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CONSENSUS STATEMENT

Treatment Options for the Management of the Postextraction Socket: Report From the First Giuseppe Cardaropoli Foundation Consensus Conference

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ABSTRACT

Aim: Different approaches have been proposed for implant placement following tooth extraction. A Consensus conference was organised to provide expert-based recommendations for the treatment of the postextraction site in the aesthetic zone in conjunction with implant therapy.

Methods: A panel of eight experts with a documented longstanding clinical and research experience in the field of implant therapy in the aesthetic zone were invited to participate in a structured survey. Participants were asked to select their preferred treatment approach for different clinical scenarios of the postextraction site from a list of different treatment options. Results were summarised and discussed in person at a 2 day consensus conference. Based on the outcome, treatment recommendations were phrased and are reported here.

Results: The group agreed that in case of an intact alveolus, immediate implant placement with immediate prosthetics represents the reference choice if proper primary stability can be achieved and the buccal bone plate is present. A bone-to-implant gap more than 2 mm should be seeked and grafted. Alveolar ridge preservation and early placement with contour augmentation may represent an alternative. If the alveolus is compromised, a staged approach (early or delayed placement) with bone augmentation may be preferred.

Conclusions: The characteristics of the site, in terms of the available bone volume, the integrity of the buccal bone plate and the periodontal phenotype are determining factors in the therapeutic choice. Therefore, case selection based on well-defined selection criteria is extremely important and is the adequate way to guide the clinician in choosing the most appropriate approach to postextraction site management and timing for implant placement.

1 | Background

Following tooth extraction, the alveolus undergoes a series of biological and anatomical events which determine the remodelling of the alveolar crest and changes the local bone and soft tissue anatomy [1, 2]. The bone modelling and remodelling phases are fundamentally inevitable and related to the resorption of the bundle bone due to the lack of blood supply from the periodontal ligament [3–7]. Added to these fundamental events are other influencing factors, such as the thickness of the buccal bone plate [8] and the elevation of a flap during extraction [9].

At the time of extraction, the anatomy of the socket may vary depending on the presence of soft tissue defects and/or bone defects linked to pathologies of periodontal or endodontic origin. Consequently, if the final rehabilitation involves an implant-supported restoration, the implant surgery can be performed at different time points precisely in relation to the residual anatomy of the postextraction site.

This topic has been thoroughly addressed by two recent consensus conferences organised by the EFP (European Federation of Periodontology) and the ITI (International Team for Implantology). In 2019, during the EFP XV European Workshop in Periodontology, Group 3 focused on the formulation of evidence-based consensus statements and clinical recommendations on the management of the extraction socket [10]. The surgical options available for the management of the postextraction socket were divided into two large groups: procedures to be performed at the time of tooth extraction and procedures to be performed after tooth extraction. At the time of tooth extraction, the two options suggested were immediate implant placement and alveolar ridge preservation. After tooth extraction, the suggested procedures were early placement, delayed placement and late placement. The workshop group identified six considerations that should assist clinicians in clinical decision making: presence of infection, inability to achieve primary stability in the restoratively driven position, presence of a damaged alveolus, periodontal phenotype, aesthetic demands and systemic conditions.

In 2023, working Group 5 of the VII ITI consensus conference focused on immediate placement with immediate loading [11], concluding that this procedure is considered predictable with high survival rates only if utilised in the anterior maxilla with favourable conditions, although surgical, technical and biological complications may occur and can compromise the positive aesthetic results.

Both articles call for more high-quality research in order to develop evidence-based clinical guidelines. A lack of knowledge is present regarding the choice of augmentation materials used to graft the space between the implant and facial bone (horizontal defect dimension, also known as bone-to-implant gap). At the same time, the choice of soft tissue grafting procedures and materials used in conjunction with the immediate placement protocol has not been adequately investigated yet.

It was the aim of the present work to build upon and supplement the important outcomes of these major conferences and at the same time to approach the daily challenges that clinicians are facing in their decision making from a different angle. The Giuseppe Cardaropoli Foundation decided to organise a consensus conference starting with and primarily focussing on typical clinical scenarios, postextraction socket case types, and to draw from the extensive clinical experience and research contributions of some of the world leading experts in the field on how to approach these various situations. Employing elements of survey research, Delphi methods and S1/S2k level clinical guideline development a consensus was reached and reported in this manuscript.

2 | Classification of Extraction Sockets

Over the years, different classifications of postextraction sites have been proposed, which have taken into consideration the timing of implant placement from a strictly chronological point of view, or the quantity of bone volume available in relation to the anatomy and the position of the root of the teeth [12–15]. None of the classifications available in literature to date, however, takes simultaneously into account the three-dimensional anatomy of the alveolar bone crest and the anatomy of the soft tissues, the periodontal phenotype, the presence of periapical lesions and/or inflammatory tissue and unfavourable anatomical structures.

Basically, the integrity of the alveolus can be defined as intact when the socket presents with three intact walls and at least 80% of the fourth wall intact [16]. During the 2017 EFP-AAP World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, the adoption of the definition ‘periodontal phenotype’ was suggested to describe the combination of gingival phenotype (three-dimensional gingival volume) and the thickness of the buccal bone plate (bone morphotype) [17] replacing the earlier term biotype [18]. The periodontal phenotype is determined by gingival phenotype (gingival thickness, keratinised tissue width) and bone morphotype (thickness of the buccal bone plate) [19]. Furthermore, available classifications do not suggest a possible therapeutic option for each particular clinical condition.

More recently, a classification has been introduced that takes into account both, the socket anatomy as well as the soft tissue dimensions [20]. In this classification system, postextraction sockets are classified into four different categories. The necessary information is collected from a careful clinical and radiological analysis, based on both standard intraoral and three-dimensional radiographic (cone-beam computed tomography, CBCT) images (Table 1).

Briefly, Class I corresponds to an intact extraction site with favourable anatomical conditions, where the buccal cortical bone is intact, there is no gingival recession and good implant primary stability can be achieved.

Class I is divided into two different categories: Subclass Ia: (intact socket with thick gingival phenotype) and Subclass Ib (intact socket with thin gingival phenotype).

Class II is an intact extraction site with partially favourable anatomical conditions where there is a difficulty in achieving ideal implant positioning and satisfactory primary stability.

Class III is a partially compromised extraction site with unfavourable anatomical conditions where there is a resorption of

TABLE 1 | Classification of postextraction sockets (Cardaropoli et al. 2021).

Class I: Intact postextraction site with favourable anatomical conditions
Specific characteristics
a. Buccal cortical bone that is intact or affected by damage not exceeding 20% of the wall's extent
b. Optimum soft tissue level (soft tissue height in relation to neighbouring teeth)
c. Local bone anatomy allows an ideal three-dimensional implant positioning and good primary stability
Subclass Ia: intact postextraction socket with thick soft tissue phenotype
Subclass Ib: intact socket with thin soft tissue phenotype
Class II: Intact postextraction site with partially favourable anatomical conditions
Specific characteristics
a. Buccal cortical bone that is intact or affected by damage not exceeding 20% of the wall's extent
b. Optimum soft tissue level (soft tissue height in relation to neighbouring teeth)
c. Difficulty in achieving ideal implant positioning and satisfactory primary stability due to the presence of large periodontal defect and/or presence of large periapical lesion and/or presence of anatomical structures limiting immediate placement (e.g., maxillary sinus floor, mandibular canal)
Class III: Partially compromised postextraction site with unfavourable anatomical conditions
Specific characteristics
a. Resorption of the buccal cortical bone amounting to between 20% and 50% of the wall
b. Suboptimal soft tissue level and/or soft tissues presenting inflammation and/or thin and scalloped soft tissue phenotype
c. Local bone anatomy allows an ideal three-dimensional implant positioning and good primary stability
Class IV: Severely compromised postextraction site with unfavourable anatomical conditions
Specific characteristics
a. Severely compromised socket walls, particularly with loss of the buccal bone wall exceeding 50%
b. Suboptimal soft tissue level and/or soft tissues presenting inflammation and/or thin and scalloped soft tissue phenotype
c. Difficulty in achieving ideal implant positioning and satisfactory primary stability due to the presence of large periodontal defect and/or presence of large periapical lesion and/or presence of anatomical structures limiting immediate placement (e.g., maxillary sinus floor, mandibular canal or inadequate Buccal–Lingual ridge thickness to place a reduced diameter implant in a prosthetically appropriate position)

the buccal cortical bone amounting to between 20% and 50% of the wall.

Class IV corresponds to a severely compromised extraction site with unfavourable anatomical conditions (Figure 1).

3 | Treatment Options for Postextraction Sockets

Following tooth extraction, due to disease or trauma with irreparable damage, several treatment modalities at different time points can be selected by clinicians [10–13].

3.1 | Alveolar Ridge Preservation (ARP)

Alveolar ridge preservation (ARP), also known as socket grafting, is a surgical procedure that aims at preserving the ridge volume within the envelope existing at the time of extraction and that is able to compensate for marginal bone remodelling [21]. A systematic review reports as alveolar ridge preservation may prevent 1.5 to 2.4 mm of horizontal bone resorption when compared to spontaneous healing [22], and a randomised controlled clinical trial reported that up to 93% of the original horizontal dimension of the ridge width can be maintained with this procedure [16]. ARP via socket sealing can be performed using different bone substitute biomaterials that are available on the market (Allografts, alloplasts and xenografts). The use of xenograft (deproteinised bovine bone mineral—DBBM) has been advocated to fill the empty socket due to its slow resorption and volumetric stability which shows superior results as reported in the literature [21]. This technique can be performed either with or without flap elevation and with or without primary closure. While flap elevation can cause bone resorption of the cortical bone [9], coronal advancement of the flap to obtain primary closure causes a misalignment of the mucogingival junction with loss of keratinised tissue [23]. Either epithelium-connective soft tissue graft, resorbable collagen membrane or collagen matrix can be used to protect the applied bone graft, following an open-healing approach [24]. ARP can be recommended for intact

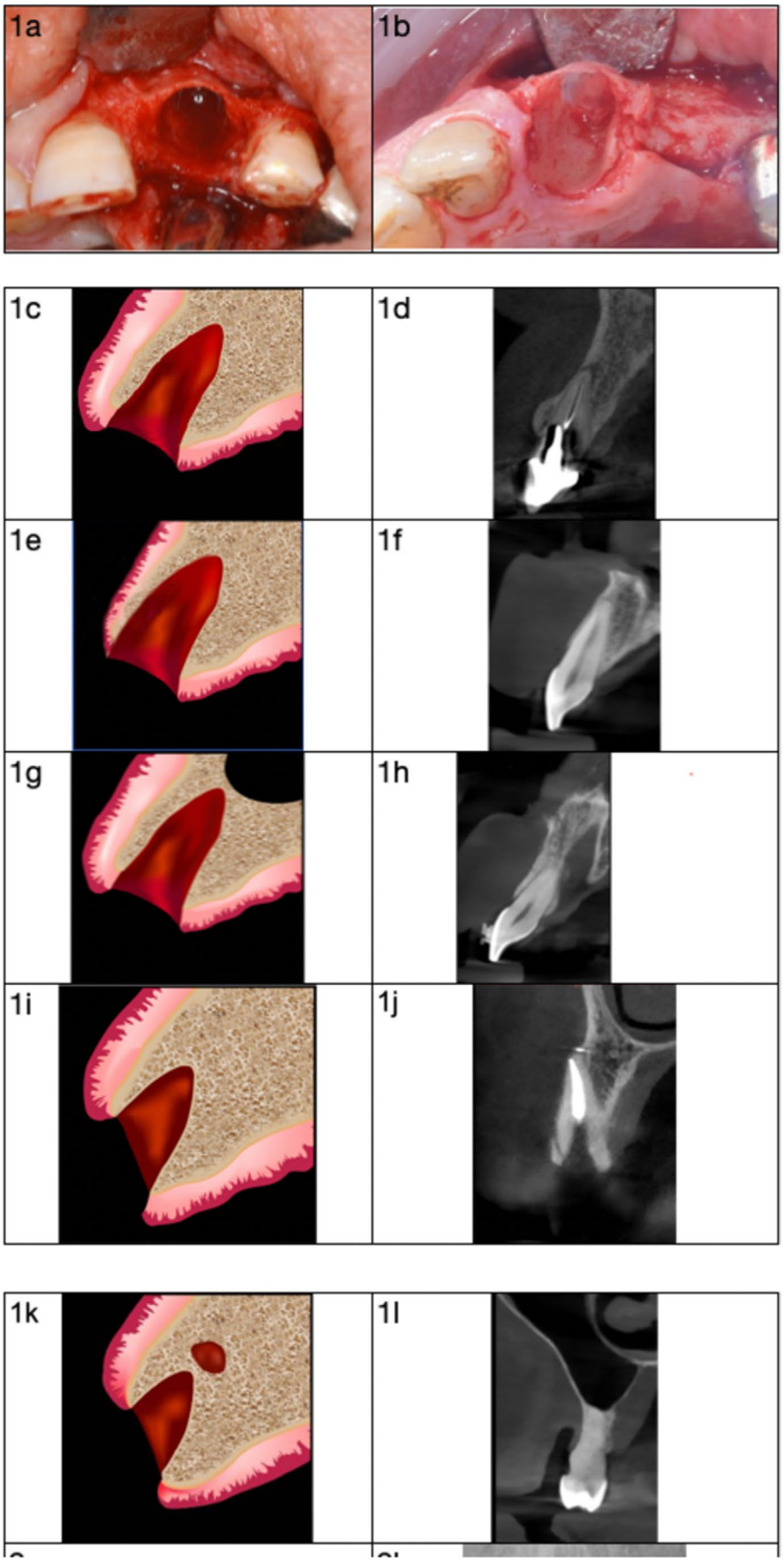

FIGURE 1 | Legend on next page.

FIGURE 1 | Postextractions sites characteristics. (a) Postextraction site showing a thick buccal bone plate, made of bundle bone and proper cortical bone. (b) Postextraction site showing a thin buccal bone plate, made solely of bundle bone. (c) Postextraction site Class Ia. Intact site with thick phenotype, possibility to achieve proper implant primary stability. (d) 3D radiological image of a Class Ia site. (e) Postextraction site Class Ib. Intact site with thin phenotype, possibility to achieve proper implant primary stability. (f) 3D radiological image of a Class Ib site. (g) Postextraction site Class II. Intact site, impossibility to achieve proper implant primary stability. (h) 3D radiological image of a Class II site. (i) Postextraction site Class III. Partially compromised site. (j) 3D radiological image of a Class III site. (k) Postextraction site Class IV. Severely compromised site. (l) 3D radiological image of a Class IV site.

sites, both with thick or thin buccal bone plate, when an implant restoration or a pontic site is planned. ARP can be used not only in aesthetic areas but also in posterior areas where it can limit maxillary sinus pneumatisation and vertical reduction of bone height [24–27]. Ideally, implant placement can be performed after 4–6 months, with a delayed approach, based on the histological healing time of the graft biomaterial used [8, 16, 22, 28].

Moreover, implants inserted in ridges treated by ARP present similar success parameters (success rate, survival rate and marginal bone level) as implants inserted in healed ridges [28] (Figure 2).

3.2 | Immediate Implant Placement

Immediate implant placement (IIP) is a treatment modality where implant surgery is performed immediately following tooth extraction and as part of the same procedure, reducing the number of surgeries and the overall treatment time. This procedure is recognised as Type 1 according to the ITI Classification [13]. This treatment approach shows survival rates similar to that of implants with early or delayed placement when a specific case selection is performed, mainly with an intact site and proper bone volume where implants apical treads can be engaged to obtain primary stability [12, 13]. Immediate placement in the aesthetic zone requires the clinician to be experienced and knowledgeable about aesthetic diagnosis, virtual CBCT planning, minimally invasive extraction techniques, as well as bone and soft tissue augmentation procedures since aesthetic complications may occur. Three-dimensional (3D) restorative-driven implant placement based on cone-beam computed tomography (CBCT) analysis is highly recommended to assess the thickness of the buccal wall, to determine the sagittal root position of the tooth and the planned implant position within the alveolar bone with good primary stability apically and/or palatally. Implant positioning should be able to assure more than 2 mm bone-to-implant gap adjacent to the intact buccal socket wall, where a low-substitution bovine bone mineral (DBBM) is commonly used [29–31]. Facial gingival grafting to create ideal soft tissue contour is often indicated [32–35] (Figure 3).

3.3 | Immediate Placement and Immediate Restoration

The immediate implant placement and provisionalisation procedure has been advocated for more than 30 years and has become a successful viable treatment option for replacing failing single maxillary anterior tooth. According to the time of delivery, the provisional prosthetic restoration has been historically classified as immediate provisionalisation (within 72 h from implant placement), early provisionalisation (between 6 and 8 weeks from implant placement) and delayed provisionalisation (between 3 and 6 months from implant placement) [36]. The definition of loading protocols has been slightly modified over the years and is currently accepted as follows: (a) Immediate loading of dental implants is defined as being earlier than 1 week after implant placement, (b) early loading of dental implants between 1 week and 2 months after implant placement and (c) conventional loading of dental implants > 2 months after implant placement [37]. There is a main difference between the concepts of loading and restoration. Immediate restoration is defined when a dental implant is connected to a prosthesis held out of occlusion with the opposing arch within 1 week subsequent to implant placement. Immediate loading is defined when the dental implant is connected to a prosthesis in occlusion with the opposing arch within 1 week following implant placement. Although it is often not clearly reported in the literature whether postextraction implants have been subjected to immediate loading or immediate prosthetic restoration, it is commonly accepted that immediate postextraction implants inserted in the aesthetic zone do not need to be subjected to immediate loading and can benefit from immediate restoration [38–41]. Literature suggests that either a screw-retained immediate provisional or a customisable healing abutment can be used. The factors that affect immediate placement and immediate restoration (IIPP) success can be broadly categorised as extrinsic (i.e., 3-D implant position, implant stability and provisional emergence profile) and intrinsic (i.e., harmonious gingival architecture and gingival phenotype) [42] (Figure 4).

3.4 | Immediate Implant Placement With Mucogingival Approach

The most common complication following immediate implant placement appears to be midfacial recession leading to unpleasant outcomes, as aesthetic single-tooth implant-supported replacement encompasses both a natural appearance of the restoration and of the peri-implant soft tissues. To avoid complications, IIP is commonly considered the treatment of choice as a flapless procedure in sites with ideal anatomical conditions, such as an intact facial bone wall with a thickness > 1 mm as well as a thick gingival phenotype [31–34]. Unfortunately, these favourable anatomical conditions may represent only 5%–10% of single-tooth extractions in the aesthetic zone [34]. A novel approach combining mucogingival, regenerative and prosthetic measures may be able to overcome the factors traditionally considered as contraindications for IIP and lead to immediate placement in case of buccal bone dehiscence. The surgical technique consists of flap elevation and tooth extraction, followed by guided implant insertion. Then a mixture

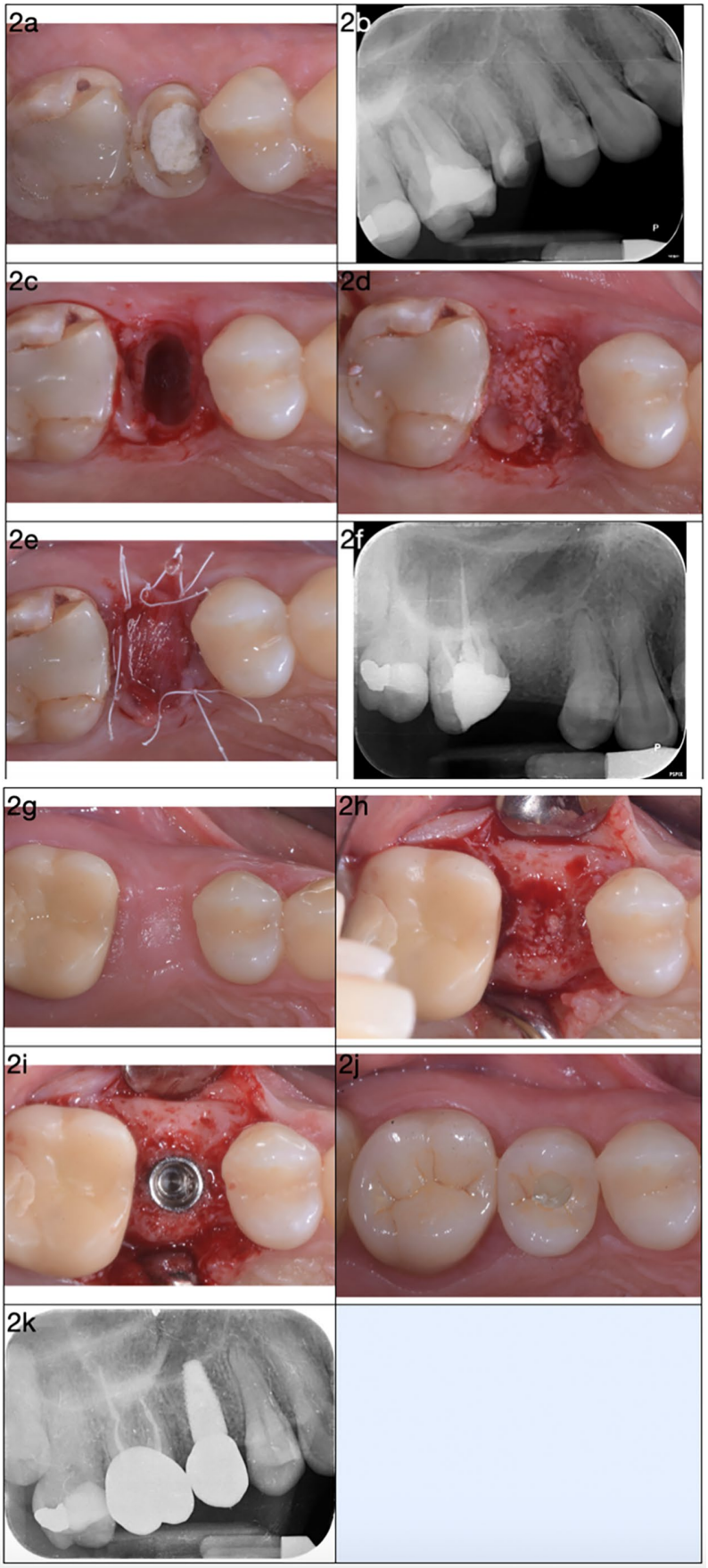

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FIGURE 2 | Alveolar ridge preservation. (a) Baseline situation of a hopeless upper right second premolar. (b) Baseline intraoral radiograph. (c) Flapless tooth extraction. (d) Postextraction site is grafted with bovine bone mineral. (e) Collagen matrix is placed to protect the bone graft and sutured to the surrounding soft tissue, acting for an open-healing (f) Intraoral radiograph after socket grafting. (g) After 4 months a complete healing of the soft tissues can be detected. (h) After 4 months of healing, a full thickness fall is raised showing the new bone formation. (i) Implant is inserted in an ideal 3-dposition. (j) Final ceramic restoration 1 year after loading. (k) Final radiograph 1 year after loading showing marginal bone level stability.

of biomaterial and autologous bone is placed, stabilised by a resorbable membrane and a connective tissue graft sutured in the inner aspect of the buccal flap. The flap is placed coronally and sutured, and a screw-retained provisional crown is delivered [41]. This approach ensures morphological and dimensional stability of the peri-implant soft tissues [43–45] (Figure 5).

3.5 | Socket-Shield Technique

Immediate placement of implants into fresh extraction sockets is not able to prevent the resorption of the bundle bone, that ultimately belongs to the deep periodontium of the tooth [1, 2]. A novel method leaving part of the root with its periodontium at the buccal side prior to immediate implant placement has been introduced, assuming that in this way the bundle bone could be maintained entirely. This hypothesis could be confirmed in a proof of principle study histologically evaluating the structures and interfaces at implant and 'socket-shield' sites in a beagle dog [46, 47]. In a prospective cohort study it could later be demonstrated that all implants inserted immediately with the 'socket-shield'-technique were fully osseointegrated and showed minimal volumetric changes as well as very good aesthetic outcomes over a period of 5 years [48]. These findings could subsequently be verified in randomised controlled trials [49] and systematic reviews [50, 51]. Nevertheless, biological complications such as infection due to the coronal migration of the shield have also been described and provide room for critical evaluation of the technique. However, already today—in close consultation with the patient—suitable indications for the 'socket-shield'-technique seem to be challenging implant cases in areas of aesthetic relevance for example in situations with multiple adjacent implants where successful treatment outcomes cannot be achieved predictably [52] (Figure 6).

3.6 | Early Implant Placement

One treatment option available at day of tooth removal is extraction and unassisted socket healing, followed by early implant placement (EIP) after 4–8 weeks [13].

Early placement can be both performed with/without simultaneous bone regeneration. The concept of early implant placement is preferred when the buccal bone wall is thin (< 1 mm) or deficient, since primary soft tissue healing postextraction increases keratinisation and the soft tissue spontaneously thickens in such patients [53]. Initial step is always suggested to be a low-trauma, flapless tooth extraction followed by a spontaneous socket healing. During this healing period, additional keratinised mucosa will form, the bundle bone will be resorbed, a spontaneous thickening of the mucosa will take place, and—if present—a local infection will be cleared. All these biologic events represent a reduction in risk factors for the planned implant surgery. A small number of articles describes the surgical techniques that can be advocated for early implant placement if bone augmentation is requested, basically all using autogenous bone and/or xenografts [10]. One option well reported in literature is to perform implant surgery with an open-flap procedure, which may be done with a triangular flap-design using the releasing incision distal to the canine. An appropriate implant must selected and inserted in a correct 3D position. The buccal bone defect may then be augmented with a two-layer composite graft. In this technique, the first layer is composed of autogenous bone chips, harvested within the same flap in the vicinity, covers the exposed implant surface and fills the bone defect. The autograft chips are used to accelerate new bone formation in the defect area. Then, DBBM particles are applied as second layer for local contour augmentation. DBBM is a bovine bone filler with a low-substitution rate and is mainly used for the long-term volume stability of the regenerated bone. The bone fillers are covered with a resorbable collagen membrane, applied with a double layer technique, followed by a tension-free primary wound closure. Usually implant reopening takes place after 8 weeks of healing, followed by the prosthetic restoration preferably with a screw-retained single crown. With this surgical approach, there is no need for a connective tissue graft in routine cases due to the spontaneous soft tissue thickening post extraction [54, 55]. In addition, early implant placement offers excellent aesthetic outcomes documented with long-term studies up to 10 years of follow-up [56] (Figure 7).

3.7 | Ridge Augmentation

Implant rehabilitation in the aesthetic zone is often challenged by horizontal and/or vertical bone defects and soft-tissue deformities [10]. Lack of an adequate bone volume can either make the placement of an implant impossible or become a limiting factor for an optimal aesthetic result. Depending on defect size and especially defect morphology, different techniques are applied. Whenever it is possible to place an implant in the ideal position and direction, even if there is only a small amount of bone left, this is done at the same time as the necessary bone augmentation. When this is not possible, a staged bone augmentation procedure allows for the placement of implants in ideal positions ideally after 6–9 months [57]. Primary bone augmentation to place implants months later is indicated only in rare cases. If the right technique is used, the desired bone volume can be built up very precisely. Guided bone regeneration (GBR) is a proven technique for such bone augmentation, where both resorbable and nonresorbable membranes or titanium meshes can be used in combination with a bone graft. The same bone graft can be a combination of autologous bone and xenograft in different proportions. Clinically, it is difficult to decide on a specific intervention given the vast variety of biomaterials and membranes available. When used

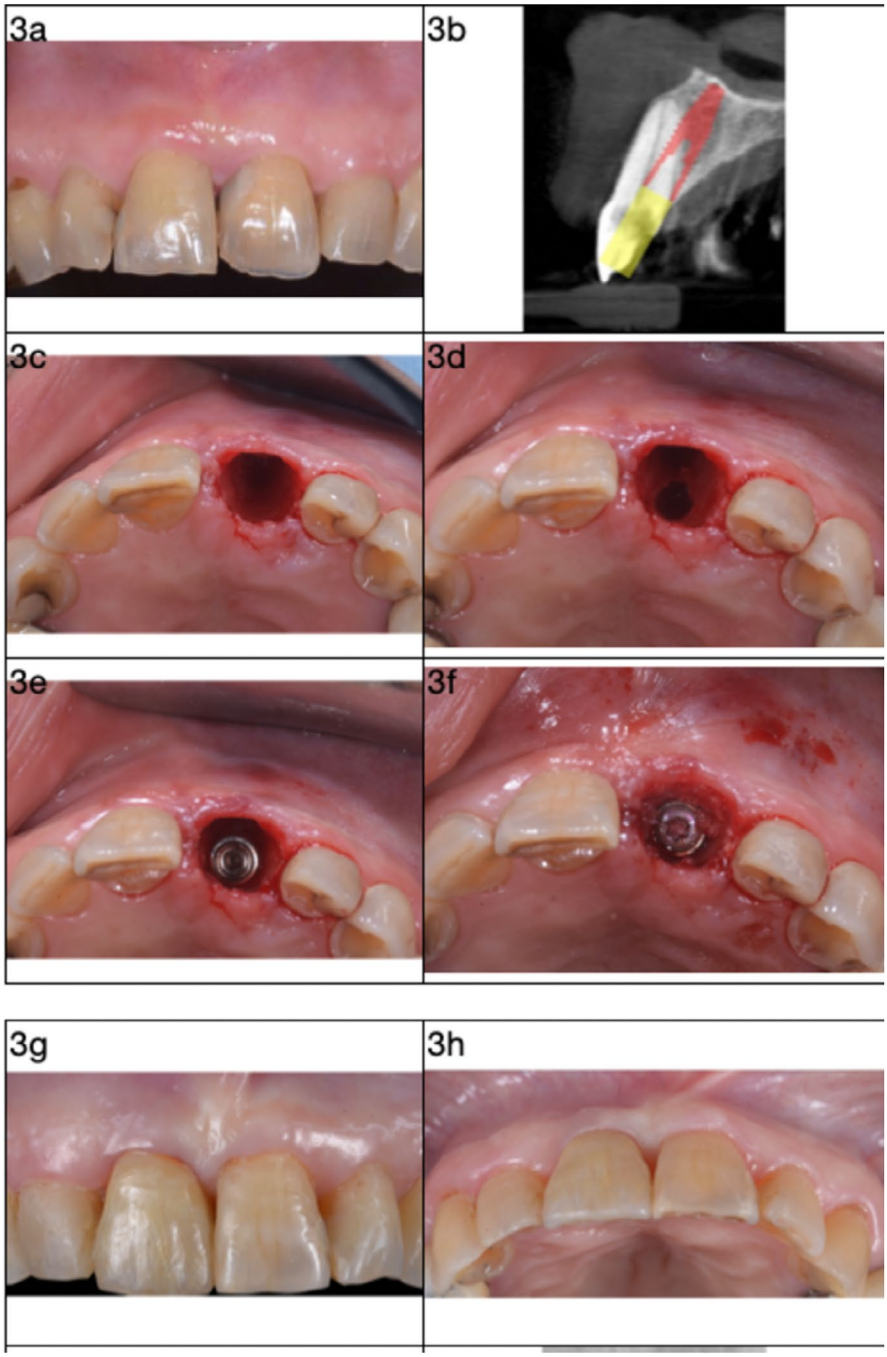

FIGURE 3 | Immediate implant placement. (a) Baseline situation of a hopeless upper central incisor. (b) Initial CBCT scan with the planned ideal implant positioning. (c) Flapless tooth extraction showing an intact postextraction socket. (d) Implant site preparation on the palatal wall of the alveolus. (e) After implant placement a > 2 mm bone-to-implant gap is evident on the buccal side. (f) Gap is grafted with a collagenated bovine bone mineral. (g) Final restoration 1 year after loading. (h) Occlusal view of the final evaluation 1 year after loading.

correctly and with the right materials, the desired result can be achieved with good long-term outcomes. However, GBR is very technique sensitive and bone augmentation alone may not be able to provide the ideal soft tissue volume. Soft tissue augmentation appears to be of enormous importance for long-term success, in reposition the mucogingival junction and re-establish an adequate amount of keratinised mucosa at the implant sites and to increase mucosal thickness [58–61]. When bone regeneration procedures are performed at the time of tooth extraction, they are better defined as alveolar ridge augmentation (RA), that includes a number of surgical techniques aimed at increasing the ridge volume beyond the skeletal envelope existing at the time of extraction [27]. Here, techniques for horizontal and for vertical augmentation can be differentiated [62] (Figure 8).

4 | Preferred Treatment Protocols for Specific Postextraction Socket Site Characteristics

It was the aim of this project to establish experts consensus-based recommendations regarding the preferred suited

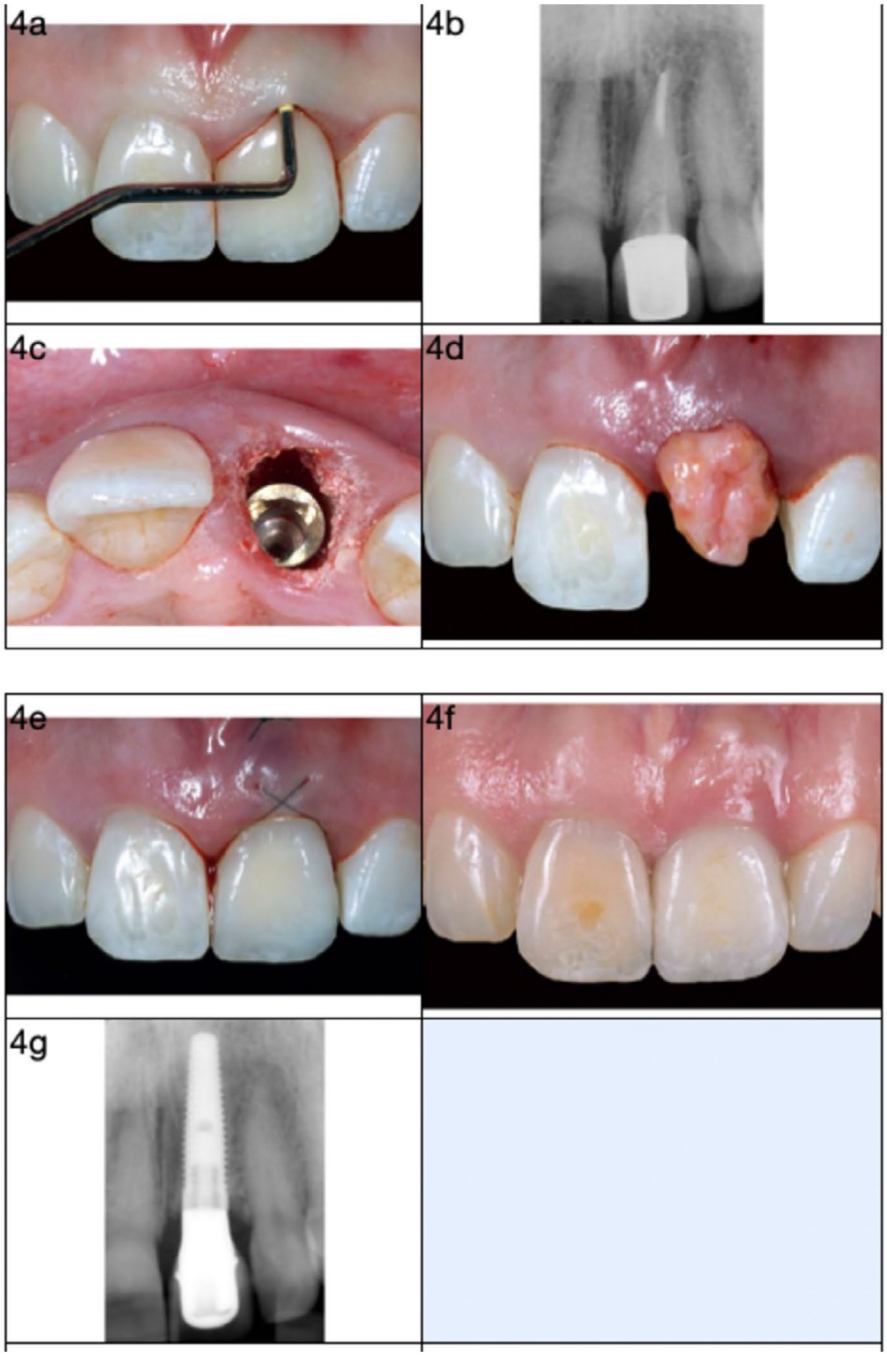

FIGURE 4 | Immediate placement with immediate restoration. (a) Upper central incisor showing a deep pocket on the buccal side. (b) Baseline intraoral radiograph. (c) After tooth extraction, implant inserted on the palatal wall leaving a wide gap. (d) After bovine bone mineral was inserted into the bone-to-implant gap, a connective tissue graft was inserted into a buccal mucosal tunnel. (e) Provisional crown immediately delivered. (f) Definitive ceramic crown. (g) Final intraoral radiograph.

treatment approaches for the postextraction site in conjunction with implant reconstruction in the maxillary aesthetic zone. The expert participants, in order to enhance the general value of the project and reduce its inherent limitations, unanimously decided to focus this work only on the sites from premolar to premolar in the maxilla, excluding the molar sites. The present consensus report included elements of survey research, Delphi methods, S1/S2k level clinical guideline development and a consensus meeting to achieve its goal.

Expert participants from implant dentistry, prosthodontics and periodontics (MA, DB, UG, JK, RL, MS, GZ, OZ) under the organisation of the Giuseppe Cardaropoli Foundation, together with the chairman (DC) and the co-chairman (SJ), were first requested to complete a Delphi survey indicating their preferred treatment options for each one of the four classes of postextraction sites. Every expert participant indicated his first and second preferred treatment option for each class of the postextraction sites (Table 2). The results were pooled and the treatment options with the majority of votes were presented to the

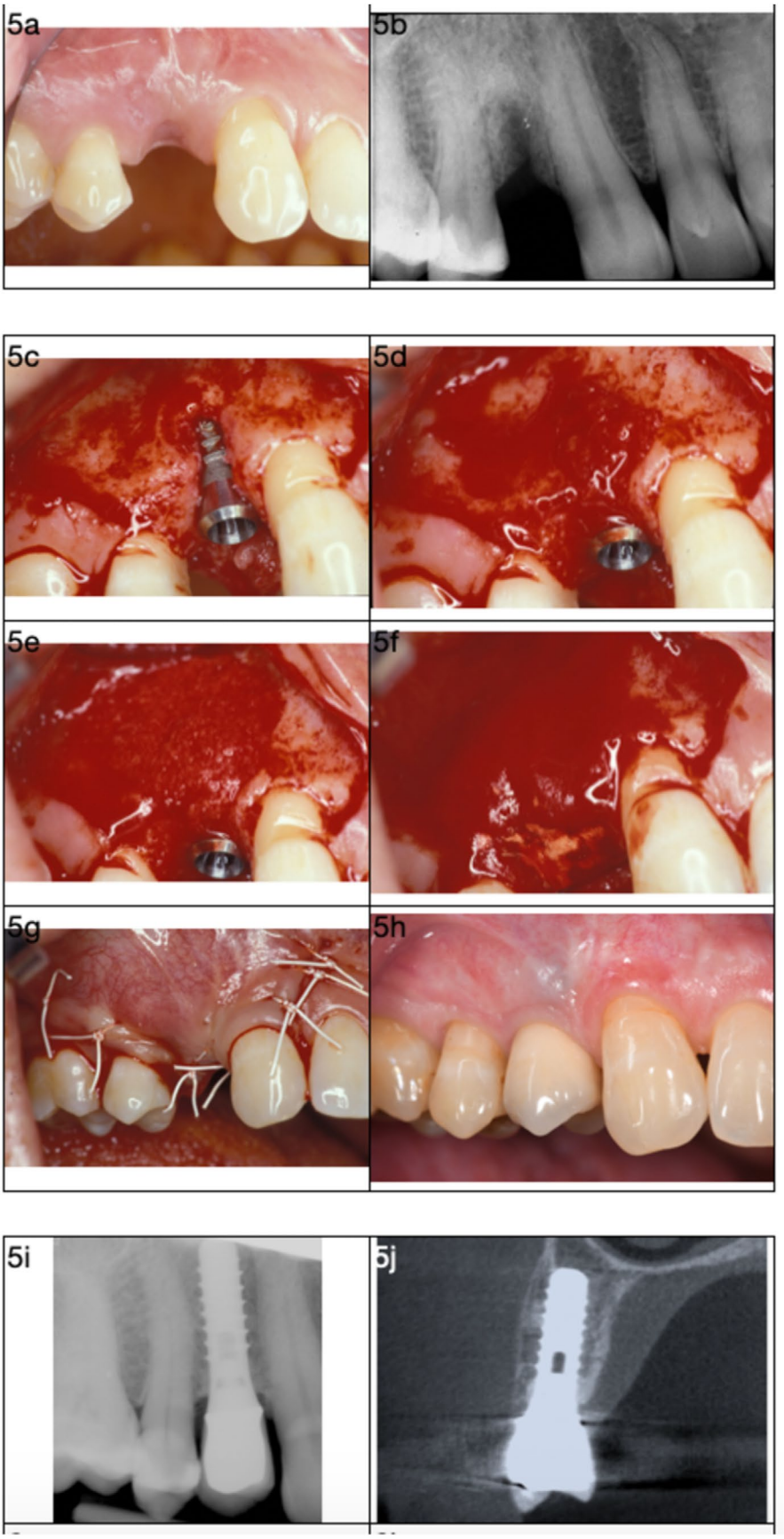

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FIGURE 5 | Early implant placement. (a) First patient treated in 1998 at the University of Bern using this technique. Clinical status 6 weeks following extraction. (b) Periapical radiograph. (c) Implant is inserted leaving a buccal bone defect measuring 6 mm in the vertical dimension. (d) Bone defect is filled with autologous bone chips. (e) Second layer of bovine derived DBBM particles is applied. (f) Porcine collagen membrane is placed. (g) Tension-free primary wound closure for a submerged healing of the implant was reached. (h) Clinical examination in 2024 shows a 26-year follow-up with optimal soft tissue stability. (i) Periapical radiograph 26-years postplacement shows excellent bone crest levels. (j) Orofacial CBCT cut at 26 years postplacement shows a fully intact buccal bone wall.

experts as preferred treatment options. The eight experts then met in person for a 2-day consensus conference, moderated by the chairman (DC) and the co-chairman (SJ), that was held in Torino, Italy, on 1–2 February 2024.

During the consensus conference the participants were given the opportunity to discuss the results of the first survey again, conducting a collegial critical analysis of the individual treatment options, until reaching a unanimous agreement on the recommended treatment options for each clinical scenario. These treatment options are presented below.

Extraction Site Class Ia (intact socket, thick phenotype):

Preferred and recommended treatment option:

- Immediate implant placement and provisionalisation (IIPP) with internal gap grafting (optional soft tissue augmentation).

Alternative treatment option:

- Tooth extraction with spontaneous healing followed by early implant placement (after 6–8 weeks) and contour augmentation if needed.
- Alveolar ridge preservation with delayed implant placement after 4–6 months.

Extraction Site Class Ib (intact socket, thin phenotype):

Preferred and recommended treatment option:

- Immediate implant placement and provisionalisation (IIPP) with internal gap grafting and a soft tissue augmentation procedure.

Alternative treatment options:

- Tooth extraction with spontaneous healing followed by early implant placement (after 6–8 weeks) and contour augmentation if needed.
- Alveolar Ridge Preservation with delayed implant placement after 4–6 months.

Extraction Site Class II (intact socket, no bone housing for IIP):

Preferred and recommended treatment options:

- Tooth extraction with spontaneous healing followed by early implant placement (after 6–8 weeks) and contour augmentation if needed.
- Alveolar Ridge Preservation with delayed implant placement after 4–6 months.

Extraction Site Class III (partially compromised socket):

Preferred and recommended treatment options:

- Tooth extraction with spontaneous healing followed by early implant placement and contour augmentation after 6–8 weeks.
- Alveolar ridge augmentation at the time of tooth extraction with delayed implant placement after 4–6 months.

Alternative treatment option:

- Tooth extraction with spontaneous healing followed by delayed implant placement and ridge augmentation after 4–6 months (soft tissue augmentation is suggested).

Extraction Site Class IV (severely compromised socket):

Preferred and recommended treatment options:

- Tooth extraction with spontaneous healing followed by early implant placement and ridge augmentation after 6–8 weeks.
- Tooth extraction with spontaneous healing followed by delayed implant placement and ridge augmentation after 4–6 months (soft tissue augmentation is suggested).

5 | Discussion

The management of the postextraction site is still a matter of ongoing debate with regard to the recommended timing of implant placement.

The experts invited to participate in first Giuseppe Cardaropoli Consensus Conference were able to agree on a series of recommendations, based on their extensive clinical experience and research contributions, regarding the best treatment option for a specific clinical scenario. The present consensus report included elements of survey research, Delphi methods, S1/S2k level clinical guideline development and a consensus meeting to achieve its goal. A key element of the Delphi method are repeated rounds of questionnaires/surveys, where a facilitator provides an anonymised summary of the experts' assessments from the previous round as well as the reasons they provided for their judgements. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers will decrease and the group will converge towards the 'correct' answer. Clinical guideline development on the S1/S2k level is based on an expert group representative for the respective subject and a structured consensus process. Therefore, for the present topic experts from implant dentistry, prosthodontics and periodontics

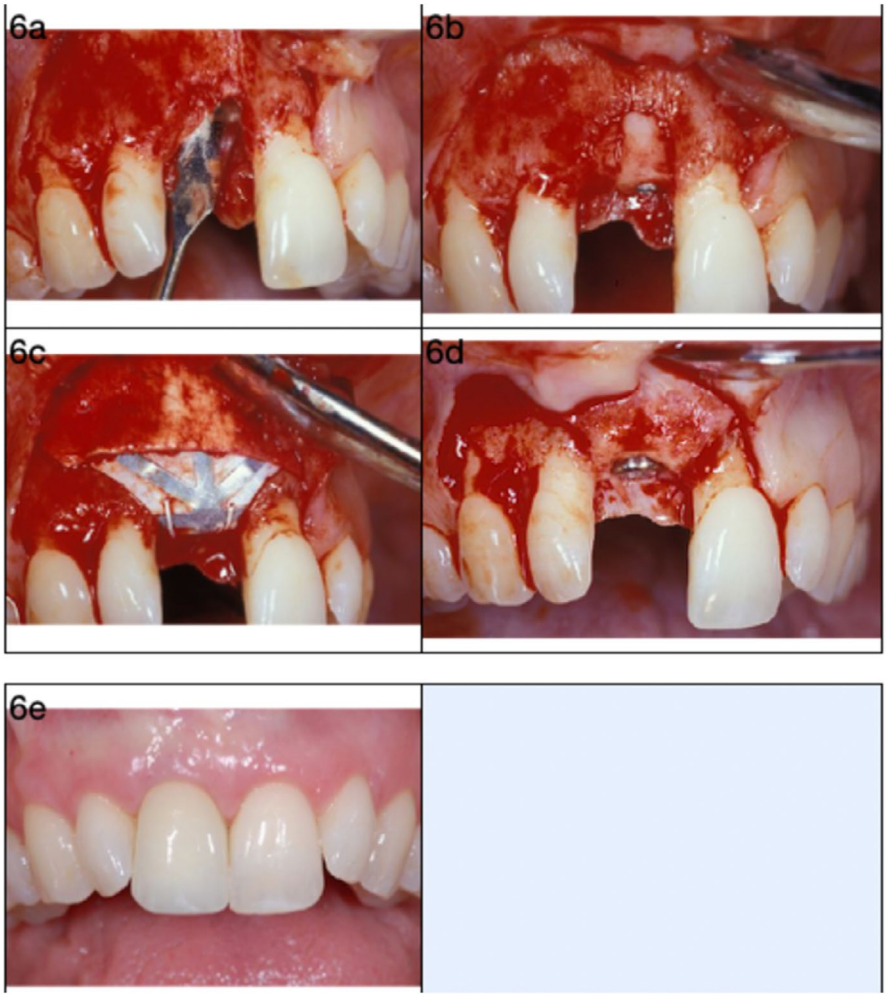


FIGURE 6 | Ridge augmentation. (a) Intrasurgical view 3 months after extraction showing a deep bone defect. (b) Ridge augmentation performed used an autogenous bone block. (c) After additional bovine bone mineral particles were placed on top of autogenous bone, a titanium-reinforced PTFE membrane is placed over the graft and sutured, and a resorbable collagen membrane is placed on top of it. (d) Implant is inserted after 8 months. (e) Definitive implant-supported ceramic crown.

were invited and independent moderators were involved to lead the process. However, unlike in S3 level clinical guidelines no attempts are made to grade the strength of the recommendation (i.e. 'we recommend' as opposed to 'we suggest').

If the extraction socket is intact, with the buccal bone plate preserved and no soft tissue deficiency, and if the site presents with an adequate volume of bone available to reach implant primary stability (Class I), the experts suggest to perform an Immediate Implant Placement. This option is supported by literature [10, 11, 63, 64]. In case of thick phenotype (subclass Ia), a flapless approach can be preferred, in order to avoid any remodelling of the outer bone surface [9, 64, 65, 66]. Despite the thick phenotype, in highly demanding aesthetic sites, to minimise the risk of gingival margin recession, simultaneous soft tissue augmentation may be taken into consideration. A correct 3D 'virtually planned' implant placement is mandatory and the use of a computer-guided surgical stent is recommended. The implant platform should be placed more than 2 mm from the inner aspect of the buccal bone plate in the horizontal dimension, and 3.5–4 mm from the expected emergence profile in the vertical dimension, intended as the distance from the implant platform to the free gingival margin. The use of a reduced diameter implant requires a slightly deeper placement to allow for necessary emergence profile. Following implant placement, it is recommended to fill the internal bone-to-implant gap with a bone graft in order to limit buccal bone remodelling, as already reported in literature [67]. Bovine bone mineral seems to be a suitable bone substitute for this purpose [29, 32, 68–73]. Primary stability of minimum 65 ISQ or 30 Ncm is suggested to deliver immediate restoration [39, 40]. The risk for micromovement should be minimised by avoiding any centric and eccentric occlusal contacts and the provisional restoration should not be removed during the osseointegration period [36]. The advantages of immediate restoration include aesthetics and the shortening of the treatment time [40, 71, 72]. Screw-retained temporary crowns are preferred over cemented crowns [73].

In case of thin phenotype (subclass Ib), soft tissue augmentation procedures can be used to increase thickness. Although the literature reports the use of biomaterials replacing autologous grafts for the management of peri-implant soft tissues, these seem to find indications in selected cases. In this perspective, the use of a volume stable collagen matrix has been proposed [74, 75].

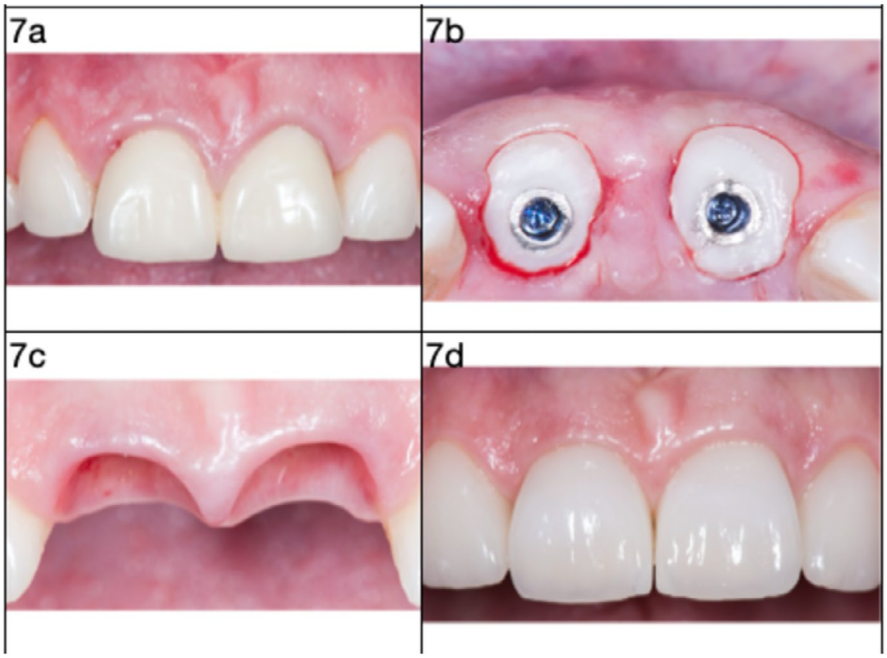


FIGURE 7 | Socket-shield technique. (a) Baseline situation before extraction of the two upper central incisors. (b) Two implants were inserted following the socket-shield protocol and two customised healing abutments were delivered. (c) Soft tissue healing after 4 months. (d) Final evaluation of the two ceramic crowns.

However, the use of a subepithelial connective tissue graft still seems to be the most predictable procedure to date, and even the experts participating in the consensus conference agree on this point [32, 33, 41, 42, 76] It has been reported that a connective tissue graft is able to promote greater stability of peri-implant bone levels, improve mucosal thickness and peri-implant conditions around the implant-supported crown and prevent risk of future aesthetic and biological complications [34].

Alternative options for Class I sites include Early Implant Placement 6–8 weeks after tooth extraction possibly with contour augmentation using a two-layer composite bone graft and barrier membrane [53–55] and alveolar ridge preservation. This procedure can compensate for the marginal bone remodelling following tooth extraction [26, 77] and the implant can be inserted after 4–6 months of healing. Literature suggests the use of a bone substitute, that is, bovine bone mineral, to graft the empty socket that should be protected either by a free gingival graft, barrier membrane or collagen matrix [16, 21, 24, 78].

In postextraction sites Class II, when an implant cannot be immediately placed, experts suggest either Early Implant Placement [53–55] with contour augmentation or Alveolar Ridge Preservation with a delayed implant placement [27–29].

In presence of a partially compromised postextraction site (Class III), the suggestion is Early Implant Placement and simultaneous GBR. With this approach, following tooth extraction complete soft tissue coverage is usually achieved after 6 to 8 weeks. At the end of the healing period, the increased soft tissue area and volume facilitates soft tissue flap management. Since socket walls are compromised, adjunctive surgical procedures are required to augment the bone volume (horizontal and/or vertical bone regeneration using bone substitutes and barrier membranes) as well as soft tissues augmentation (CTG or collagen matrix) if needed [56].

A second option of treatment could be horizontal and/or vertical alveolar ridge augmentation, corresponding to a bone augmentation procedure performed at the time of tooth extraction without simultaneous implant placement. These procedures are usually performed with flap reflection and advancement, using autogenous bone chips mixed with bone substitutes and protected with a nonresorbable or resorbable barrier membrane. Implant placement is usually performed after 6 months [62].

As alternative, spontaneous healing followed by delayed implant placement and ridge augmentation after 4–6 months (soft tissue augmentation is suggested) can be considered [57].

If there is a Class IV postextraction site, severely resorbed, early implant placement 6–8 weeks after tooth extraction with ridge augmentation [53–55] or delayed implant placement 4–6 months after tooth extraction with ridge augmentation and possibly also soft tissue augmentation can be recommended [57, 62].

5.1 | Specific Considerations

Socket-shield technique (SST):

- Notwithstanding the scientifically documented successes achieved with the SST in the meanwhile, it is clear though that the risks associated with partial root retention can be considerable, especially when used for immediate implant placement in the aesthetic zone.

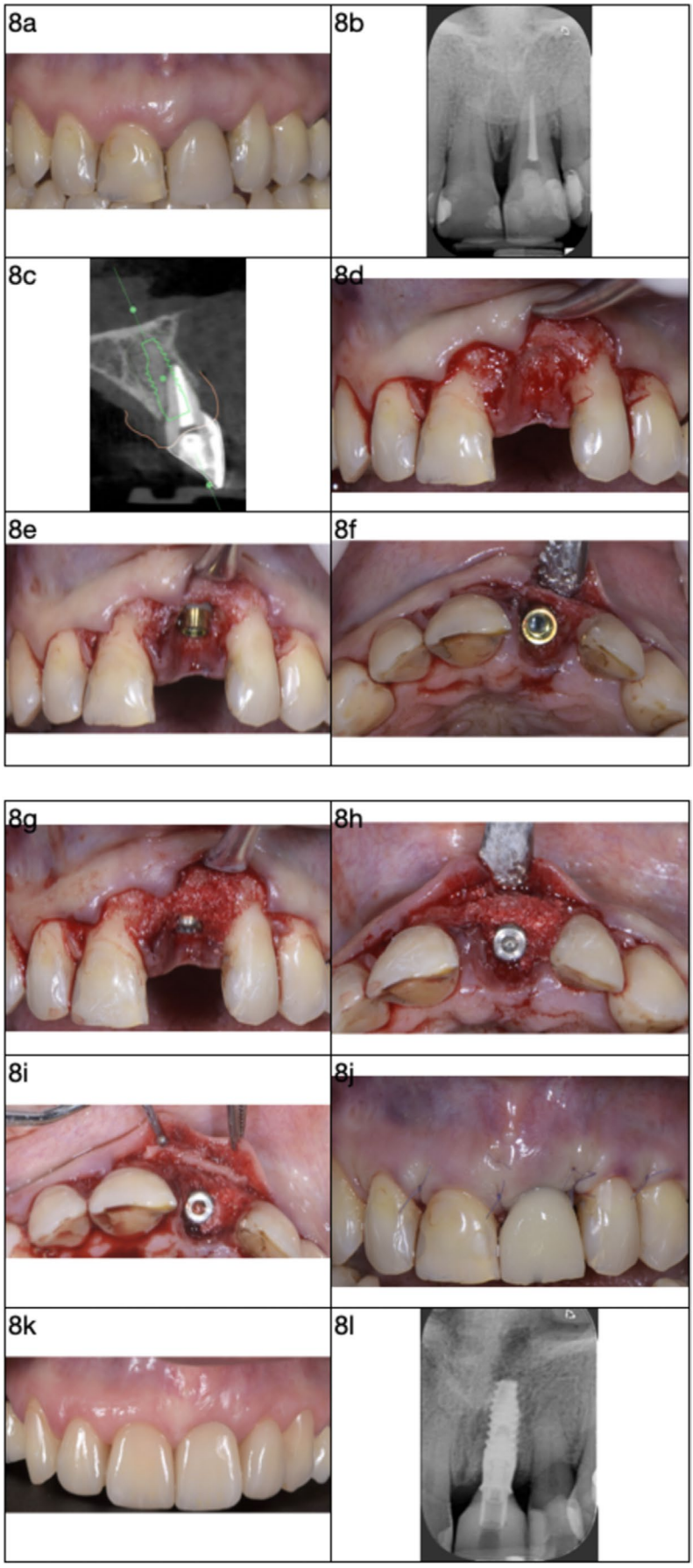
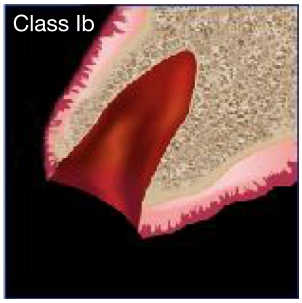
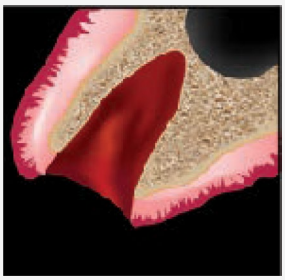


FIGURE 8 | Legend on next page.

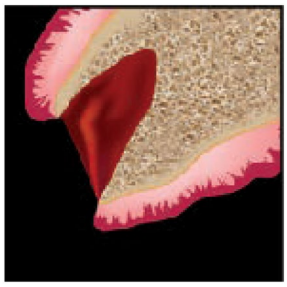
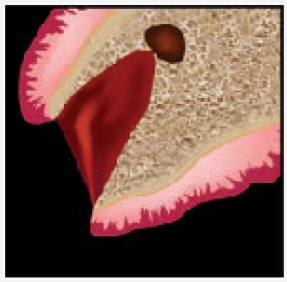
FIGURE 8 | Immediate Implant Placement with Mucogingival Approach. (a) Baseline evaluation of a hopeless left upper central incisor. (b) Baseline intraoral radiograph. (c) Initial CBCT scan with the planned implant positioning. (d) After tooth extraction, two surgical papillae are created and the flap is raised. (e) Implant is inserted in the ideal position showing the bone dehiscence. (f) Occlusal view after implant placement. (g) Implant gap is grafted with bovine bone mineral. (h) Bovine bone mineral is also used to over contour the buccal bone dehiscence. (i) Connective tissue graft is placed under the buccal flap, over the bone graft. (j) Provisional crown is immediately delivered and the flap is sutured. (k) Final evaluation after 1 year, with the definitive ceramic crown. (l) Intraoral radiograph at 1 year showing stable marginal bone level.

TABLE 2 | Preferred treatments by consensus conference participants for each type of post-extraction site.

Postextraction site classification	First choice of treatment from the participants	Second choice of treatment from the participants
 Class Ia	1. IIP with gap grafting 2. IIP flapless and CAIS 3. IIP with CTG 4. IIPP with CTG 5. IIP with CTG and gap grafting 6. IIP 7. IIPP 8. IIPP gap filling	1. 1. ARP with late placement 2. Early implant placement 3. — 4. Early impact placement 5. ARP 6. ARP 7. — 8. Delayed placement
 Class Ib	1. IIP with gap grafting 2. Early placement with GBR 3. IIP with CTG 4. IIPP withCTG 5. IIP with CTG and gap grafting 6. IIP with CTG 7. IIPP with CTG 8. IIPP with gap filling and CTG	1. 1. ARP with late placement 2. ARP and late placement (ev GBR) 3. — 4. Early placement 5. ARP 6. ARP 7. — 8. Socket shield or delayed
 Class II	1. Ridge Augmentation and early implant placement 2. ARP and late placement 3. Early placement with GBR and CTG 4. ARP and delayed implant placement 5. ARP 6. ARP 7. IIPP and CTG 8. IIPP with gap filling and CTG	1. Ridge Augmentation and late implant placement 2. — 3. 8 weeks after: GBR and 6–8 months after IP with another GBR 4. Early placement 5. Type II- Delayed placement at 8–12 weeks: with contour augmentation 6. Early placement 7. ARP 8. Socket shield or delayed

(Continues)

TABLE 2 | (Continued)

Postextraction site classification	First choice of treatment from the participants	Second choice of treatment from the participants
 Class III	1. Ridge Augmentation and early implant placement 2. Early placement with GBR 3. Early placement with GBR and CTG 4. ARP with CTG, then implant and GBR 5. ARP 6. Early placement with soft and hard tissue augmentation 7. IIPP, GBR, CTG 8. IIP with socket shield	1. Ridge Augmentation and late implant placement 2. ARP and late placement (ev GBR) 3. — 4. Early Implant placement with contoured grafting and possible CTG 5. Type II- Delayed placement at 8–12 weeks: with contour augmentation 6. Ridge Augmentation 7. — 8. IIP with GBR or delayed
 Class IV	1. Ridge Augmentation and early implant placement 2. Ridge Augmentation and late placement 3. Soft tissue aug, after 6 weeks Implant Placement and GBR 4. ARP with CTG, then implant and GBR 5. Type II- Delayed placement at 8–12 weeks: with contour augmentation 6. early placement with soft and hard tissue augmentation 7. IIPP with GBR and CTG 8. IIP with simultaneous immediate dentoalveolar restoration (evtl. sinus elevation)	1. Ridge Augmentation and late implant placement 2. Ridge augmentation with GBR and Implant placement 5 months later 3. Soft tissue aug, after 6 weeks GBR, after 6–8 months IP and ev GBR 4. Early Implant placement with contoured grafting and possible CTG 5. Horizontal & or Vertical Ridge GBR 6. Alveolar ridge augmentation and staged implant placement 7. Delayed implant placement 6 months 8. Delayed implant placement

Abbreviations: IIP, immediate implant placement; IIPP, immediate implant placement and provisionalisation; ARP, alveolar ridge preservation; CAIS, computer aided implant surgery; CTG, connective tissue graft; GBR, guided bone regeneration.

- Consequently, as long as well-designed prospective and controlled studies with larger patient populations and longer follow-up periods are not available, SST cannot be recommended for routine use in clinical practice.
- It appears that for the moment the SST may be a viable option only in clinical situations where predictable aesthetic success is not possible with traditional implant protocols in particular if more than one tooth next to each other needs to be replaced.

5.2 | General Treatment Considerations

In order to reduce the risk for biologic peri-implant complications, mucositis and peri-implantitis, the expert group, strongly and unanimously, recommends never considering implant placement in the presence of periodontal inflammation. Implant therapy can be performed, in periodontal patients, only after comprehensive infection and inflammation control, in highly motivated patients. Implant surgery can only be taken into consideration within or after STEP 3 of the periodontitis treatment guidelines issued by the EFP [79, 80], that is, when the patient has completed STEP 1 (motivation, compliance, risk factor control) and STEP 2 (cause-related, anti-infective therapy) to the defined therapeutic endpoint. The implant sites must receive regular supportive peri-implant care (SPIC, STEP 4) [81].

6 | Conclusions

The results of the First Giuseppe Cardaropoli Foundation Consensus Conference on the treatment of the postextraction sites in anticipation of implant placement, suggest to accurately evaluate:

- the characteristics of the site,
- the available bone volume,
- the integrity of the buccal bone plate and
- the gingival phenotype

before taking clinical and surgical decisions.

With a proper case selection, immediate placement with immediate restoration represents a valid option when the alveolus is intact, with alveolar ridge preservation and early placement as possible alternatives.

Early placement may be suggested when there is a thin gingival phenotype or when the site is partially compromised.

Bone augmentation with delayed placement is a valid choice in the presence of a severely compromised site.

It is hoped that this article will be helpful to provide dentists with specific clinical recommendations that they can use in drawing up the most appropriate treatment plan for their patients following tooth extraction and before implant placement.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no data sets were generated or analysed during the current study.

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