Acta Scientific Dental Sciences (ISSN: 2581-4893)

Volume 5 Issue 2 February 2021

Research Article

Updated Protocols in Immediate Post Extraction Implants

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DOI: 10.31080/ASDS.2020.05.1029

Received: October 14, 2020

Published: January 28, 2021

Abstract

Background: Nowadays Immediate Implants represent a widely spread and predictable treatment option; but, different protocols have been proposed along the years and it is still debated which of them could lead to better results.

Objectives: The objective of our study is to analyze the updated guidelines to follow when placing immediate implants and to discuss the esthetic and functional results obtained. We will investigate the surgical and the prosthetic protocols individually and combined each other taking into account the follow up period and the survival rate.

Materials and methods: The research was performed on Pub-Med and Med-Line. Applying all of the inclusion and exclusion criteria 13 articles have been collected with a total of 893 subjects and 1193 implants placed. For each of the articles we gathered the surgical and the prosthetic protocol, the implant design, the follow up, the survival rate, the bone loss, the functional and aesthetic values.

Results and Discussion: After analysing different articles proposing alternative treatment options we observed that: The most used surgical techniques were the Flapless without Guided bone regeneration (46%) and the Flapless with guided bone regeneration (33%); The prevalent prosthetic protocol used was the Immediate loading (76%); The most frequent implant design was the Tapered one with Platform switching; The survival rate of immediate implants ranged from 97,4% to 100%. Finally we discussed and compared the results obtained focusing on our objectives.

Conclusion: Depending on the socket situation, either a Flapless or a Flap elevation+ Guided bone regeneration + Connective tissue graft or collagen membrane would be a good option. Less bone loss was observed for the Flap+ Guided bone regeneration+ Connective tissue graft +Delayed loading and Flapless +Guided bone regeneration+ Connective tissue graft+ Immediate loading techniques, showing the second one an higher PES value together with the Socket shield technique. Considering the limitations of our research, further studies are needed.

Keywords: Immediate Implants; Post-Extraction Implants; Bone- Grafting; Socket Preservation; Immediate Loading; Delayed Loading

Abbreviations

IIP: Immediate Implant Placement; GBR: Bone Grafting; CTG: Connective Tissue Grafting; CM: Collagen Membrane; SST: Socket Shield Technique; IL: Immediate Loading; DL: Delayed Loading; PES: Pink Esthetic Score

Introduction

Patient satisfaction together with rapid treatment execution, represents the main source of gratification for a dentist. Over the years, oral implantology has moved forward, getting increasingly

closer to the above mentioned objectives, with the introduction of the concept of Immediate implant placement.

When Branemark in 1960 first described osseointegration as " a direct connection between living bone and a load-carrying endo-osseous implant", he assumed that an healing period of 4 to 6 months was required before implant insertion [1]. More than ten years later, Schulte and Heimke described a new protocol of implant placement into fresh sockets immediately after tooth extraction, which was applied for the first time on humans by Lazzara in 1989. This new approach aimed at significantly reducing treatment time so as to increase patient comfort [2].

Nowadays this technique is considered highly predictable and several articles reported an extremely high success rate raging from 95% to 100%; results which are comparable to that of implant placed in healed sites [3].

According to the classification of Hammerle., *et al*.:

This type of implants, inserted in the same surgical procedure as extraction, are categorized as Type I implants (Immediate implants);

Implants inserted from 4 to 8 weeks after extraction and after soft tissues healing are named Type 2 implants (Early implants);

Implants inserted after partial bone healing (from 12 to 16 weeks) are Type 3 implants (Early implants);

Type 4 implants are the ones placed in healed sites, from 3 to 4 months after tooth extraction (Delayed implants) [4].

Indications and contraindications

Although this technique provides several advantages both for the patient and the practitioner, some specific criteria must be fulfilled in order to achieve effective results (Table 1). First of all, for an immediate implant placement it is important to achieve an adequate primary stability, which is defined as an absence of implant mobility in the bone socket in a lateral, axial, and rotational direction immediately after its insertion and it can be influenced by several factors including bone density and quantity, the surgical technique used, the implant characteristics and the osteotomy size [5]. On that purpose it is important to evaluate the amount of bone available after tooth extraction and it has been observed that at least 4 to 5 mm of bone apically beyond the fresh extraction socket and a thick palatal wall is needed to favor the mechanical engagement between bone and implant [6]. Another important concerning of this technique is the esthetic outcome, so it is indicated to select patients with the following characteristics: A thick gingival biotype and an intact buccal wall with a thickness of >1 mm in order to reduce the risk of fenestration, dehiscence and soft-tissue recession [7]. The reason for tooth extraction also plays an important role; in fact, it is indicated to immediately place implants in case of extraction of residual temporary teeth, horizontal and vertical root fractures, endodontics failures, non-restorable teeth and avulsion of teeth by traumas, even though in all of these situations it is important to consider a possible buccal wall fracture and in that case it would be a relative contraindication together with periodontal disease and smoking patients. Among the absolute contraindications (Table 1) we can find: absence of adequate amount of bone apically and palatal, excessive proximity to vital elements, not controlled systemic diseases and acute infections [7,8]. There are still controversial opinions regarding post-extractive implant placement in infected sites; some authors believe that a high success rate can be achieved and propose a new Laser technology for the decontamination of the socket, but further investigations are needed [2].

Indications	Contraindications	Relative contraindications
4-5mm of bone apically	Absence of adequate bone apically and palatal	Extraction due to: Residual temporary teeth Horizontal/vertical fractures Endodontic failure Non-restorable teeth Trauma (if buccal wall is fractured)
Thick palatal wall	Proximity to vital elements	Smoking
Thick gingival biotype	Non-controlled systemic disease	Periodontal diseases
Buccal wall > 1mm	Acute infections	

Table 1: Indications and contraindications for immediate implants [2,6-8].

Advantages and disadvantages

Focusing on the advantages of this method (Table 2) compared with the traditional one, we can state that it is a faster approach because the healing of the bone after the extraction and the osseointegration process happens at the same time and also it requires less surgical procedures. Another high point of immediate implants are the great esthetic results that can be achieved by preserving the buccal wall of the extraction socket; this can lead to a better stabilization of the soft tissues around the implant thus reducing the gingival recession and improving the general gingival profile [9]. Nowadays it is highly agreed that even though a slight bone resorption cannot be avoided, immediate implant placement significantly reduce it [10]. An important aspect to consider is the possibility of having a direct visualization of the socket limits so that to allow a correct inclination of the implant; on the other hand, the osteotomy can result more insidious due to the bur shifting over the palatal wall. Lastly, a great psychological advantage is provided by the fact that the patient will never be in a "transitional state" with or without teeth leading to a major satisfaction [8].

Advantages	Disadvantages
Fast method	Hard to achieve adequate primary stability
Less surgical procedures	Traumatic tooth extraction
High esthetic results	Incomplete soft tissue coverage
Reduced gingival recession	Increase in price due to additional grafting procedures
Direct visualization of socket limits	
Psychological advantage	

Table 2: Advantages and disadvantages of immediate implants [8-10].

Although all of the benefits of this procedure, it is very hard to achieve a correct primary stability of the implant because most of the times a gap between the implant and the socket wall is present thus reducing the implant- bone contact. Then an incorrect extraction procedure can lead to buccal and palatal wall expansion or a buccal wall fracture making it harder the success of the technique; this could be the case of harder situations like Ankylosed teeth. Sometimes incomplete soft tissue coverage can compromise the results and a soft tissue grafting could be required, but the price of the grafting procedures can increase the overall cost of the treatment constituting a potential disadvantage (Table 2) [8].

Implant geometry and surface preparation

As already mentioned, primary stability is the cornerstone of immediate implant placement and, in addition to the amount of bone available apically and palatal, it can be influenced by other factors including the implant macro-design, the surface preparation (implant micro-design), the implant length and width.

It is believed that implant geometry is crucial for the stabilization of the blood clot formed in between the socket wall and the implant surface, which is essential for the bone apposition [11]. Since Branemark first proposed cylindrical implants, so many advantages in macro-geometry have been done, getting now to the so called Tapered implants which seems to be one of the most used for the immediate implant surgical technique. They present a divergent design; the coronal width is bigger and it gradually diminish going toward the apex resembling the natural dental root shape; the apical part can present deeper cutting threads that favor insertion and stabilization, and the coronal part of the implant present squared threads that are able to enhance bone condensation (Figure 1) [3]. Some authors propose the use of implants with a micro-thread design at the marginal bone level, but it is still debated whether this characteristic can lead to better results compared to alternative implant neck configurations [11].

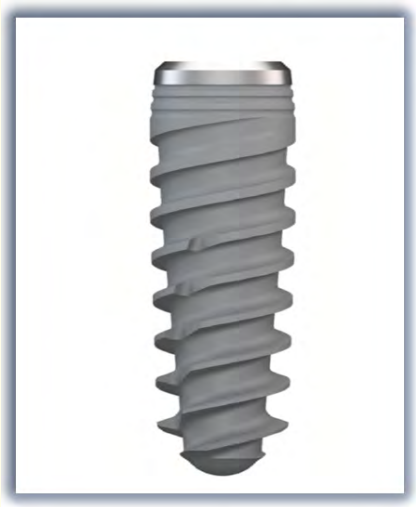

Figure 1: Tapered macro-design of immediate implants with deep apical threads [3].

New implant designs such as custom-made and hybrid macro-geometry implants are developing giving positive feedbacks, but still they have not been applied in clinical human cases. The hybrid macro-geometry consist of a coronal portion which presents a cylindrical shape and it is narrower than the apical portion which is tapered; this conformation permits to achieve great primary stability thanks to the apex and to reduce the stress at the crestal level leaving space for the blood clot to form [12].

Another important factor to consider is the surface preparation of an implant; in the past, implants used to have a machined surface, that means turned, milled or polished manufacturing processes and the defects over these implant allowed the osteogenic cells to grow and generate a bone to implant interface, but the healing time was from 3 to 6 months. Nowadays more surface preparation techniques have been introduced such as the subtractive methods like sand-blasting, grit-blasting (with titanium oxide, calcium phosphate and alumina), acid etching and the additive methods as titanium plasma spry; they present more micro- irregularities that lead to an increase in bone to implant contact. There is no evidence confirming that one technique is better than the other [13].

According to the classification of Smith and Tarnow, it is important to choose the implant diameter in relation to the existing gap between the implant surface and the socket wall, it is for that, in case of absence of septal bone, a wide diameter implant should be preferred [13]. Increasing the diameter can favor the engagement with the surrounding wall, but, we should be careful not to compromise the " jumping space" because we can undermine the osso-integration process and the buccal plate reshaping by inducing necrosis of the surrounding tissues [12].

In general:

- In the posterior sector a wide diameter is preferred to increase primary stability
- In the upper anterior sector, short and narrow implants can be used due to the high esthetic demand and the possibility of damaging the thin buccal wall [14].
- Long and narrow implants can be used in practice, but we should be aware of the anatomical limitations such us the nasal floor, the sinuses, the inferior alveolar nerve and the adjacent roots [12].

Surgical and prosthetic protocols

In recent years, both the surgical and prosthetic protocol of immediate implant placement have improved a lot with the common end of increasing the success rate (and so the functional and esthetic outcome), together with the further reduction of the treatment time. Before starting with the surgical procedure, the patient should undergo an antibiotic prophylaxis with Amoxicillin and Clavulanic acid during one week.

Subsequently, after having performed an adequate local anesthesia, the clinician can proceed with the tooth extraction that should necessarily be atraumatic; it is fundamental to maintain the cortical bone as intact as possible. On that purpose, it is preferable not to apply too much strength on the facial bone wall and to use devices such as periotomes, luxators and piezo-surgery; in case these instruments cannot be applied, the tooth should be separated longitudinally in an orofacial direction in order to extract the tooth fragments independently [14]. In addition, there are two ways of managing soft tissues; the first one is a flapless approach which is more conservative since it doesn't disrupt the blood supply from the underlying periosteum, the second one is a more aggressive approach and consists of raising a flap to have access to the socket, but in order to limit the bone resorption, most of the times it is necessary to introduce a bone graft to maintain the alveolus structure as stable as possible [7,15]. The gold standard for grafting procedure in immediate implants is considered the Autologous bone, but it has been demonstrated that a combination of the latter with polylactic polyglycolic acid polymer alloplast or lyophilized demineralized bovine bone granules also achieve optimal results; moreover the application of membranes also seems to improve the final effect, regardless if they are resorbable or non resorbable [10,16].

As far as the soft tissue augmentation procedures, the use of autologous connective tissue seems to be the best choice since it reduces the risk of complication that can be induced by synthetic materials. Also the use of rotational palatal flap is a good option to increase the final esthetic because it maintains some of the blood supply and so it reduces a potential bone resorption [17].

As previously mentioned in the indications of immediate implants, in order to achieve an adequate primary stability, a certain amount of bone apically and a thick enough palatal wall are required to permit an implant inclination of maximum 3 mm toward

palatal to favor the mechanical engagement and to leave a "jumping distance" within the implant and the buccal plate of at least 2 mm; this helps in the bone remodeling process. Also the cervico-apical depth of the implant plays an important role; in fact, it has been demonstrated that placing the implant juxta osseous or 1-2 mm infra osseous could ensure peri-implant bone preservation and limit the risk of implant exposition. According to Madani., *et al.* [18], the optimal implant depth is 1,08 mm sub crestal especially when platform-switching implants are used. The platform switching concept (Figure 2) can be defined as the application of an abutment which presents a smaller diameter compared to that of the implant platform and it has been observed that this characteristic allows bone apposition over the implant shoulder and an increased stabilization of the soft tissue [18].

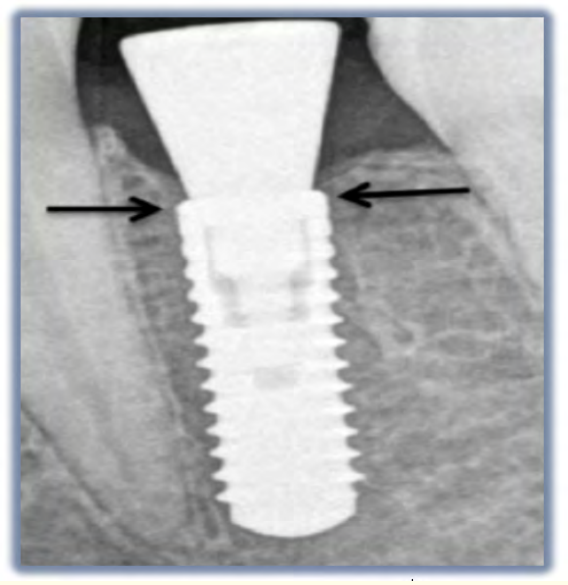

Figure 2: Platform switching implants [19].

Nowadays, new techniques are raising with the aim of preserving the socket wall and so to improve the esthetic results; one of them is the "Socket-shield technique" (Figure 3) which was first introduced by Hurzeler., *et al*. and it consists of leaving the buccal part of the root in its place on the labial bone plate, ideally with a flapless procedure not to impair the blood supply, and a bone graft in between the residual root and the implant surface. This new method has been introduced with the aim of maintaining the marginal bone level and the peri-implant soft tissue, but still more investigations are needed to prove its efficacy [20].

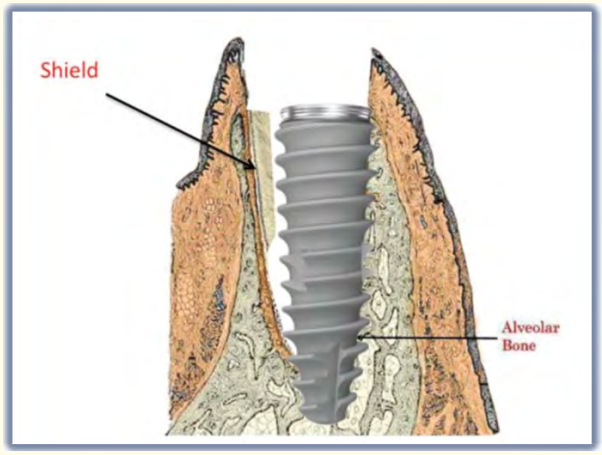

Figure 3: Socket shield technique [8].

For post-extractive implants, the site preparation is considered a demanding procedure, because, even though the limits of the socket are visible, the implant require a specific palatal inclination that most of the times is difficult to achieve since the socket diameter is bigger than that of the drill and the surface is irregular leading to a shifting of the bur [4]. The conventional drilling protocol consists of incrementing the bur diameter gradually up to get to 1 mm less than that of the implant, but it is believed that the enhanced attrition with the rotating burs can lead to an overheating of the surrounding bone inducing a necrosis, an increase in bone loss and consequently an implant failure; therefore, a new protocol was introduced which consists of one single cylindro-tapered bur with 4 cutting blades and a canal between the cutting threads. It is recommended to use a pilot drill before this single bur in order to drive it in the preparation [4].

Another more conservative approach is the Biological drilling which is characterized by low speed bur rotations and no irrigation is required; this allow us to collect autologous bone graft (with maintained cellular vitality) and prevent overheating of surrounding bone [21].

Moving to the prosthetic protocol, there are two different approaches that have been proposed: The first one is the immediate

loading which means that the provisional is placed as soon as the implant is inserted into the socket; the second is the delayed loading which means that the provisional restoration occurs within months from the implant placement. In order to immediately load an implant, it is necessary to have a sufficient primary stability to prevent possible micromovement that can compromise the success of the immediate implant; it is for that, the minimum insertion torque (IT) of the implant should be ≥ 45 N cm and the implant stability quotient (ISQ) should be at least ≥ 70 N cm at the time of the provisional placement [22]. The superiority of one prosthetic protocol compared to the other is still debated also because more long term studies are needed. In order to further increase the soft tissue stabilization over the restoration of immediate implants, new solutions are developing and among them we can find custom-fit abutments which are created using the natural tooth shape as a template. The advantages of this techniques are that a continuous healing of the soft-tissue is provided with a natural emergence profile and that all the necessary information are obtained through intraoral scanners eliminating the use of impression materials and plaster models [23].

As we can see, post extractive implants represents an advantageous solution to replace missing teeth; but, it is important to follow specific indications in order to achieve the desired results and above all, an adequate treatment protocol should be applied in relation to the situation we are facing. As previously mentioned, several surgical and prosthetic options have been adopted along the years and new ideas are raising to strengthen this technique, some of them have been widely accepted, while others are still debated. Our research will focus mainly on comparing different protocols with the aim of investigating this discrepancy of opinions.

The objective of our study is to analyze the updated guidelines to follow when placing immediate implants and to discuss the esthetic and functional results obtained. On that purpose, we will:

- Investigate the fundamentals of post-extractive implant surgical act analyzing aspects such us implant design, and comparing different techniques including the Flap or Flapless one, the use or not of GBR and the use or not of a Soft tissue grafting; we will also take into account the outcomes of a new surgical technique called Socket shield.
- Assess the different options of post-extractive implants prosthetic protocol considering the Immediate Loading and the Delayed Loading.
- Discuss the functional and esthetic outcomes of each surgical and prosthetic protocol combination in order to identify what may be a beneficial treatment option for immediate implants. Then we will analyze the survival rate at follow up for each case.

Materials and Methods

The entire research was performed using the platforms of PubMed and Med-Line introducing the following keywords " immediate implants", "post-extraction implants", "bone- grafting", " socket preservation", "immediate loading", "delayed loading", "implant macro-structure", "implant micro-structure", "socket shield technique", "platform switching implants", " primary stability".

Inclusion criteria

- Articles from 2016 to 2019
- Systematic reviews, Cohort studies, Case series and Randomized clinical trials.
- Languages: Italian, Spanish and English
- Evidence of at least 10 patients for article to demonstrate or reject the hypothesis of the research.
- Follow-up period of at least 6 months.

Exclusion criteria

- All the criteria that don't comply with the inclusion ones.
- All of the articles with limited access.
- Experiments performed on animals.
- All of the articles in which the applied protocols were not specified properly.

Applying all of the inclusion and exclusion criteria 13 articles have been collected with a total of 893 subjects and 1193 implants. The data obtained have been summarized in table 3 considering the following variables:

- The gender: M (male), F (female).
- The number of patients included in the research .
- The number of implant placed in each case (i).
- The surgical protocol: IIP, GBR or not, flap or flapless approach, use or not of CTG or CM and SST.
- The prosthetic protocol: IL or DL.

- The type of implant selected for the case (micro-design and macro-design) including the type of platform and the surface preparation technique.
- When possible the amount of bone loss after the surgery and the loading, expressed in "mm".
- The functional and the esthetic value at follow up. They have been expressed in three different ways: 1) PES; 2) Making a comparison between different groups (with different techniques); 3) A percentage (%).
- The survival rate of the post extraction implants (expressed in %)

Authors and year	N° of patients	Gender	N° of implants placed	Surgical protocol	Prosthetic protocol	Implant design/ surface	Follow up	Bone loss (mm)	Functional and esthetic value (pes)	Survival rate (%)
Arora., *et al.* [24] 2018	40	16 (M) 24 (F)	40	(A) 20 i: IIP+ GBR+ Flapless (B) 20 i: IIP+ GBR+ Flap + Collagen membrane	(A)IL (B)DL	- Cylindrical tapered - Platform switching - Coronal micro threads	3y.	(A) - 0.05 mesial. - 0.06 distal. (B) - 0.30 mesial. - 0.21 distal.	PES: Group A(11.1) > Group B(10.3)	100%
Velasco ortega., *et al.* [25] 2018	56	28 (M) 28 (F)	116	IIP +Flapless (without GBR)	IL	- Tapered - Platform switching - Sand blasted, acid etched surface. - Tapered - Screw shape	4y.	From 0 to 1.6	100%	97.4%
Sethi., *et al.* [26] 2017	274	---	375	IIP +Flapless (without GBR)	IL	- Tapered - Deep threads.	3y.	---	---	97.6%

Khorsand., *et al*. [11] 2016	30	12 (M) 18 (F)	41	IIP +Flap (without GBR)	DL	- Tapered - Platform switching - Send blasted, acid etched surface. - (A)22i: Standard threads - (B) 19i: Coronal micro threads	1y.	(A=B): 0.1-1.6	---	100%
Bettach., *et al*. [4] 2018	133	54(M) 79(F)	261	(A) 165 i: IIP +Flapless (GBR if necessary) (B) 96 i: IIP+ Flap (GBR if necessary)	(A)IL (B)DL	- Cylindrical-tapered - Platform switching - Send blasted, acid etched surface. - Large threads	1y.	(A)0.48 (B)0.52	Esthetic: -Excellent 85.6% - Poor 2.5%	(A)98.8% (B)99%
Bramanti., *et al*. [20] 2018	40	---	40	(A) 20 i: IIP +Flapless (B) 20 i: IIP+ Flapless +GBR+ Socket shield technique	(A=B): IL	- Apical macro threads	3y.	(A)1.12 (B)0.60	PES: Group B(12.15)> Group A(10.3)	100%
Amato., *et al*. [15] 2018	77	29(M) 48(F)	80	Flapless for all the groups: (1) 13 i: No GBR (2) 13 i: GBR (3) 20 i: No GBR (4) 34 i: GBR	(1)DL (2)DL (3)IL (4)IL	- Tapered - Screw shape - Platform switching	6m.	(1)2.07 (2)0.82 (3)0.48 (4)0.27	> Group 4	100%

Redemagni., *et al*. [17] 2019	14	5(M) 9(F)	14	IIP+ Flap + GBR+ collagen membrane	IL	- Tapered - Platform switching	1y.	0.2	Maintain original gingival architecture	100%
Kolerman., *et al*. [28] 2016	39	16(M) 23(F)	38	IIP+ Flapless + GBR	IL	- Tapered - Acid etched, sand blasted	4y.	1.17	PES: 7.92 (range:5-10)	97.4%
Kolerman., *et al*. [29] 2016	34	14(M) 20(F)	34	IIP+ Flap+ GBR+ Collage membrane + Connective tissue graft	IL	- Tapered - Platform switched implants	2y.	-1.10 mesial -1.19 distal	---	100%
Groenedijk., *et al*. [30] 2019	100	41(M) 57(F)	98	IIP+ GBR+ Flapless	DL	-Tapered - Platform switching	1y.	---	PES: 12.1	100%
Sun., *et al*. [31] 2019	30	23(M) 7(F)	30	(A) 15 i: IIP+ Socket shield technique+ GBR (B) 15 i: IIP+ Flapless + GBR	(A=B) IL	-Tapered - Platform switching	2y.	(A) 1.23 (B) 2.00	PES: Group A(12.07)> Group B(11.33)	100%
Noelken., *et al*. [32] 2018	26	14(M) 12(F)	26	(A) 13 i: IIP+ Flapless +GBR (B) 13 i: IIP+ Flapless + GBR+ connective tissue graft	(A=B) IL	-Tapered	3y.	(A) 0.70 (B) 0.30	PES: Group B(13)> Group A(12.2)	100%

Table 3: Summary of the articles selected.

Results

With regard to the articles found, 1193 implants have been placed in 893 subjects, subdivided in 252 males and 325 females (for the rest of the individuals the sex was not specified).'

The surgical and prosthetic protocols were distributed as follows.

Surgical protocol distribution

In this systematic review, one of the variables to take into account is the type of surgical protocol applied in each case. Analyzing all of the selected articles, the surgical protocols have been divided in two main groups depending on the use of a Flap or Flapless technique; then they have been subdivided in the following way:

- Flap technique: (A)With GBR; (B)Without GBR; (C)With GBR + CTR or CM.
- Flapless technique: (A)With GBR; (B)Without GBR; (C)With GBR + CTR; (D)With SST.

In Figure 4 it is possible to observe the distribution of the surgical protocols; in particular we can see that the most used techniques were the Flapless without GBR(46%) and the Flapless with GBR (33%).

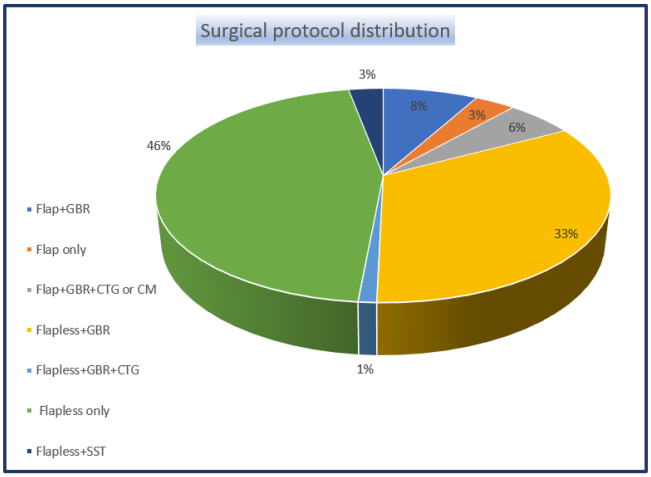

Figure 4: Surgical protocols types and distribution (expressed as a percentage) for immediate implant placement.

Prosthetic protocol distribution

As shown in figure 5, the prosthetic protocol has been simply divided in Immediate Loading (IL) and Delayed Loading (DL), being the first one the most used in the selected articles(76%).

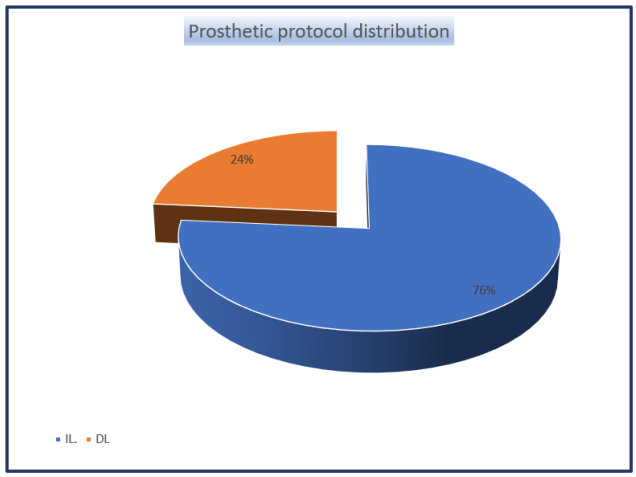

Figure 5: Prosthetic protocols types and distribution for immediate implant placement.

Prevalence of implant design and surface preparation

Over a total of 1193 implants immediately placed in these studies, the majority of them were with a Tapered body (1153),with a platform switching (714) and a sand blasted, acid etched surface (456). A small amount of implants presented Coronal micro threads(59) (Figure 6).

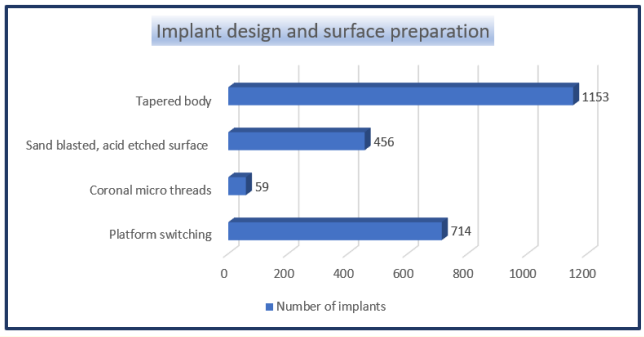

Figure 6: Number of implants with a specific design and surface preparation.

Immediate implants survival rate

As it is possible to observe in figure 7, nowadays the survival rate of immediately placed implants is really high; it ranges from 97,4% to 100%.

Figure 7: Survival rate of immediate implants in the selected articles.

Mean bone loss in relation to surgical and prosthetic protocol

In figure 8, it has been summarized the mean bone loss of each surgical protocol applied in combination with the prosthetic one. From the graph we can observe that the procedures that lead to a major reduction in bone loss are the Flap + GBR + CTG + DL and the Flapless + GBR + CTG + IL with a mean of 0,3 mm loss. The worst value is represented by the Flapless procedure with DL (2,1 mm). The rest of the procedures range from 0,5 to 0,9 mm of bone loss.

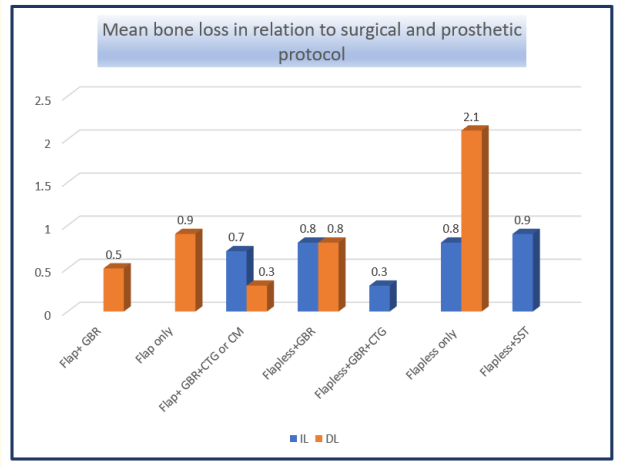

Figure 8: Mean bone loss in relation to the surgical and prosthetic protocol.

Discussion

The concept of post- extractive immediate implant placement dates back to 1970s; since then, this technique has shown to have several advantages compared to the traditional ones and with time it has been modified and improved with the aim of granting a successful outcome for the patient [15]. In order to propose a reliable technique to follow for this procedure, we will analyse different articles proposing alternative treatment options and we will discuss and compare the results obtained.

The first step to consider when applying an immediate insertion protocol, is the selection of the implant. As we can observe from the results in figure 6, in the majority of cases, implants with a tapered body and a platform switching design has been chosen. According to Cucchi., *et al.* [3], a big incongruence in shape between the implant body and the socket can interfere with primary stability, for that reason it is important to use an implant that resemble as much as possible the root shape and it is the case of the Tapered one with the additional use of apical deep threads to favour stabilization. The same authors promote the use of a platform switching assuming that they present an excellent biological seal, maintain the soft tissue thickness and serves as a barrier to microbials [3]. In support of the previously mentioned hypothesis, Milillo., *et al.* [9] affirm that tapered implant with Platform switching increase the Implant Stability Quotient (ISQ), thus improving osseointegration and reducing healing time; in addition, this type of platform helps to distribute the mastication strains in the implant neck and framework. Velasco- Ortega., *et al.* [25], confirm that this type of implant configuration leads to a more rapid bone formation and favour the maintenance of the crestal bone level, focusing particular attention to the deep threads that increase the initial fixation of the implant. They also concluded that implant roughened surfaces by acid-etching and sand-blasting procedures produce an increased bone response; in fact more differentiated osteoblasts are present on prepared surfaces compared to smooth ones [25]. A similar opinion is shared by Bettach., *et al.* [4] who affirm that a completely acid etched and sand blasted surface can reduce the amount of bone loss, the implant-abutment micro gap and the implant-bone distance. However, in the same article the authors suggest that there is not a sufficient evidence that confirm a superiority of roughened implant neck compared to machined ones in marginal bone preservation; but, coronal micro-threads seems to achieve slightly better results [4]. In contrast, other studies failed to demonstrate that

higher outcomes are obtained with coronal micro-threads, showing that a similar bone resorption pattern is obtained with or without micro-threads, so this debate still remains unsolved and more studies are needed to get to a conclusion [11].

The following aspect to consider before placing immediate implants, is the selection of the surgical procedure and the respective loading protocol we want to apply in order to achieve the best aesthetic and functional results as possible. First of all, we should assess the presence or not of a residual buccal bone defect after tooth extraction because, depending on this, a different treatment would be followed [25,27]. Considering a situation in which the buccal bone level is acceptable, according to Amato., *et al*. [15], in most cases a flapless approach is preferred compared to raising a flap because it enables us to maintain intact the periosteal attachment and so the blood supply, reducing bone resorption. In addition, a combination of a flapless procedure with GBR and immediate provisional restoration can have a positive impact on the final aesthetic since the graft material can guide the blood clot organization creating the space for the correct tissue regeneration and the provisional can immediately reshape the gingival contour; in fact, the results obtained for this technique show that a bone loss of 0,27 mm is obtained which is less compared to the other methods used in the same article (Table 3). The same statement is shared by Alkudmani., *et al*. [16] who sustain the use of a flapless approach to preserve the periosteum and conclude that the use of GBR could increasingly reduce the vertical and horizontal bone loss stabilizing hard and soft tissues by filling the 2 mm gap in between the implant and the socket wall; instead, it is still uncertain whether the use of a bone graft alone, a membrane or a combination of both lead to better results [16].

In a study conducted by Noelken., *et al*. [32] a flapless approach with immediate loading was used with GBR only in some patients and with GBR and connective tissue grafting(CTG) in others showing that both of them lead to a reduction in marginal bone loss and to an improvement in the general aesthetic results with slightly more positive values when using CTG (also considering that this group included patients with a mean of 2 mm of gingival recession). The amount of bone loss was respectively 0,7 mm in case of just using bone graft and 0,3 mm when GBR plus CTG was used [32]. In contrast to what previously mentioned, another study [30] obtained good long term results applying a flapless approach with GBR but without any connective tissue grafting showing a stable socket dimension at follow up and an high aesthetic score.

The problem with these procedures is that most of the times, at the beginning of the treatment, the buccal cortical of the socket can be compromised presenting dehiscence or fenestration and in that case it could be necessary to adapt our treatment choice to the situation we are dealing with. In a study carried out by Redemagni., *et al*. [27] 14 implants were inserted in sockets were the buccal wall was almost completely missing, by elevating a flap to expose the defect, filling the gap with bone graft, covering everything with a collagen membrane and immediately loading the implants obtaining the following results: a mesial and distal mean bone loss of 0,2 mm, a recovery of the buccal bone plate obtaining a similar thickness of the adjacent structures and thanks to the immediate provisional the soft tissue submergence profile has been maintained leading to an increased aesthetic. The same procedure has been applied by Kolerman., *et al*. [29] with the addition of a CTG and reported similar success values and aesthetic results to the technique applied in sites in which the original buccal bone plate was intact. Also Arora., *et al*. [24], in case of buccal bone defects preferred to raise a flap and to use a GBR with a membrane showing an overall bone loss of 0,25 mm which is quite an acceptable result, even though an immediate loading was not possible in this situation.

The main goal when placing an immediate implant is to try to preserve as much as possible the socket volume and on that purpose new techniques have been proposed. Among them the "Socket shield technique" seems to fulfil these requirements in fact in a study conducted by Sun., *et al*. in 2019 [31] it is possible to observe a reduction in bone loss compared to a conventional flapless procedure and this has been justified by the fact that with the root fragment, also the periodontal ligament has been preserved thus enhancing the defence mechanism against bacteria and reducing the buccal bone loss; since the soft tissue is in straight contact with the bone, also the aesthetic seems to be affected positively. Another study [20], confirm that this is a safe technique that provide better aesthetic results due to the fact that the remaining periodontal ligament provide blood supply to the buccal bone plate and the gradual root resorption goes along with a new bone apposition. However a recent systematic review asserts that the clinical evidence of the success of this novel approach is still limited by the high number of failures regarding osseointegration, and periodontal ligament de-

generation; in addition more case reports and an increased follow up is needed to support this technique [33].

Focusing exclusively on the prosthetic protocol applied and considering the thirteen articles selected for this review, 76% of them applied an immediate loading and 24% applied a delayed protocol with immediate implant placement (Figure 5). A review by Perez., *et al*. [7] show that in the long term, there is no difference in the survival of implants immediately or delayed restored and also similar results are obtained regarding soft tissue maintenance; however the results obtained with immediate loading seems be more predictable due to the slow and gradual modification of the tissues and in general because it shortens the treatment time which is of great relevance both for the patient and for the professional. Another article assume that immediately loaded implants result in a higher primary stability and also in a more comfortable condition for the patient because the missing tooth is replaced immediately [9]. To strengthen this hypothesis, Arora., *et al*. [24] conducted a study comparing the aesthetic outcomes of both immediate and delayed restoration and the results revealed that an higher aesthetic value was obtained with the immediate one, being it a scaffold for the soft tissue from the first day of treatment. Anyway it is important to specify that the treatment selection is highly dependent on the clinical condition presented so even though the immediate loading seems the most predictable and aesthetic solution, we should consider that it is not always possible to apply it [7].

Analysing all of the selected articles it is possible to conclude that whatever is the surgical and prosthetic protocol applied, the survival rate of immediately placed implants is really high and range from 97,4% to 100% so we can confirm that this technique is nowadays really predictable and accepted. Regarding the PES value, in general we have to consider that that higher values were obtained for a socket shield technique compared to the conventional flapless one; also higher results have been obtained when a Flapless procedure was combined with GBR, CTG and immediate loading compared to when the CTG is not used regardless of the prosthetic protocol applied; and finally a Flapless procedure combined with GBR and immediate loading showed higher results when compared to a Flap procedure with GBR, membrane and delayed protocol (Table 3). As far as the amount of bone loss is concerned, by doing a mean of all of the values obtained it turns out the flap (with DL) and flapless (with IL) procedures combined with GBR and CTG had the lowest bone loss values (Figure 8).

The limitation of our review is that even though these articles seems to compare similar variables, the majority of them don't show any data related to the original socket situation including the amount of buccal wall available, the pre existing gingival recession and also another important factor as the insertion torque of the implant which is fundamental when choosing the type of loading; these factors inevitably could lead to impaired results. Another limitation is that the measurements reported in Table 3 has been taken at different follow up periods raging from 6 months to 4 years and of course the longer is the follow up period the more reliable are the results.

For future investigations, considering our limitations, a more detailed analysis of the initial socket situation should be included in the research because it could be a determining factor when choosing the most adequate treatment option. In addition, further articles are needed to make more emphasis on the difference between immediate loading and immediate provisionalization (without loading) which sometimes is not properly specified but it can play an important role on the implant survival rate. Another aspect that could be considered would be type of GBR material to be used focusing mainly on the complications that are more likely to appear and how they could be prevented, on the quality of bone obtained and on the survival rate of the implant in relation to each of the selected materials. A similar analysis could be conducted with the soft tissue grafting materials considering also the aesthetic results.

Conclusions

Regarding the surgical technique for immediate implants:

- Implants with a tapered body, deep apical threads, platform switching design and acid etched/sand blasted surface seems to be the one of choice; there is not sufficient scientific evidence confirming the superiority of coronal microthreads.
- In case of a pre-existing buccal bone defect, the most predictable treatment option would be the Flap elevation+ GBR + CTG or CM; instead, with an intact buccal bone a Flapless procedure+ GBR+ CTG proved to be more reliable. However, further studies are needed that include the initial soft and hard tissues exact measurement and also regarding the SST.

Regarding the prosthetic protocol, the immediate loading seems to have more positive effects regarding aesthetic and marginal

bone maintenance even if in the long term the results are similar to the delayed loading.

Regarding the survival rate and PES value:

- The overall survival rate of immediate implants is really high (near 100%).
- Higher PES values were obtained for: A) SST; B) Flapless technique combined with GBR (with or without CTG) and immediate loading.
- Less bone loss was observed for : Flap+ GBR+CTG+DL and Flapless +GBR+CTG+IL.

Acknowledgements

I would like to express my gratitude to my tutor, the Doctor Jose Aguado Gil, for his constant willingness in moments of needs, his competence, professionalism, humanity, and his capacity to guide me, giving me the right foundations and accurate guidelines to follow for the development of my investigation.

Conflict of Interest

In this review there is no conflict of interest and financial interest.

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