. Healthcare (Basel). 2021 Nov 30;9(12):1663.

36. Amid R, Kadkhodazadeh M, Moscowchi A. Immediate implant placement in compromised sockets: A systematic review and meta-analysis. J Prosthet Dent. 2023 Sep;130(3):307-317.

37. Meijer HJA, Slagter KW, Vissink A, Raghoebar GM. Buccal bone thickness at dental implants in the maxillary anterior region with large bony defects at time of immediate implant placement: A 1-year cohort study. Clin Implant Dent Relat Res. 2019 Feb 1;21(1):73–9.

38. ElAskary A, Elfana A, Meabed M, Abd-ElWahab Radi I, Akram M, Fawzy El-Sayed K. Immediate implant placement utilizing vestibular socket therapy versus early implant placement with contour augmentation for rehabilitation of compromised extraction sockets in the esthetic zone: A randomized controlled clinical trial. Clin Implant Dent Relat Res. 2022 Oct 1;24(5):559–68.

39. Cochrane. Methods for Risk of Bias 2 (RoB 2) Tool. Available online: https://methods.cochrane.org/risk-bias-2 (accessed on 3 January 2024).

40. Slagter KW, Meijer HJA, Bakker NA, Vissink A, Raghoebar GM. Immediate Single-Tooth Implant Placement in Bony Defects in the Esthetic Zone: A 1-Year Randomized Controlled Trial. J Periodontol. 2016 Jun;87(6):619–29.

41. Slagter KW, Meijer HJA, Hentenaar DFM, Vissink A, Raghoebar GM. Immediate single-tooth implant placement with simultaneous bone augmentation versus delayed implant placement after alveolar ridge preservation in bony defect sites in the esthetic region: A 5-year randomized controlled trial. J Periodontol. 2021 Dec 1;92(12):1738–48.

42. Hamed MM, El-Tonsy MM, Elaskary A, Abdelaziz GO, Saeed SS, Elfahl BN. Effect of three different grafting materials on immediate implant placement using vestibular socket therapy in class II extraction sockets in the maxillary

esthetic zone: a randomized controlled clinical trial. BMC Oral Health. 2023 Dec 1;23(1).

43. Ortega-Martínez J, Pérez-Pascual T, Mareque-Bueno S, Hernández-Alfaro F, Ferrés-Padró E. Immediate implants following tooth extraction. A systematic review. Med Oral Patol Oral Cir Bucal. 2012 Mar 1;17(2):e251-61.

44. Mizuno K, Nakano T, Shimomoto T, Fujita Y, Ishigaki S. The efficacy of immediate implant placement in the anterior maxilla with dehiscence in the facial alveolar bone: A case series. Clin Implant Dent Relat Res. 2022 Feb;24(1):72-82.

45. Denardi RJ, da Silva RD, Thomé G, Andrighetto AR, de Freitas RM, Shimizu RH, Shimizu IA, Melo ACM. Bone response after immediate placement of implants in the anterior maxilla: a systematic review. Oral Maxillofac Surg. 2019 Mar;23(1):13-25.

46. 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.

47. Mello CC, Lemos CAA, Verri FR, Dos Santos DM, Goiato MC, Pellizzer EP. Immediate implant placement into fresh extraction sockets versus delayed implants into healed sockets: A systematic review and meta-analysis. Int J Oral Maxillofac Surg. 2017 Sep;46(9):1162-1177.

48. Bakkali S, Rizo-Gorrita M, Romero-Ruiz MM, Gutiérrez-Pérez JL, Torres-Lagares D, Serrera-Figallo MÁ. Efficacy of different surgical techniques for peri-implant tissue preservation in immediate implant placement: a systematic review and meta-analysis. Clin Oral Investig. 2021 Apr;25(4):1655-1675.

49. Meijer HJA, Slagter KW, Vissink A, Raghoebar GM. Buccal bone thickness at dental implants in the maxillary anterior region with large bony defects at time of immediate implant placement: A 1-year cohort study. Clin Implant Dent Relat Res. 2019 Feb 1;21(1):73–9.

50. Yoda N, Zheng K, Chen J, Li W, Swain M, Sasaki K, et al. Bone morphological effects on post-implantation remodeling of maxillary anterior buccal bone: A clinical and biomechanical study. J Prosthodont Res. 2017 Dec 1;61(4):393–402.

51. Tsuda H, Rungcharassaeng K, Kan JY, Roe P, Lozada JL, Zimmerman G. Peri-Implant Tissue Response Following Connective Tissue and Bone Grafting in Conjunction with Immediate Sigle Tooth Replacement In The Esthetic Zone: A Case Series. Int J Oral Maxillofac Implants. 2011;26:427-36.

52. 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.

53. Puisys A, Auzbikaviciute V, Vindasiute-Narbute E, Pranskunas M, Razukevicus D, Linkevicius T. Immediate implant placement vs. early implant treatment in the esthetic area. A 1-year randomized clinical trial. Clin Oral Implants Res. 2022 Jun 1;33(6):634–55.

54. 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.

55. Rondone EM, Leitão-Almeida B, Pereira MS, Fernandes GVO, Borges T. The Use of Tissue Grafts Associated with Immediate Implant Placement to Achieve Better Peri-Implant Stability and Efficacy: A Systematic Review and Meta-Analysis. J Clin Med. 2024 Jan 31;13(3):821.

56. De Cunto R, Ruscica C, Franceschi L, Massaglia MM, Bellantoni G, Leone M. Comparison of the pink esthetic score between the digital and analogical workflow. DoctorOs. 2022 Jul 12.

57. Capparé P, Ferrini F, Ruscica C, Pantaleo G, Tetè G, Gherlone EF. Digital versus traditional workflow for immediate loading in single-implant restoration: A randomized clinical trial. Biology (Basel). 2021 Dec 1;10(12).

58. Borges T, Fernandes D, Almeida B, Pereira M, Martins D, Azevedo L, et al. Correlation between alveolar bone morphology and volumetric dimensional changes in immediate maxillary implant placement: A 1-year prospective cohort study. J Clin Periodontol. 2020 Sep 1;91(9):1167–76.

59. Franchignoni M, Giordano A, Brigatti E, Migliario M, Levrini L, Ferriero G. Proprietà psicometriche della versione italiana dell'Oral Health Impact Profile forma ridotta (OHIP-14) [Psychometric properties of the Italian version of the reduced form of the Oral Health Impact Profile (OHIP-14)]. G Ital Med Lav Ergon. 2010 Jul-Sep;32(3 Suppl B):B71-8. Italian.

60. Delgado DA, Lambert BS, Boutris N, McCulloch PC, Robbins AB, Moreno MR, Harris JD. Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. J Am Acad Orthop Surg Glob Res Rev. 2018 Mar 23;2(3):e088.

8. ANNEXES

VIII. ANNEXES

Submission of the systematic review on Prospero.

Status: Registered.

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