To graft or not to graft? And what to graft with

Ali Abdellatif discusses the raging debate between the two schools of thought when it comes to bone augmentation

Most of us who are involved in dental implantology, from surgical placement to just the restorative aspect, are aware of the raging debate between the two schools of thought with regards to bone augmentation. On the one side, the use of bone substitutes such as anorganic freeze dried bone and its derivatives, is at best no more than a loose filling material and at worst damaging, while on the other side it is a commonly employed, highly effective method to replace missing bone, provide better anchorage for implants and allow for better positioning, without having to obtain bone from other sites in the patient and thus reducing patient discomfort.

Having been trained by proponents of the former school of thought, I entered implant practice with an almost pathological fear of using well-known materials such as Bio-Oss and Bone Ceramic. The basic statement put forward by the former school is that 'the patient's own bone is best. The 'gold standard'. The questions we need to ask ourselves though are:

• Why is the patient's own bone best? Is it best in all situations?
• How important is it that we fill bone defects?
• What kinds of bone defects need filling and what kinds don't?
• How do bone substitutes compare to autologous bone when comparing longevity, osseointegration and implant stability?
• What kinds of bone substitute exist and which of them fulfil the necessary criteria?
• What are the criteria – why are we filling defects – do we need to – what does it do for the implant/patient?

Bone defects defined

From the implantologist's point of view, a bone defect could be defined as a situation where an implant's osseointegrative surface would not be completely surrounded by bone. This would result in part of the implant surface being in direct contact with soft tissue such as the Schneiderian membrane, peri-implant mucosa or unattached oral mucosa or none of these, in which case there would be 'exposure' of the implant surface to the external environment (oral or nasal).

General wisdom would suggest that this is at best an unfavourable situation because mucosae tend to adapt better to smooth surfaces (most implant surfaces today being roughened by some method) and at worst disastrous with potentially poor aesthetics and poor peri-implant health due to constant colonisation of these rough surfaces by oral or nasal micro-organisms. See Figures 1a, b.

The other reason why more bone-to-implant contact is required, and probably the more important one from the long-term viewpoint, is the distribution of masticatory forces along the implant and its absorption by the surrounding bone. It has been shown that bone density around implants in function increases with time in function. This could be referred to as 'osseostimulation'. This would clearly lead to better long-term stability of the implant and avoid the concentration of forces at 'break-points', leading to further resorption at these points. This phenomenon has been shown whereby masticatory forces tend to be concentrated at the most coronal point of contact with the implant and gradually lessen to a distance of 9-11 mm, depending on the width, thread diameter and distribution, the shape of the implant and its abutment connection, and the surface treatment. This would be another good reason to ensure that an adequate radius of bone sufficiently surrounds the implant especially at its most coronal aspect. The location of the defect makes a difference though.

Dehiscences

Dehiscences are defects involving the bone crest. These are very common on the labial aspect of the maxilla in the aesthetic zone where it is least desired. They often result from chronic periodontal/endodontic infections of the original teeth prior to their extraction. It has also been shown that a thin labial plate of bone (1mm or less) will resorb following implant placement, probably due to reduced blood supply. This will create a 'post-implantation' labial defect.

Ignoring the labial bone defect can result in 'recession' of the peri-implant mucosa based upon the need to establish a 'biologic' width of about 3mm. This can be unsightly and difficult to keep clean. If the peri-implant mucosa is of a good biotype and morphology (thick, fibrous, wide), this mucosa can be resilient enough to remain firmly attached to the implant surface and mask the grey colour. Thin gingival biotypes are much less resistant and the result may be undesired. Some form of augmentation, sometimes with a membrane is often recommended. See Figure 2.

Fenestrations

These are defects further apically where the crest remains intact. A window to exposed implant surface is seen on implant placement. Usually as long as the crest remains intact, this crestal bone will maintain the biologic width at its desired position at the implant shoulder and the implant can fully osseointegrate. The question then posed is whether or not to do anything about the fenestration. This would depend on whether or not it was effectively reparable and whether or not the mucosa is so thin that it is likely to cause future problems. A repairable defect is usually a volumetric defect, one surrounded by bone on all sides. Successful attempts have been made with the use of bone/bone substitute and membranes to 'build out' areas of bone that are non-volumetric. This is sometimes referred to as tenting.
Clinical

Circumferential defects in extraction sockets

Implants are commonly placed nowadays into fresh extraction sockets. The benefits of doing so are quoted as: shorter treatment time; preservation of ridge dimensions and maintenance of bone height. Certainly difficulties that arise include: precise positioning of the implant, as it has been shown that implants should normally be placed within the palatal wall of upper extraction sockets; ensuring adequate primary stability to avoid fibrous encapsulation often requiring drilling beyond the apex of the extracted tooth; and circumferential defects between the walls of the socket and the implant shoulder.

Again the debate continues on whether to do nothing with a circumferential defect and to allow the blood clot to go through its natural process of bone formation (assuming adequate primary stability) or whether to place bone or a bone substitute. This often depends on the width of the defect and the position of the bone crest. Gaps of 1mm or less have been shown to be bridged by normal bone forming from the blood clot. Larger gaps can result in the bone crest dropping and it is thought that they should be augmented in some way. One study shows very little difference whether the defect is filled with autologous bone, say taken from a bone trap, or bio-oss. The use of a membrane was proven to be useful and resulted in a higher crest position.1

Concavities

Buccal concavities are often found apical to the bone crest in maxillary anterior and premolar sites. Again we need to ask ourselves the benefit of investing time and money into restoring these concavities. Is it going to affect treatment outcome if an implant is placed at an angle avoiding the concavity or do we have to place the implant in a precise desired position? Figures 5a–e shows a case involving a large buccal concavity that was managed simply by placing the implants at angle. The outcome was acceptable. With today’s well-designed implants there is ample evidence to suggest that the bone level will be maintained at the implant shoulder (bearing in mind biologic width requirements). Figure 4a–c shows the use of a ramus block plus Bio-Oss to rebuild a ridge where it would be difficult to place an implant.

Maxillary sinus defects

Augmentation of the maxillary sinus when the available ridge height is 5mm or less is a common procedure. This is a very large subject, impossible to cover in this article alone. Studies have described the use of autologous bone taken from intraoral and extra-oral sites, using the bone in a particulate form or in block form, or the use of xenograft material such as Bio-Oss or synthetic material such as hydroxyapatite, tricalcium phosphate or both. All sorts of possible combinations and permutations have been used including iliac crest bone in particulate form, iliac crest bone blocks with simultaneous implant fixation, bone from oral sites such as the ramus or the chin, all these possibilities mixed with PFR, Bio-Oss, beta tricalcium phosphate and so on.

One the non-grafting side of the argument could be the positioning of implants at an angle, running along the anterior-inferior border of the maxillary sinus. A long implant is placed and extends to a fairly distal location at the ridge. Good, sound bone is used. No grafting was necessary and most descriptions of this method show good long-term restorative success.2

Requirements of a graft material

Whatever material being used (bone or other material), it would be useful to us to know what the ideal requirements are. We would probably agree on the following:

- A material that is non-antigenic
- A material that is at least osseoconductive and preferably also osseoinductive
- Sterile
- Easy to use
- Has long-term stability
- Integrates with the implant surface or promotes bone formation that will integrate with the implant surface
- Low cost to the patient
- Low morbidity to the patient.

Knowing whether a material is osseoinductive or osseoconductive or both allows one to make a better informed choice about the method they wish to use.

The Master’s Choice

Osseosynthesis is when a material acts as a scaffold, attracting bone-forming cells from surrounding bone. Effectively it acts as a bridge between bone and a non-ossified site. New bone forms as a result and, in theory, the material should resorb. Often, studies will show new bone formation around particles of the material and some will even show evidence of resorption of this material. We tend to accept that some of this material itself will remain in situ for an extended period at least, which is why we ask, with reference to synthetic and xenograft materials, if the bone will have the same quality as bone that is purely of the patient’s own. Here we need to also ask: ‘how good is good?’ or ‘good enough’ to ensure long-term (15 years or more) stability and integration of a dental implant.

Ossintegration is when a material can induce new bone formation even at a distance from bone. It can attract (or provide) mesenchymal osteogenic cells and induce their differentiation into osteoblasts and osteoclasts. Patient’s own bone naturally has both osseoinductive and osseoconductive properties. Bone morphogenetic proteins have been found to be instrumental in this osseoinductive nature and studies into plasma rich protein, containing osseoinductive agents such as BMPs have been shown to have some benefit.

Types of material

Autograft:

- Taken from the patient and placed in the same patient. Osseoconductive and osseoinductive properties. No antigenicity. Sterile (if maintained). Varying degrees of mineralisation and long-term stability.

Allograft:

- Decalcified freeze-dried bone eg Bone from human cadavers. A good source of BMP. Quality can be poor due to freeze drying and decalcifying. Possible cross-infection risk.

Xenograft:

- Allogenic calcium bone matrix blended with collagen (eg MPS)

Alloplasts:

- Tricalcium phosphate
- Hydroxyapatite
- Blends of tricalcium phosphate and hydroxyapatite (eg Straumann Bone Ceramic)
- Bio-active glasses (eg Perioglass)
- Calcium Carbonate.

Only the die-hard researchers and the MSc students really have the time to trawl through the endless literature available. Certainly, some publications make it easier to obtain the necessary information by publishing symposia of relevant literature. Without doubt, for those who want to know the most reliable research findings would do worse than look up the
Cochrane reports on implant related subjects. These are very thorough systematic reviews of reliable randomised controlled trials. Interestingly, it is often reported in these reports on how poorly conducted most research is. Often too few subjects, bias or just poor planning make the research unreliable. It is notable to infer from this that the numerous lists of research that manufacturers provide when trying to sell new products may not be as reliable as they seem.

The Esposito paper
The conclusions of the Esposito paper suggest several important factors to take into consideration when deciding on the best treatment option for your patient. Firstly, pain. Is it going to hurt more? I often find when presenting the case for taking bone from another area of the mouth to place in implant site that the patient balks at the suggestion of another area that’s going to hurt as much as the main site we’re treating. If you then tell your patient that you could use a material out of a bottle, a sterile material that has been found to have comparable results the patients will often opt for the easier way.

The Cochrane report suggests that autogenous bone collected in bone trugs, even in dedicated lines, may still contain a large amount of bacteria. One study quoted in this paper reported a significant number of infections associated with collected autogenous bone, compared with the use of Bio-Oss alone.

Furthermore, it has been shown in one study that although iliac crest bone is highly osteoinductive and contains a very large percentage of osteoprogenitor cells, its degree of mineralisation (and assumedly its resilience in function) is rather poor in comparison to bone harvested from intra-oral sites such as the chin and the ramus of the mandible. The chin and ramus of the mandible are (as anyone who performs these procedures will confirm) rather tricky to get to and take chunks of bone from. There is no doubt they do provide bone of good quality that can be used for block grafting, but a degree of morbidity is has to be expected (especially at the chin) and certainly the patient has to be informed of this. There is a risk of soft tissue damage, damage to teeth etc.

Histological sections of Bio-Oss and other similar materials such as Gen-Oss show new bone formation in direct contact with implant surfaces with fragments of the original graft material either latent present or resorbing. The quality of this bone is thus probably comparable to normal bone and with much less hassle. Studies have shown very little difference between the use of autogenous bone and Bio-Oss in extraction sites, especially when membranes are used.

Further research
Other studies show that there is no statistically significant difference between the uses of autogenous bone and bio-oss in the augmentation of maxillary sinuses with regards to graft volume. Both seem to shrink by the same amount and both seem to keep the implants in function, at least for the period of the study. So why would we take bone from the ramus, break or grind it, place it by itself or (more commonly) in combination with a graft material, cause the patient quite a bit of pain in another site, risk nerve damage and risk infection when transporting the bone from one site to the other when it seems to work just as well or marginally better than using graft materials alone. Is the quality of the bone in contact with the implant in the autogenous bone augmentation case better? So what? Is it going to last longer? Is it going to keep the implants in function for longer? Perhaps these questions are still unanswered.

Animal-derived materials
Another point of contention is the question of the use of bovine, porcine or equine materials. Some authorities disagree with the idea of putting animal derived materials in their patients. My question is ‘are most of us not ingesting animal derived proteins in our diets? We drink milk containing calcium from cows. We eat chicken skin contributing to our waistlines. Ultimately what is the difference between a piece of cow on our plate and a piece of cow that has been very thoroughly sterilised and deproteinised and placed directly at the point of need without the necessity of sending it past our digestive system.

Common wisdom would agree that bone chips and bone blocks taken from the patient and placed in the patient seem to be a better idea than rebuilding an entire ridge with Bio-Oss alone. On the other hand, one paper shows them doing just that.

The use of membranes in guided bone regeneration has been shown to be an effective adjunct to treatment. The membranes tend to keep whatever you’ve put there stable while the bone cells are forming new bone. Perisutrem alone seems to be unpredictable. At times, there is no difference, while at times, quite rapid resorption of the graft can happen if a membrane is not used. This is based on my personal experience and that of colleagues.

Areas of confusion
An investigation of the literature on bone graft materials can often lead the investigator into a state of perplexity. Most studies will show very little difference between the use of bone and bone substitutes. It all seems to ‘work’. But ‘most studies’ are usually performed on dogs and rabbits, as it would be difficult to ‘sacrifice’ a human with an overdose of GA to obtain a histological section of the grafted area. Dogs and rabbits heal more quickly and efficiently than humans. Their diets are often well controlled and a rabbit’s leg is a very different site to a human’s mouth.

Certainly, all clinical cases require a high degree of attention when placing implants in compromised sites. Some amount of augmentation should be planned and considered well when placing in the aesthetic zone or directly into extraction sockets. The cost of the additional materials versus the use of the patient’s own bone but with the possible complications resulting from this should be considered. For example, a small bone defect could be easily managed by taking shavings from a neighbour site rather than using a bone substitute. This would be effectively cheaper and potentially ‘better’ for the patient.

The latest research
In today’s climate where everything we do has to be justifiable and evidence based, it is important that we pay attention to the latest research findings in our field. It would be highly benefi-
efficient if we all also performed some form of audit of our cases and from time to time submitted this in some commonly accepted format to authorities that would be able to make use of our own experience and present to the society as a whole.

The majority of implants dentists or dentists placing implants were introduced to a certain method of grafting and to certain techniques during their initial training and introduction to the discipline. As time goes by and we get better at what we do and get better at using the materials and implants we use, we tend to get stuck in our ways, finding it difficult to justify the seismic shifts necessary to jump from one implant system to another or from one grafting (or non-grafting) technique to another. I hope with this article that I have been able to present some arguments for and against grafting and some scientific evidence supporting the different types of grafting systems. I dare not even make the assumption that I have the answer!

References

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