Nowadays, implant supported prosthetic rehabilitation is a reliable procedure to replace compromised or untreatable teeth (1-26). Dental implants can be placed at different times after tooth extractions (27).

Since Branemark introduced the implant osseointegration system, a time of healing for the extraction socket of 12 months was expected, before implant surgery (28, 29). This time has been shortened during the years, till an immediate post-extraction implant placement was proposed (30).

The purpose of this review is to explore the concept of post extractive implant and the indications for clinical practice through an analysis of recent studies in the literature. All the main factors that could influence the outcome of this treatment will also be considered.

Implant insertion time protocols

Focusing on the extraction-socket healing time, three different implant insertion protocols have been defined: immediate implant placement (IIP), early implant placement (EIP), delayed implant placement (DIP). The entity of bone remodeling can be associated with different factors: three dimensional implant position, presence/absence of platform switching, absence of facial bony wall, inter implant/tooth distance.

RESULTS

All the studies in literature agreed that implant primary stability is the main condition for a successful osseointegration of dental implants. Primary implant stability is influenced by many factors including local bone quality and quantity, implant macro-design, soft tissue conditions and rehabilitation, surgical technique, prosthetic load timing, oral hygiene. Conclusions. There is insufficient evidence in literature to determine possible advantages or disadvantages of IIP, EIP or DIP. Studies suggest that IIP and EIP may be at higher risks of implant failures and complications than delayed implants; on the other hand the aesthetic outcome might be better when placing implants just after teeth extraction.

Key words: post extractive implants, implant stability, bone remodeling.
for soft tissue healing; delayed implant placement (DIP), implants that are placed thereafter in partially or completely healed bone (31, 32). The DIP, with an healing period of 6-12 months, has been traditionally considered the standard procedure: the edentulous ridge will be completely healed and should guarantee stable dimension after implant placement, but the bone volume may have been reduced due to the resorption process occurring in the ridge after tooth extraction.

To overcome this potential disadvantage, combined with patient’s discomfort due to the long treatment time, clinicians have approached the IIP procedure.

Different studies have indicated that IIP could offer several advantages (33-37) both for patients and clinicians: patients do not have to wear provisional removable prostheses, without discomfort in terms of function and aesthetics. Furthermore, treatment time and the number of surgeries can be reduced and bone volume might be partially maintained thus possibly providing good aesthetic results (31-38).

On the other hand, the potential drawbacks are: an increased risk of infection and implant failure; the possible lack of keratinized mucosa; the need to advance the flap to obtain primary closure; complications while trying to achieve implant optimal primary stability; presence of a discrepancy between the surface of the implant and the socket wall; an increased risk for gingival recession on the vestibular side (31, 35, 39).

To overcome some of these potential risks, the EIP protocol has been proposed, as it could share the advantages of both IIP and DIP, utilizing the ridge volume before it’s fully resorbed and at the same time allowing primary healing after tooth extraction, thus achieving enough soft tissues in case of need for flap closure and reducing the risks for infection during implant placement (39, 40). EIP protocol results to be convenient if associated to augmentation techniques, as there is no need of advancing the flaps because soft tissues healing after tooth extraction is completed (40).

Recent studies (31, 35, 41) have evaluated the efficacy of these protocols, and there is a suggestion that although IIP and EIP may be at higher risks of implant failures and complications than DIP, on the other hand the aesthetic outcome might be better when placing implants just after teeth extraction (31). Nevertheless failures and complications have been more frequently described for IIP and EIP protocols (35).

### Bone remodeling

During the 12-month period following the tooth extraction, the edentulous ridge undergoes a reduction of 50% in its width and, in lower proportion, in his height. The most of its resorption occurs in the first three months (42, 43). At six months following tooth extraction, horizontal bone loss of 29-63% and vertical bone loss of 11-22% can be expected. After that period, a further horizontal resorption of the vestibular bone may occur, resulting in a more palatal position of the ridge (43, 44). Moreover, Saldanha et al. (45) showed that smoking habit may lead to an enhanced dimensional reduction. These changes affect both hard and soft tissues (43, 44).

The entity of bone remodeling can be associated with different factors: three dimensional implant position, presence/absence of platform switching, absence of facial bony wall, inter implant/tooth distance (46, 47).

All these changes that take place in the post extraction socket area, especially when regarding an anterior maxilla with thin facial socket wall and tissue biotype, could be associated with the risk of marginal mucosal recession after immediate implant placement and possible aesthetic problems (48).

It is known that implants placed into the fresh extraction sockets do not prevent the resorption of the alveolar bone and that the use of root-formed implants does not preserve alveolar ridges (49).

Some studies suggest that IIP could reduce bone resorption (31, 49, 50), maybe as response to the
functional stimulation exerted by the implant loading. An important contribution to partially resolve alveolar bone resorption is given by simultaneous guided bone regeneration procedure (49).

Soft tissue grafts or primary closure did not show beneficial effect on preserving the alveolar bone (49), but can efficiently compensate the soft tissue volume loss (51).

Primary stability

All the studies in literature agreed that implant primary stability is the main condition for a successful osseointegration of dental implants (52). Primary implant stability is influenced by many factors including local bone quality and quantity, implant macro-design and surgical technique (52, 53).

While in DIP initial implant stability is obtained by intimate contact with the newly formed bone in healed sites, when performing IIP residual bony defects are always expected around implants. Therefore, primary stability is only achieved by anchoring the implant in the apical bony region (3-4 mm), where cancellous bone predominates (46).

If performing immediate loading together with IIP it’s important to consider the concept of “jumping distance” developed by Knox (54): if alveolar ridge preservation (ARP) or guided bone regeneration (GBR) procedures are not foreseen, the gap between the extraction socket and the implant surface must be lower than 0.5 mm to ensure an optimal osseointegration (54).

Implant design

Implant design plays a major role to reach a good primary stability. Tapered implants were introduced to overcome the poor bone quality and quantity limitations. The conical and progressive shape of these implants could provide a degree of compression of the apical cancellous bone (55) and the decrease of the apical diameter allows the clinician to place the implant even in little bone volumes, like the labial concavity or between adjacent roots (52).

Implant surface characteristics and diameter have also been shown to influence primary stability (56). Rough implant surfaces present a larger surface area and allow a firmer mechanical link to the surrounding tissues (52). Clinical studies have shown that implants with smaller diameters (less than 3.0 millimeters) provide sufficient primary stability in cases with a limited bone volume (52, 57).

Prosthetic load timing

IIP protocol, both for single tooth and for full-arch rehabilitations, is often associated to immediately loaded prosthetic restoration. Several studies agree that IIP with immediate loading can be considered a valuable and predictable option in terms of implant success (34, 58-62), however surgeons should carefully select those cases which can be immediately loaded (53, 63).

Some studies suggest that IIP with immediate loading, could provide enhanced implant stability when compared to non-immediately loading implants, facilitating the osseointegration process (53).

Nonetheless, there seems to be more complications with IIP in comparison to DIP. After 4 months of socket healing, with sockets preserved with anorganic bovine bone (41, 64) or algal-derived bone substitute (64), it seems more difficult to obtain an implant insertion torque superior to 35 Ncm than with IIP. The aesthetic outcome appears to be similar for all these protocols.

Also immediate non-functional loading with IIP seems to have positive results comparable to the previous ones (65).

A recent randomised controlled trial by Felice et al. (35) has shown that there are no statistical-
ly significant differences in terms of failures, complications and patient satisfaction when placing single implants immediately, 6 weeks or four months after tooth extraction. This study also revealed that bone level changes were similar between the different procedures, but the aesthetics showed better results for IIP and EIP, although performing these two protocols may involve higher risk for implant failures and complications (35).

**Alveolar ridge preservation (ARP) and guided bone regeneration (GBR)**

After IIP it’s a common procedure to fill the gap between the implant and the socket walls with bone graft. The placement of graft material has been indicated as an ideal procedure in order to maintain adequate bone levels (66, 67). Several studies (66-68) have proven that bone grafting can contribute to reduce bone remodeling, despite a slight bone loss at buccal and lingual aspects may occur despite preservation procedures, probably in response to inadequate blood supply (69).

A few studies show that the use of adjunctive anorganic bovine bone placed buccally at preserved buccal sites of immediate post-extractive implants may not improve the aesthetic outcome (70). Also the histomorphometric evaluation at 6 months after extraction reports that ARP provide less ridge reabsorption of the post-extractive sites, but it’s difficult to obtain a complete preservation of the buccal area (71).

The results of a systematic review and subsequent meta-analysis by Avila-Ortiz et al. showed that ARP via socket filling with a bone graft can be an effective therapy to prevent physiologic bone loss after tooth extraction. Subgroup analyses showed that flap elevation, the usage of a membrane, and the application of a xenograft or an allograft may contribute to enhance the outcomes, particularly on midbuccal and midlingual height preservation (72).

It has been shown that performing GBR with the adjunctive use of a bone substitute combined with resorbable collagen barriers at IIP in fresh extraction sockets could further improve the aesthetic outcome (69).

**Implant connection and abutment choices**

Regarding the implant-abutment connection, it has been hypothesized that platform switching could minimize bone remodeling after prosthetic loading (46). Canullo et al. showed that immediate single implant restorations rehabilitated with platform-switching protocol may provide peri-implant alveolar bone-level stability and avoid continuous soft tissue shrinkage after 10 years of prosthetic loading compared to a platform-matching restoration (58).

For all two-piece implants, the bone crest level changes seem related to the micro-gap position (73). Histological and radiographic studies by Herman et al. have proven that for submerged two-piece implants, an average crestal bone resorption of about 2 mm occurs, while non submerged one-piece implants leads to minimal or no reabsorption (74).

A crucial factor for maintaining the ridge volume is to consider the lateral distance between implants: an inter-implant distance <3 mm seems to lead to more crestal bone resorption, if compared with a distance >3 mm (75). When performing IIP with multiple implants in the aesthetic zone, the use of implant with smaller diameter at the implant-abutment interface is recommended, so that a minimum of 3 mm of bone can be retained between them at the implant-abutment level (75).

Different studies also evaluated the difference in bone level maintenance when using immediately definitive abutments (one abutment-one time
concept) versus provisional abutments later replaced by definitive abutments (59, 76). The non-removal of abutments placed at the time of surgery resulted in the maintenance of 0.2-0.5 mm more bone levels around implants than repeated abutment removal, although this difference may not have a clinical impact (59, 76).

Implant connection choice is of paramount importance to reduce the risk of peri-implantitis (77-116).

**Soft tissue augmentation (STA) procedures**

To achieve aesthetic success in post extractive implants, several factors must be taken into account: the location of the implant, gingival marginal position, width and thickness of keratinized mucosa, gingival biotype, vestibular cortical thickness, and the size of the horizontal “gap” buccal or sagittal position of the root (51).

Clinician often choose to perform IIP to maintain bone architecture and immediate provisionalization to maintain soft tissue level (35, 117). However, the appearance of vestibular gingival recession after the first year has been often reported (35, 37, 51). Different reviews show the effectiveness of soft tissue augmentation procedures around dental implants to effectively compensates for the expected loss of volume of the oral soft tissues and maintains high success rates with good aesthetic results over time (51, 61).

Two main techniques are used to compensate the expected vestibular soft tissue volume loss: the autologous connective tissue graft (ACTG) and the rotational palatal flap (RPF). Both procedures have been proved effective and reliable to maintain good aesthetic results over time, minimizing vestibular gingival recession (51). These techniques don’t make use of synthetic membranes, that sows more clinical complications, such as colonization and bacterial infection (118, 119). Biological membranes, instead, could improve soft tissue local metabolism, preserving the amount of keratinized tissue and allow for optimal marginal and peri-implants seals (120).

The ACTG proved to be an effective technique to improve soft tissue metabolism and increase its thickness, especially if the implants are positioned palatally (121).

Performing the RPF could be advantageous because it retains some of the blood supply (122), but it’s not always possible to carry out this technique and it is not advisable when the probing of the palatal gingiva measured <4 mm (122).

**Oral hygiene**

Although the influence of oral hygiene on implant success has been controversial, all Authors agree that plaque accumulation could induce a negative response in the mucosa without a good level of oral hygiene (123, 124). To minimize the potential retraction to the peri-implant soft tissue and to maximize the outcome of soft tissue augmentation techniques, clinicians should encourage the patients to rinse with chlorhexidine solution and refrain from brushing the surgical site for one month following the procedure (123, 125).

**Conclusions**

Literature data showed that IIP in fresh extraction sockets, in combination with ARS and STA, could represent reliable strategy to replace compromised teeth in both jaws, with high implant and prosthetic survival and success rates and good aesthetic outcomes. However, surgeons should carefully select those cases with IIP can be performed, particularly if immediate prosthetic loading is planned.

There is insufficient evidence in literature to determine possible advantages or disadvantages of IIP, EIP or DIP. Studies suggest that IIP and EIP
may be at higher risks of implant failures and complications than delayed implants; on the other hand the aesthetic outcome might be better when placing implants just after teeth extraction (31, 66).

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