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Bone replacement following dental trauma prior to implant surgery – present status

REVIEW ARTICLE

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Abstract –Dento-alveolar trauma often leads to a need for reconstruction of the alveolar crest before an implant can be placed. Although autogenous bone grafts is considered the 'gold standard', this may be associated with patient morbidity and graft resorption. Consequently, the use of bone substitutes has increased. Today, a substantial number of biomaterials are available on the market, but only a few are well documented. The user should be aware that these biomaterials have different properties: resorbable or non-resorbable, time of resorption and resorption mechanism. The purpose of this review is to describe the function of various bone substitutes and indications for their use in reconstructive implant surgery and to give an overview of the current situation.

Severe dento-alveolar trauma is often associated with tooth loss, root resorption and defects in the alveolar crest. Surgical repair is extremely challenging, especially in terms of aesthetics. A thorough evaluation of the hard and soft tissues has to be performed. Both horizontal and vertical augmentation, guided bone regeneration (GBR) and mucosal transplants might be needed prior to or in combination with implant placement. In some cases, it is possible to extract the tooth, immediately place the implant and perform a simultaneous augmentation, but more frequently this procedure has to be carried out in several steps (1). In special cases, when there is a combined soft- and hard-tissue problem, osteodistraction is an alternative to GBR. However, it is unclear which technique is to be preferred (2).

Because of its osteogeneic properties and compatability autogenous bone (AB) is considered as the 'gold standard' (3). AB might be harvested from extraoral sites, such as the iliac crest or from intra oral sites, used in a block or particulated. The drawbacks are patient morbidity (4) and bone resorption (5). The use of bone substitutes is therefore attractive for the patient and the surgeon.

Bone substitutes have varying properties, such as whether they are resorbable or non-resorbable, which is of major importance. If the goal is to maintain the volume of the augmented area over time, biomaterials that are non-resorbable should be the first choice (1).

There are a great number of materials on the market: demineralized freeze-dried bone (DFDB), freeze-dried bone (FDB), hydroxyapatites (HAs), deproteinized bovine bone (DBB), calcium sulphate, tri-calcium phosphate (TCP), bioglasses and biphasic materials, all with different properties (Table 3). It is important to know about the biological behaviour of these different biomaterials.

Apart from AB that has osteoinductive properties, bone substitutes are only osteoconductive. The osteoconductive process is a much slower process than osteoinduction. Therefore, the graft-healing time for non-resorbable biomaterials, before implant placement, has to be prolonged by 2–3 months compared with AB grafts (6). Bioactivity of biomaterials is another issue of importance. It seems that phosphorous, calcium and silicon ions might play an important role on the surface of some biomaterials that may stimulate bone formation (7), although the exact mechanism is not clearly understood. Calcium sulphate and TCP are examples of resorbable biomaterials, which resorb quickly and probably releases bioactive ions that can stimulate bone formation. When these kinds of materials are used, the graft-healing time is also shortened (8–10).

DBB is the most documented biomaterial and has been recommended as the first choice for sinus floor augmentation (2). As the material is non-resorbable, it also is an alternative to AB grafts for use in augmentation procedures in the anterior maxilla. One drawback is that the bone is of bovine origin.

The production of a completely synthetic material that mimics bone is, of course, advantageous.

As bone formation around synthetic HA has been found to be slower than for DBB (11, 12), a new generation of synthetic materials has entered the market (biphasic calcium phosphates). These materials resemble

bone in morphology and have one part of HA and one part of TCP, thereby being both osteoconductive and bioactive, releasing ions that stimulate bone formation (7). However, clinical studies showing that the results are equal to those for AB or DBB are still missing.

The purpose of this review is to describe different bone substitutes, their function and give indications for their use in reconstructive implant surgery.

Bone formation

Formation of new bone around a bone graft is initially controlled by living cells (osteoblasts) in the graft or in the recipient bone and periosteum. This immediate possibility of bone formation is called *osteogenesis*.

AB graft also contains bone morphogenetic proteins (BMPs) and cytokines (hormone-like peptides) that can stimulate stem cells to become bone-building cells leading to bone formation (*osteoinduction*). This osteoinductive process is completed within 4–8 months. One example of BMPs is rhBMP-2 that can be tissue engineered using recombinant-DNA. Growth hormones, proteins and cytokines most often cooperate both in the bone-building process and bone-resorptive process. BMPs belong to the 'transforming growth factor' (TGF-β) family. More than 40 related biologically active peptides, including BMP, growth and differentiation factors (GDF), inhibines/activines, and TGF-β, are known today.

A bone graft placed at the recipient bone also acts as a three-dimensional (3-D) scaffold that allows in-growth of vessels and bone-building cells (*osteoconduction*). The osteoconductive process might take as long as 3 years (13, 14).

AB and growth factors

AB contains both living cells and cytokines and is therefore suggested to constitute the 'gold standard' in bone-augmentation procedures. Bone turnover starts immediately at the time of grafting, and after a healing time of 4–9 months, the bone graft has been replaced by a newly formed bone, allowing for implant placement (13). In most respects, the healing of bone grafts follows the same procedure as the healing of a fracture.

The effects of different agents (platelet-rich plasma, growth factors and BMP) added to a bone graft have been extensively evaluated both in human trials and animal studies. However, the effects have been hard to prove and today there is lack of clinical evidence to support their use in reconstructive implant surgery (2, 15).

Guided bone regeneration

In this technique, a semi-permeable membrane is used to act as a physical barrier to protect against the in-growth of soft tissue cells. This is to enable for uneventful bone healing of the defect. These membranes can be resorbable or non-resorbable. In order to avoid collapse, the membrane can be reinforced with titanium or some kind of filler material can be used, such as AB or bone substitute, to enhance the clinical outcome (1, 16–19). Horizontal ridge augmentation using this technique is well documented with good results (15). Compared to horizontal augmentation, clinical experience of vertical GBR is limited but promising results have been reported (18, 20, 21, 22). However, there is a higher risk of an inflammatory process associated with membrane exposure, especially when non-resorbable membranes are used in vertical augmentation. Rasmusson et al. (23) also reported extensive bone resorption of the regenerated bone after membrane removal.

Bone substitutes

The use of bone substitutes has always attracted surgeons; however, the ideal material has yet to be found. There are important criteria that have to be met: safety, bio-compatability, optimal surface characteristics and porosity.

Several different possibilities exist for sterilization and elimination of the risk for immunological rejection of bone substitutes (Table 1).

Some biomaterials have the optimal morphology and scaffold and are also non-resorbable, which is important, especially if used in sites where aesthetics is important (24). Various bone substitutes have been frequently evaluated as grafting materials in the floor of the maxillary sinus (2). Today, there is no evidence that better results are achieved using AB compared with DBB or TCP in this site (2). However, there are few reports on the use and evaluation of different biomaterials for other indications.

Bone substitutes can be divided in three groups (Table 2).

Allograft is derived from another individual of the same species. Orthopaedic surgeons have a long tradition of using human bone. The bone is usually stored in bone banks and used as fresh-frozen bone (FFB). The risk of immunological rejection is eliminated by the freezing procedure. Even though all donors are tested twice

Table 1. Processes for sterilization and elimination of risks of immunological reactions

Freeze drying
Demineralization
Freezing (<70°C)
Autolysation
Chemosterilization

Table 2. Classification of bone substitutes

Allograft (same species)	Xenograft (another species)	Alloplast (synthetic)
FFB	Bovine	Calcium phosphates
FDBA	Corals	Calcium sulphate
DFDBA		Bioglasses
AAA		Polymers

before the use of the bone allograft, the risk of transmitting of diseases cannot be completely eliminated.

In reconstructive implant surgery, allografts are more frequently manufactured and used as freeze-dried bone allograft (FDBA), demineralized freeze-dried bone allograft (DFDBA) or as autolysed antigen-extracted allograft (AAA). These materials have a long and safe history (25).

In animal studies, allografts have been found to contain osteoinductive molecules such as BMPs (26). However, clinical evidence of their osteoinductive potential is still under debate (2, 27).

In the USA, allografts are frequently used in mixtures together with AB and various biomaterials (28). However, the benefits of their use are questionable.

Xenografts consist of bone mineral from animals, such as anorganic bovine bone, or from corals or algae (27, 29) and are frequently used in reconstructive implant surgery (2).

One anorganic bovine bone mineral (Bio-Oss®; Geistlich, Pharma, Switzerland) is extensively investigated in both experimental and clinical studies (2) and probably sets the 'standard of care' among biomaterials. The composition and morphology of the material is similar to that of human bone and is osteoconductive. This material was initially launched as a resorbable, slowly degradable material, and in several clinical histological studies, the finding of osteoclasts in close contact with the biomaterial has been interpreted as that the cells actually resorb the material (30, 31). However, several other clinical histological studies have showed that Bio-Oss® does not resorb (9, 32), which makes sense, as the material does not contain any proteins [Arg-Gly-Asp adhesion molecules (RGD)-sequences] that can activate the osteoclast (33). Bio-Oss® can be used in the floor of the sinus or for widening of the alveolar crest, with or without adding AB (2, 34, 35). However, other indications such as filling of extraction sockets, cysts or defects after apical surgery are dubious. These defects normally heal after surgery without any intervention, through the osteoconductive coagulum.

The risk for transfection using bovine bone has been frequently debated. Today, there is no evidence for such risks (36).

Another kind of xenograft is made from corals (goniopora coral extract) and commercially manufactured as Algipore® (Friadent GmbH, Manneheim, Germany) or as ProOsteon® (Interpore Cross International, Inc., Irvine, CA, USA). These materials consist of tri-calcium carbonate with a structure similar to cortical and spongious bone. The material is biocompatible, osteoconductive, non-resorbable and has been recommended for sinus floor augmentation (37).

Alloplastic bone substitutes are calcium-based ceramics, polymers, calcium sulphate and bioactive glasses (Table 3). This is a huge group of biomaterials with a variety of chemical compositions and biological characteristics.

The most frequent composition is HA, β-TCP, biphasic calcium phosphate or in a form of non-sintered calcium phosphate (calcium-poor apatite). Pure calcium phosphate is, in general, weaker than HA in its constitution and can chemically dissolve into ions, which is not possible for HA.

Calcium phosphates are made from TCP powder solved in naphthalene, to form uniform crystals with an optimized porosity of 100–300 μm. This solid structure can be sintered under high pressure and temperature to obtain a uniform material with more structured crystals (β-TCP). The material is solved chemically and ions are released that can stimulate bone formation. The most commercially widely used is Cerasorb® (Curasan AG, Kleinostheim, Germany). This material can be used in the floor of the maxillary sinus but cannot be recommended for use in the aesthetic zone, as the volume of the graft will probably not remain due to fast resorption of the material (9).

Examples of synthetically manufactured hydroxy apatites are Calcitec® (Calcitec Inc., Austin, TX, USA) and Osteogen® (Impladent Ltd, Holliwood, NY, USA). These materials are osteoconductive and non-resorbable and can be used in the floor of the sinus and in the aesthetic zone.

Biphasic materials are produced by sintering HA and TCP to a chemically composite material where the TCP part will dissolve and the HA part remain. It has been shown that biphasic materials are effective for the treatment of skeletal defects (12, 38). Examples of these materials are TRICOS® (Baxter AB, Bern, Switzerland) and Bone Ceramic® (Straumann, Basel, Switzerland). However, they cannot yet be recommended for maxillary reconstructions, as clinical studies are still lacking.

Table 3. Different properties of grafting materials

	Osteoinductive	Osteoconductive	Resorbable	Bioactive	Biocompatible
Autogenous bone	+++	++	+++	−	+++
Allogeneic bone	+	++	+++	−	++
FDBA	−	++	+++	−	+++
DFDBA	+	++	+++	−	+++
DBB	−	++	−	++	+++
TCP	−	+	+++	+	+++
Coral	−	+++	−	−	+++
HA	−	+++	−		+++
HA/TCP	−	+++	++	+	+++
HA/collagen	−	+++	++	−	+++
HA/TCP/collagen	−	+++	++	+	+++
Calcium sulphate	−	+	+++	+	+++
Bioactive glass	−	++	++	++	+++

Calcium phosphates can also be bounded to collagen or fibrin. It is possible for minerals to be released on the surface of the network of collagen or fibrin. Collagen also binds to extracellular matrix proteins, which are important mediators for the mineralization process. Helaos® (Orquest, Mountain View, CA, USA) is a mixture of HA and bovine collagen, and Collagraft® (Zimmer, Corp., Warsaw, IN, USA) is a mixture of 65% HA and 35% TCP in combination with an equal amount of bovine collagen. TRICOS® is a mixture of HA/TCP and fibrin.

Calcium sulphate (surgical plaster) is probably the oldest biomaterial of all initially used for covering of skull defects. The material is osteoconductive but resorbs readily, and thus the volume of the graft is not maintained. This material can be used in the floor of the sinus (8) but, due to the quick resorption, probably should be avoided in the aesthetic zone. The material is commercially manufactured from ClassImplant® (Roma, Italy).

Calcium phosphate silicates or bioactive glasses (Biogran®, BIOMET 3i; Biomet Inc., Warsaw, IN, USA) are made of silicon and are slowly resorbable materials that are also osteoconductive. Such material corrodes when it is placed as a graft, and hydrogen ions are released on its surface. Sodium and silicon ions are released starting stimulation and recruitment of stem cells (7). These cells can turn into osteoblasts, thereby initiating bone formation. The volume of the graft is probably much better maintained compared with TCP or calcium sulphate. The material has been used in the floor of the maxillary sinus for augmentation prior to implant surgery (10, 39).

Surgical considerations

Treatment planning in reconstructive surgery is crucial. Dental trauma is easily visualized using traditional radiography (plain film). However, to be able to visualize structural changes and defects in the bone, 3-D imaging, using tomography or computed tomography, is mandatory. Clinical examination of the traumatized area and soft tissue is also important for choosing the right therapy. Furthermore, the health of the patient and her/his smoking habits are factors of importance. Smokers might be more prone to complications and early implant failure (40). The surgeon has to decide what material is to be used. As there are a huge number of biomaterials available, the decision has to be made on the basis of clinical experience. AB can be used for all indications; however, the choice of different biomaterials has to be made on the evidence available in the literature. Most materials can probably be used in the floor of the maxillary sinus; however, the manufacturers should be able to provide adequate clinical documentation. In the aesthetic zone, the first choice probably should be a non-resorbable material for long-term predictability.

Surgical technique

If bone harvesting is necessary, the mandibular ramus is the first choice of donor sites. Bone blocks harvested from the mandibular symphyses has a higher incidence of morbidity (4). If a larger amount of bone is needed, the iliac crest is the first choice. AB may be grafted in cortical, cancellous or cortico-cancellous form and can be placed onto the recipient bed either as a block or in particulated form.

Sinus floor augmentation

Sometimes, the floor of the maxillary sinus interferes with the traumatized site and has to be augmented. Augmentation of the sinus has been found to be a predictable method and excellent results have been presented using various kinds of biomaterials (2, 6, 8–10).

In an evidence-based review, DBB and TCP were recommended as the first choice comparable to AB (2).

The maxillary sinus is a protected area surrounded by bone walls, which is probably the perfect environment for the incorporation of biomaterials.

The graft-healing time is 4–6 months if only AB, or a resorbable biomaterial, is used (calcium sulphate and TCP) (6, 9). If only a non-resorbable material is used, the graft-healing time has to be prolonged by 2–3 months (6). Adding AB to the graft might shorten the healing time, but it is unclear to what extent.

Lateral augmentation of the alveolar crest

Due to loss of the buccal bone plate after trauma or bone resorption after extraction of a tooth (41), the ridge often has to be augmented both laterally and vertically. The size of the defect or any concavity must be evaluated before treatment planning. If the concavity or defect is small, the augmentation can be performed without adding AB, preferably with a non-resorbable material and covered with a resorbable membrane (42).

The graft has to heal for 9–12 months before implant placement (34) (Fig. 1). When there is a larger defect or even a vertical loss of bone, a bone block is needed, which can be covered with a non-resorbale biomaterial and a membrane to minimize the risk of resorption (1).

Studies by Gordh and Alberius (43) concluded that a uni-cortical cortico-cancellous bone graft is best placed with the cancellous part towards the recipient site. Cortical perforations were also found to facilitate revascularization of the graft.

Rigid fixation of a block bone graft with mini-screws is important for healing in that it prevents in-growth of fibrous tissue between the graft and the recipient bone (44).

Veneer grafts can also be used to solve a 3-D lack of bone with or without a membrane (45, 46).

Vertical augmentation

Vertical bone loss is the most complicated situation for reconstruction. Bone blocks in a J-shape or as a top onlay, retained by mini-screws, constitute one solution. However, the procedure might be complicated by graft resorption and postoperative wound dehisences.

If there is a soft-tissue problem in combination with a vertical loss of bone, osteodistraction is a treatment alternative.

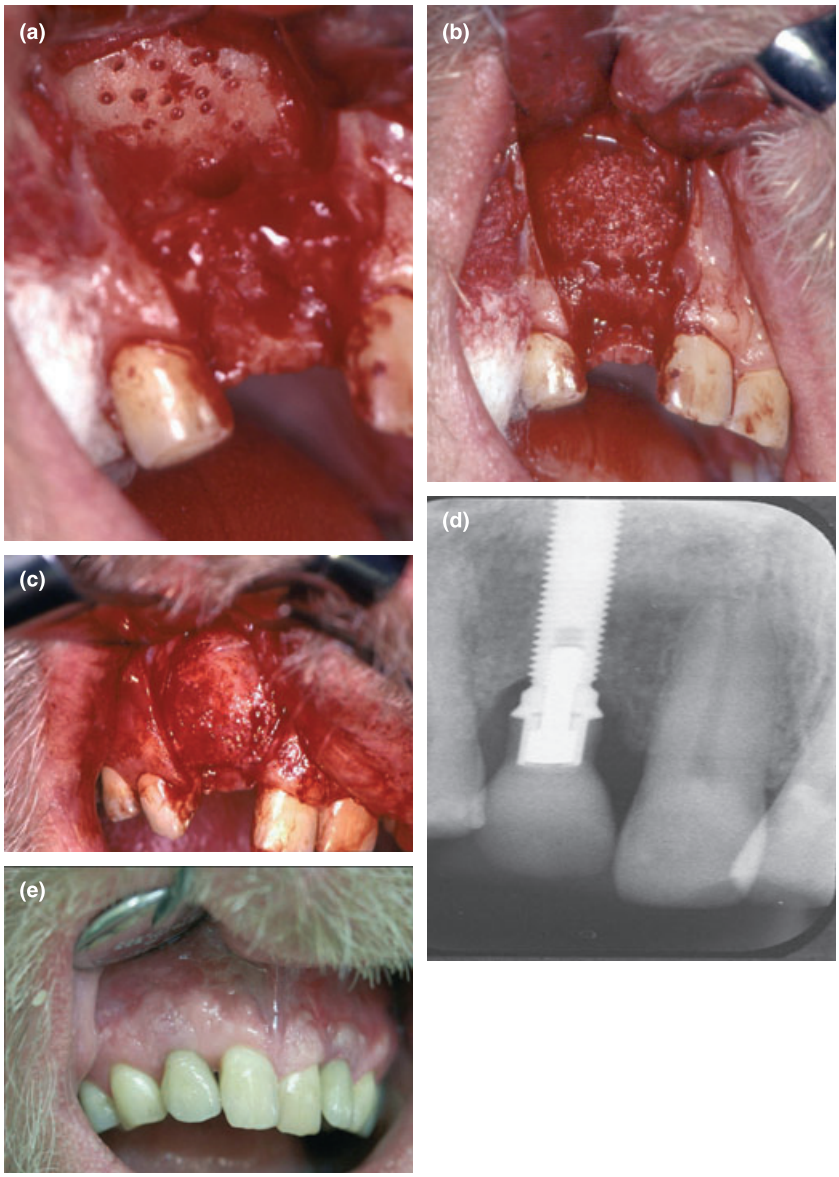

Fig. 1. (a) Narrow alveolar process in the region for the right lateral incisor with small buccal perforations made prior to augmentation; (b) augmentation with 100% Bio-Oss before coverage with a resorbable membrane (BioGide); (c) mucoperiostal flap after 9 months graft healing prior to implant placement; (d) radiography after 6 years of functional loading; (e) screw retained crown after 6 years in function.

Dental trauma in still growing patients might lead to infra-occlusion of the teeth and vertical loss of marginal bone. Rehabilitation of such cases is difficult (Fig. 2).

Distraction osteogenesis

The concept of distraction osteogenesis was developed by Ilizarov (47) in the 1960s but did not gain popularity until it was 'rediscovered' in the 1990s. The technique was first used for distraction of the long bones but in time, with the miniaturizing of devices, it could be used in the oral and maxillofacial field. Further development made it possible to go from extra- to intra-oral applications and even to treat parts of a bone, such as in the mandible or maxilla.

The biological condition for distraction therapy is the fact that the healing tissue of bone – the callus – is elastic. If a distractive force is applied over an osteotomy with early callus formation (48), the callus reacts and responds to this by stretching itself and filling in the increasing gap. The pace of the distraction must be slow enough to allow the callus to be formed but not to mature into non-elastic bone tissue. After completed distraction, the device should be stable enough to allow the callus to mature into solid bone.

The clinical protocol for distraction

1 Latency phase: after completed osteotomy and the mounting of the device, a period of 4–7 days is required for the callus formation.
2 Distraction phase: the rate of distraction should be 0.5–1 mm daily.
3 Consolidation phase: approximately 90 days for the maturation of the callus.

One of the major problems with distraction osteogenesis is predicting and controlling the direction of the transported segment – the vector. In the case described

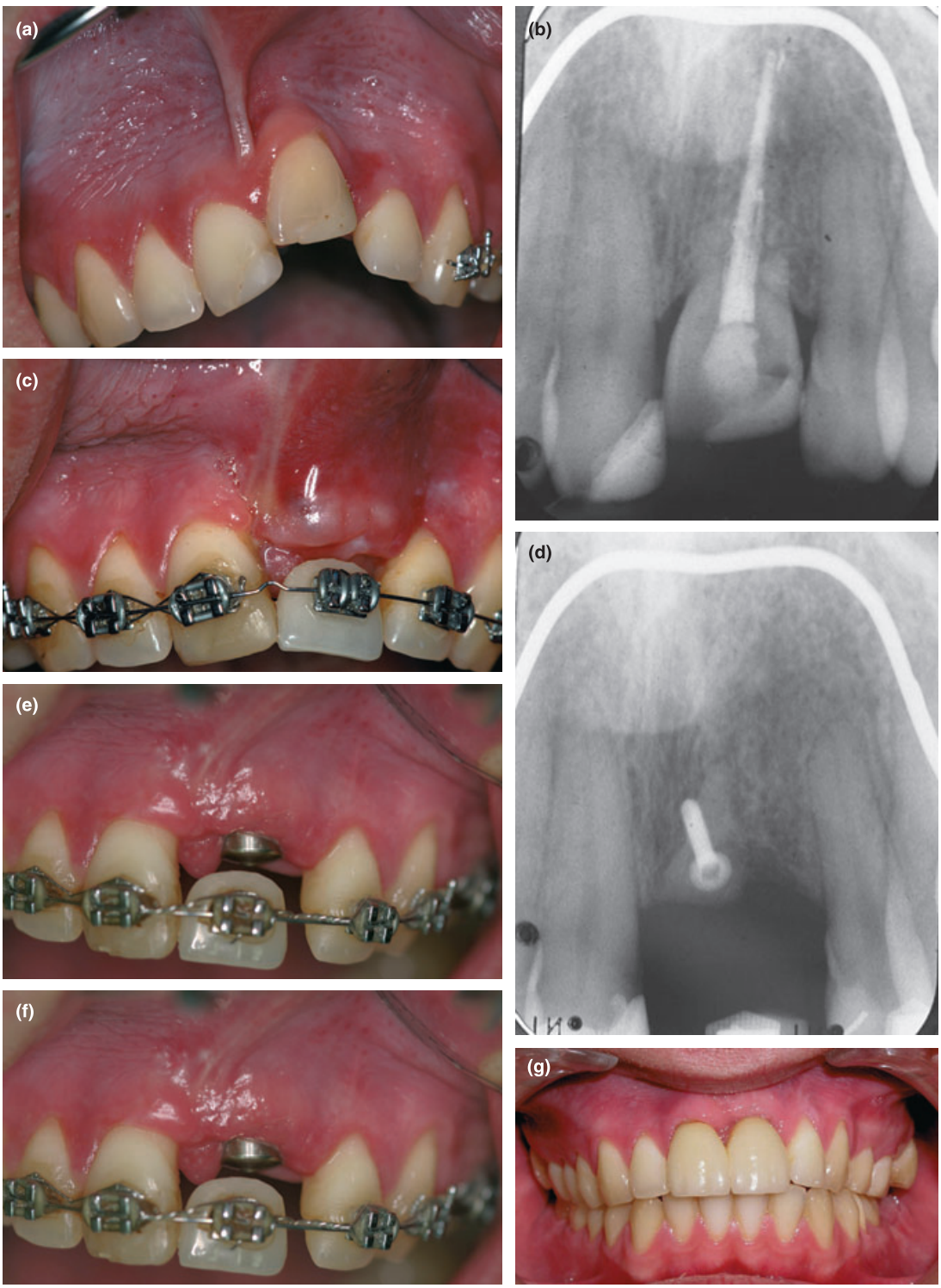

Fig. 2. (a) Clinical view of ancylosis of the upper left incisor; (b) radiography; (c,d) orthodontic alignment of the root and bone and bone grafting after tooth extraction; (e) 1 month after abutment connection; (f) radiography after abutment connection; (g) clinical view after placement of the screw retained crown.

(Fig. 3), we used the SYNTHES® Alveolar Distractor (Synthes, Oberdorf, Switzerland) with which the vector is easily controlled by means of a locking screw. The case presented shows that alveolar distraction osteogenesis is the tool of choice for achieving a vertical increase of both bone and the surrounding soft tissues. When the underlying bone and the soft-tissue envelope are in the correct position, implants can easily be optimally placed.

Distraction therapy requires good patient compliance because the distraction phase is often painful and the

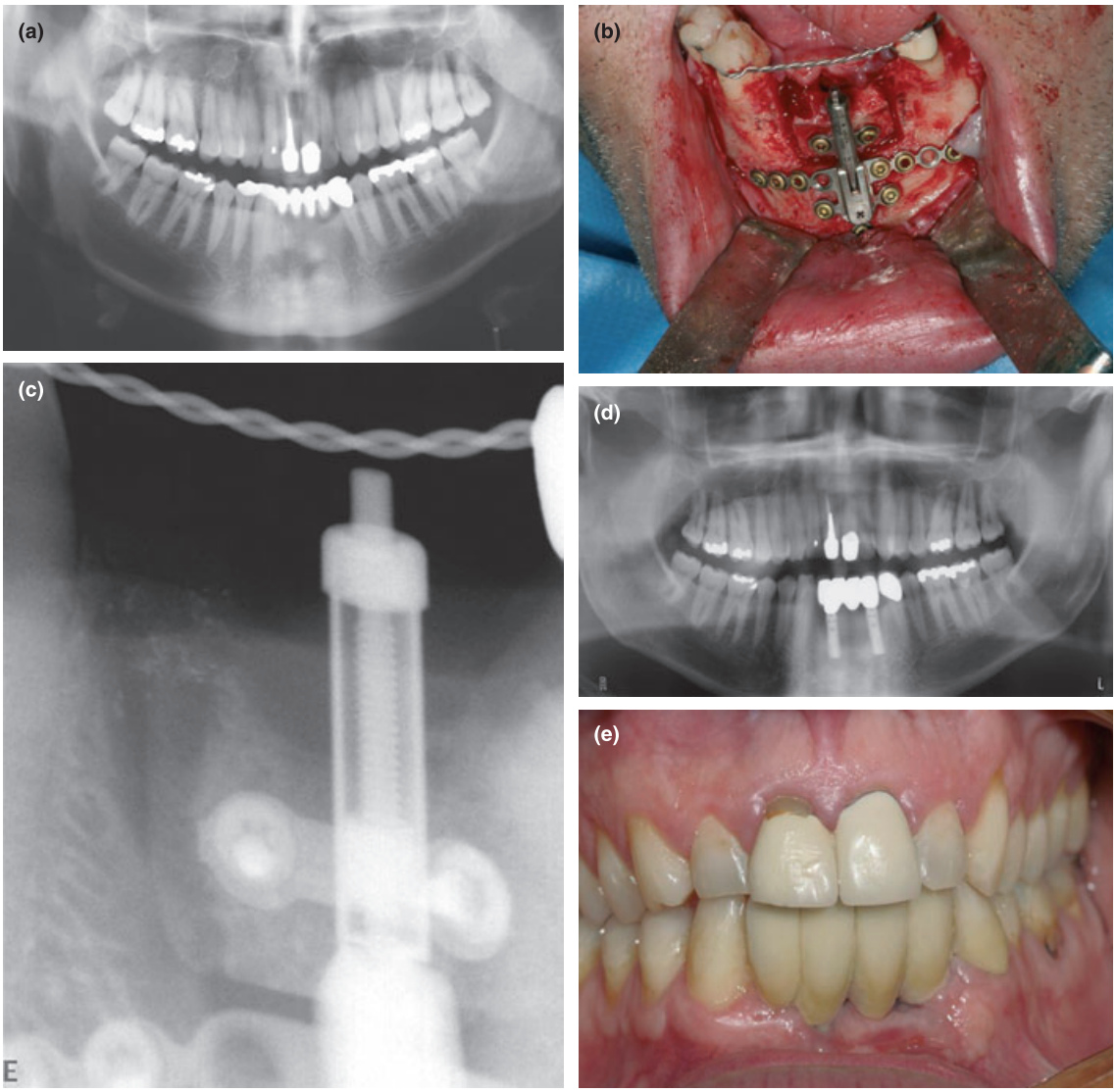

Fig. 3. (a) Panorama showing loss four anterior teeth in the mandible following trauma and also loss of bone height; (b) surgical field after osteotomy and placement of the distractor; (c) radiography after completed distraction; (d) implants and fixed bridge; (e) clinical view of fixed bridge.

device has to remain in place during the long consolidation phase. The devices are also expensive.

The goal in dento-alveolar trauma cases is often reconstruction with optimal placement of dental implants, both aesthetically and functionally. Loss of teeth and alveolar bone frequently involve a shortage of soft tissue, making conventional bone grafting unpredictable, especially in the vertical dimension. In this context, a major advantage of distraction therapy is the simultaneous lengthening of the soft tissue involved.

Immediate placement of implants and augmentation

It has been found that, after tooth extraction, there will be less crestal resorption (49) if sockets are protected with barriers. However, most surgeons think that this procedure is unnecessary. Some surgeons prefer to have a 4–8 week soft-tissue healing time before implant placement. However, there is always a risk of resorption of the buccal bone plate during this time (41), thus the use of other techniques might be a solution.

Placement of implants at the time of extraction has become a predictable method (50, 51) and is one solution for minimizing ridge resorption compared with the delayed extraction approach (52). The implant does not completely fill the extraction socket, but any space is filled with a blood cloth and bone formation will completely obliterate the gap without any intervention. However, if the lateral bone wall is resorbed and threads are visible, the defect should be covered with a non-resorbable material and a resobable membrane, for example (Bio-Gide®, Geistlich; Pharma AG, Wolhusen, Switzerland), if the lateral wall is to be restored.

Extraction, implant placement and lateral augmentation can be performed in one stage with good aesthetic results (Fig. 4). However, the long-term predictability of this method is unknown.

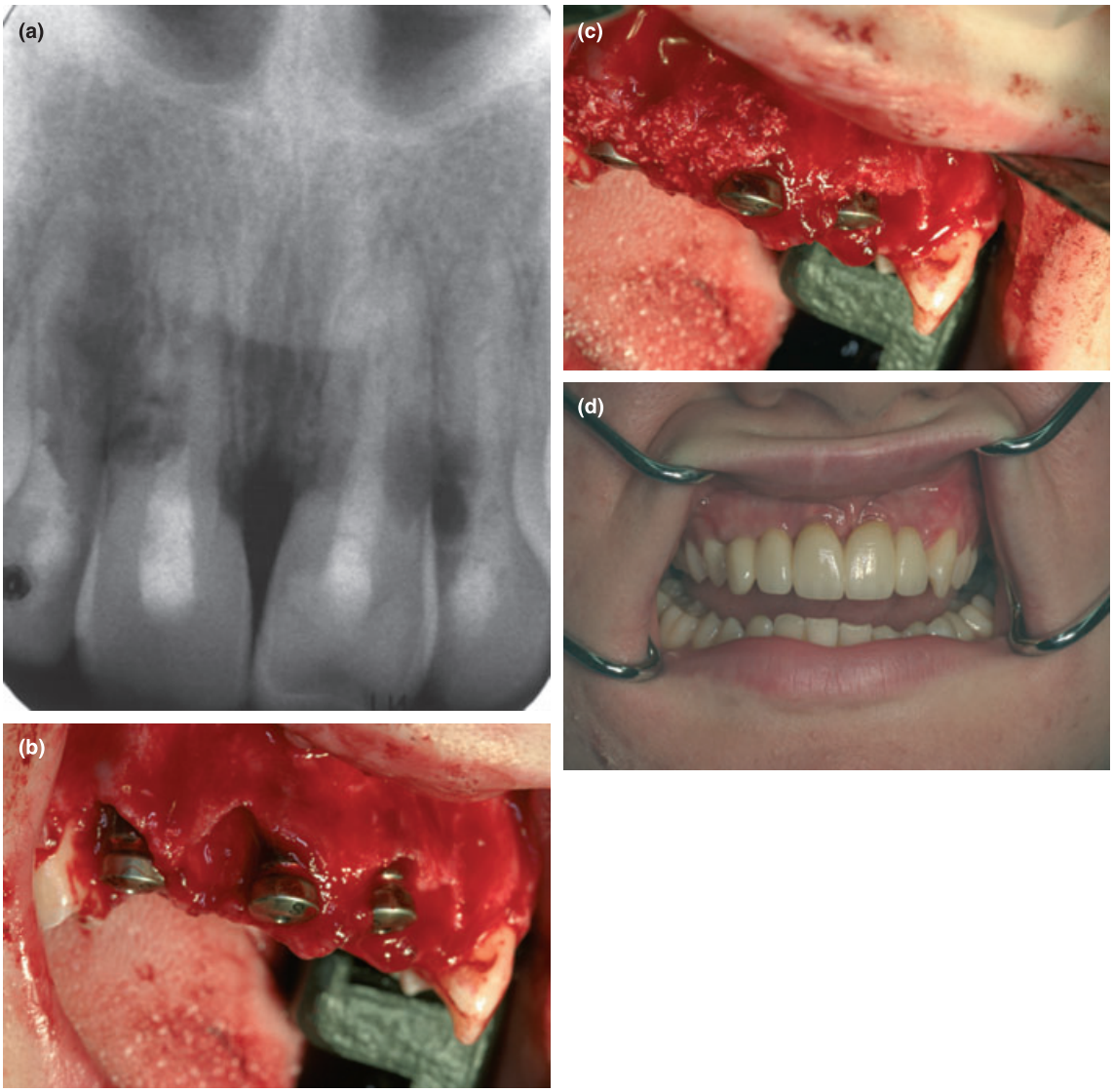

Fig. 4. (a) Posttraumatic external root resorption in five anterior teeth in a 16-year-old girl. The teeth were knocked out 2 years earlier, and reinserted to preserve the bone, but after 2 years they were candidates for extraction. (b) Tooth extractions and simultaneous implant placement. (c) Filled defects around the implants, Bio-Oss mixed with blood before membrane coverage (BioGide). (d) Fixed bridge after 2 years in function.

Discussion and Conclusion

Even though most surgeons find the use of bone substitutes attractive, there are several reasons for resistance to their use. Historically, bone substitutes have been used in wide indications without considering the biological response, for instance, as subperiostal onlay in the mandible, immediately loaded with a removable prosthesis, leading to migration of material and infections. Moreover, in implant reconstructive surgery, graft-healing times have been too short and the material has been used to fill defects, such as cysts and alveolus or during apical surgery-defects that normally heal without intervention.

In experimental studies, AB has been compared with different biomaterials after short graft-healing times, leading to a histology showing the superiority of AB. However, longer graft-healing times probably should have revealed more equal results (53).

The osteogeneic potential of AB and lack of immunological reactions is of importance. However, today there is no clinical evidence that better results are achieved using AB than some biomaterials in the floor of the maxillary sinus (2).

From a biological point of view, there are several aspects to be considered before deciding what material should be chosen for a specific indication. We have to understand the differences between the functioning of these materials before the final treatment plan can be considered.

Different defects have to be treated with different strategies. If there is a concavity, the material is surrounded by more residual bone and augmentation can be performed without adding AB. However, if there

is no cavity and the material has to be placed on top for horizontal or vertical augmentation, AB probably must be added and the graft also has to be covered using a reinforced membrane. This will shorten the graft-healing time and make the outcome and bone formation more predictable (21, 22). The graft-healing time for such cases varies between 9 and 12 months, and there might be individual responses from the patient recipient site, which has to be taken into consideration.

We also have to consider whether AB should be added to the graft for sinuslift procedures. In one randomized and controlled study, AB or a 20/80 mixture with DBB was used in a split-mouth design in the floor of the maxillary sinus. A control group was augmented using only DBB as a grafting material. In the latter group, the graft-healing time was prolonged from 6 to 9 months, showing no statistically significant difference between the groups (14).

Today there are a huge number of biomaterials available on the market and it is not easy to decide which to use. Clinical documentation is sparse; however, some materials are well documented, especially for use in the floor of the maxillary sinus. DBB is the best documented of all biomaterials and can be used in the floor of the maxillary sinus or for widening of the alveolar crest with results that equal those when AB is used (2).

Bioactive glasses seem to be biologically promising materials; however, slow dissolution leads to prolonged healing times before implant placement, and over time the volume of the graft is probably not sustained. In one study, a mixture of bioactive glass and AB was used in the sinus compared with only AB at the contralateral site. After 1 year of graft healing, equal results were obtained (10). This material corrodes, releasing ions, especially silica, inside the granuale where bone formation is first seen. These ions are probably bioactive, which is an interesting topic for future research.

TCPs and calcium sulphates are probably also bioactive, but they dissolve readily meaning that the volume of the graft will not be maintained. These materials can only be recommended for use in the floor of the maxillary sinus (8, 9).

The osteogenicity of allografts is one factor that makes this material interesting; however, the propositions have not yet been clearly established.

New materials are rapidly launched on the market and, recently, biphasic ceramics consisting of a mixture of HA and TCP have become popular. The material has been used for several years in orthopaedic surgery (38), but studies in the field of reconstructive implant surgery are still lacking. In an experimental study, in standardized bone defects in minipigs, more bone formation was found after 8 weeks in defects grafted with AB or TCP compared with TCP/HA or only HA (12), and it is not yet concluded if biphasic materials may contribute to the field of bone regeneration.

Today, there is an intensive focus on bone-stimulating agents, such as proteins and platelets that can stimulate bone formation. However, today there is no clinical evidence to support their use (15).

If there is a combined bone and soft-tissue problem, distraction is a possibility. However, this method is difficult, time-consuming and painful and patient compliance is essential.

The use of different bone substitutes is increasing, thus clinicians have to be aware of their functions and application. The manufacturers launch new materials without any clinical documentation, a fact that has to be considered before using such materials.

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