Investigations
This is a critically important stage in the preliminary assessment of any case that involves implants. A detailed assessment of the hard and soft tissue would normally be accompanied by study models, photographs, radiographs and, if appropriate, cephalometric views, CT scans and 3-D reconstructions. It is essential to confirm that any implant fixture can be placed without damage to adjacent structures, and with sufficient bone available. Bone mapping allows a three-dimensional assessment of proposed implant sites to be made, although the quality of the bone in the proposed site may not be fully determined until the time of operation.

Consent
It often becomes clear that a clinician has given little or no consideration to any treatment option except that of placing implants. In some cases this is because the patient has been referred to the clinician in question by the patient’s regular general dental practitioner, specifically for the purpose of assessing the patient’s suitability for implants. In other cases, it appears that the clinician is simply keen to provide implants rather than to consider any alternative options.

In these cases there is a real risk that patients will be “talked into” implants without going through a detailed consent process. Implants are generally only one of many available treatment options, and each of these options needs to have been considered and discussed with the patient in detail. These discussions should include the purpose, nature, risks, benefits, and limitations of each treatment option in turn. Avoid using universal “blanket” information that does not take into account the specific factors that apply to the situation of an individual patient.

Clinicians who are keen to be involved in implant dentistry might be tempted to spend too much time explaining the benefits and predictability of implant dentistry—perhaps with the help of persuasive colour brochures provided by implant manufacturers—while spending less time explaining the potential risks and drawbacks. Many negligence claims arise from a failure to understand and manage the patient’s expectations. It is particularly important that the patient should have a clear understanding, at the outset, of the likely appearance and function of the completed restoration, whether this is fixed or removable. By the time the patient is in a position to appreciate the final result at first hand, it is often too late to make fundamental changes to the treatment approach. Given the considerable investment of time, money, inconvenience and discomfort involved in implant procedures, this is likely to result in a very angry and aggrieved patient.

Record Keeping
The clinical records (including any available correspondence and documentation) will often be pivotal in determining the outcome of any complaint or negligence claim relating to implant dentistry. The records should comprehensively demonstrate each of the key stages in the provision of implants.

Consultation and preliminary discussions.
- Why are implants being considered, and at whose suggestion?
- Medical history
- Dental history
- Social history (including details of the patient’s employment)
- Assessment of risk factors
- Detailed clinical examination (intra- and extra-oral)
- Investigations (see above)
- Diagnosis
- Provisional treatment plan and costing
- Consent (see above)
- Final treatment plan and costing
- Preliminary treatment (eg, preparation and trial placement of stents or other aids)
- Treatment carried out (including preparatory and preventive treatment and advice)
- Outcome
- Any adverse consequences and their management
- Follow-up and maintenance

Collateral Damage
Most such damage relates to the surgical phase, which possibly explains why this phase does seem to be responsible for the larger share of the total problems encountered (Fig. 8). Damage to the inferior dental nerve or the mental nerve is the problem most commonly encountered in the mandible, although lingual nerve damage and complications involving the maxillary sinus or adjacent natural teeth, are not uncommon in certain situations.

Contractual Issues
Because of the cost involved in implant dentistry, the technical nature of the procedures, and their unfamiliarity to most patients, it is essential to explain the proposed treatment clearly and associated costs in advance and in writing. Try to use language that the patient is likely to understand, and avoid technical jargon.

It should be made clear if the fees quoted are an estimate and/or illustration, or a firm quotation of the treatment that is to be provided and the costs involved. If, as can happen in implant dentistry, the treatment plan subsequently changes for any reason, it is prudent to confirm the revised treatment plan and associated costs in writing once again. Many disputes have arisen from a breakdown in communication where such changes have been explained to the patient verbally, perhaps at a time when they were nervous or distracted, and less able to listen to and appreciate the information being provided for them.

Details that have created problems in the past include:
- The number and type of implant components required.
- The materials to be used.
- The design of the final restoration.
- Patients cannot be expected to appreciate fine distinctions and technical details such as these unless the clinician takes the time to explain them. Similarly, the use of treatment that is different in nature or extent to that agreed with the patient can lead to allegations of breach of contract, as well as of negligence.

Summary
There has been a steady increase in the provision of implants. It appears that they are being placed in more clinical situations, by more clinicians than ever before. Not all of these clinicians can demonstrate that they have received adequate formal training or supervision, and have sufficient technical knowledge and experience, to carry out these procedures safely and successfully. This factor causes great concern for the future. Furthermore, our patients are living longer and the fast-evolving science and technology of implant dentistry is perhaps leading some clinicians into this field who might otherwise have been prepared to refer their patients on to more experienced colleagues. While this increased clinical ambition is understandable, it is important for dentists to be aware that this is a potentially high-risk field for the inexperienced. In the longer term, the greatest threat to clinicians may well come not from negligence claims, but from the activities of regulatory bodies around the world. These organisations are becoming increasingly intolerant of dentists (and doctors) who show an apparent disregard for their responsibilities to patients and the public in undertaking procedures for which they are not sufficiently skilled and trained.
Bone is formed by osteoblasts derived from uncommitted mesenchymal stem cells. After implant surgery the biomaterial surface is populated by these progenitor cells and eventually bone is formed directly along the surface. Astra Tech embarked on a research program to define a method of modifying the TiOblast™ surface to support even more rapid bone formation by the implant surface adherent cell. The discovery that ionic fluoride modification of the TiOblast™ surface improved the bone-to-implant interface resulted in an intensive research program and development of an improved dental implant surface, namely the OsseoSpeed™ surface.

Clinical challenges to osseointegration

Today, there are indications for dental implants that challenge osseointegration's success, including type IV bone, implant placement in extraction sockets, and immediate loading of dental implants. Further improvement in the rate and the amount of bone formation at implants may overcome these clinical challenges. OsseoSpeed™ has the potential to provide these improvements.

Studies confirm greater osteoblast differentiation

One way to examine the role of an implant surface in bone formation is to measure stem cell differentiation to osteoblasts in the cell culture laboratory, as Professor Cooper did at the University of North Carolina. When human mesenchymal stem cells were cultured on TiOblast™ surfaces modified with ionic fluoride, the rate and extent of osteoblast differentiation was greater than on the surface without fluoride modification. An excellent indicator of osteoblast differentiation is the increased level of Bone Sialoprotein (BSP). Measurement of BSP after 14 days revealed that three times more BSP was made by cells grown on fluoride-modified surfaces than on unmodified ones. This important initial finding was reproduced in three different independent experimental models. The tests were carried out completely ‘blind’ on the samples sent from Astra Tech in Sweden. “I wanted to know what they were sending me, but I was told that the whole procedure had to be kept completely blind,” says Professor Cooper. “They were not going to tell me anything until we had finished.”

The confocal microscopic image reveals the cellular cytoskeleton (red) of three cells tightly adherent to the OsseoSpeed™ surface. A second cytosolic protein is stained yellow. A DNA specific dye prominently reveals the nuclei of the adherent cells. J-shaped cell and molecular biology techniques, the adherent cell nuclei. Beyond engineering of the surface to support cell attachment, careful consideration of gene regulation by the OsseoSpeed™ adherent cells suggests rapid differentiation of adherent cells along the osteoblastic lineage.

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Positive effects on adherent stem cells

Additional details of the OsseoSpeed™ surface’s effect on the adherent cell stem cells have recently emerged. For example, human mesenchymal stem cells produced 2.5 times more of the key regulator for osteogenesis (cbfa1) when they were grown for only one day on OsseoSpeed™ compared with TiOblast™. More information from genome wide microarray analysis of the adherent cells’ behavior indicates that specific signal transduction pathways important to cell proliferation and differentiation are upregulated within the OsseoSpeed™ adherent cell. Microarray analysis comparing cells cultured on the TiOblast™ and fluoride-modified surfaces showed the presence of a number of key ‘enabler’ genes that play an important role in osteogenesis.

Professor Lyndon Cooper says he is excited about the new opportunities that OsseoSpeed™ can provide for clinicians. The clear conclusion from his work is that the implant surface can be an active component of clinical success. A relatively small, but effective fluoride modification of the TiOblast™ surface is associated with greater osteoblast differentiation of adherent mesenchymal stem cells as well as increased bone-to-implant contact in vivo. The advantages of more rapid and greater bone formation around dental implants may be clinically realized.

Summary

To examine the role of an implant surface in bone formation, Professor Cooper measured stem cell differentiation to osteoblasts in the cell culture laboratory. When human mesenchymal stem cells were cultured on TiOblast™ surfaces modified with ionic fluoride, the rate and extent of osteoblast differentiation was greater than on the same surface without fluoride modification. In fact, measurement of Bone Sialoprotein (BSP) after 14 days revealed that three times more BSP was made by cells grown on fluoride-modified surfaces than on unmodified ones. In addition, microarray analysis comparing cells cultured on the TiOblast™ and fluoride-modified surfaces showed the presence of a number of key ‘enabler’ genes that play an important role in osteogenesis. Results from in vivo studies are consistent with the in vitro findings.

Interviewed: Professor Lyndon F. Cooper, DDS, PhD, Department of Prosthodontics, University of North Carolina, School of Dentistry, North Carolina, USA


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The truth is out there—looking for the evidence behind bone regeneration

By Anthony Bendkowski oral surgeon and president of the Association of Dental Implantology (UK)

It is widely recognised that one of the key factors contributing to the long term success of dental implants is the quantity and quality of supporting bone. When undertaking implant surgery we are frequently faced with defects in the bone that are a consequence of previous underlying periodontal disease, infection or the trauma associated with the preceding extractions.

Even a minor bony defect can be a significant barrier where the correct placement of implants is concerned. Without appropriate bone support there is often less than optimal soft tissue profile and consequently compromise in the aesthetic outcome. As clinicians, we are fortunate that bone has a unique potential for regeneration without scarring, provided it is given the correct environment in which to do so.

The vascular and mechanical considerations are important, as is the need for contact with underlying sound living tissue together with passive tension free primary soft tissue closure. The fibrin clot serves as the initial calcifiable matrix containing a concentration of calcium and phosphate ions onto which precursor cells can migrate. This clot needs protection from mechanical stress as any distortion or disruption can profoundly impair the regeneration process.

A further major hindrance to new bone growth is the rapid formation and ingrowth of soft tissue in competition with the slower forming bone regrowth. Fibroblasts have a faster rate of migration than osteoblasts and their proliferation may totally prevent osteogenesis. It is therefore desirable that the soft tissues are excluded from the graft site. This can either be achieved by the use of a barrier membrane, either laid or pinned in place over the underlying particular graft, rather like a tarpaulin covering a mound of sand or by incorporating an additional hard-setting resorbable chemical phase into the graft material which acts as a barrier to soft tissue downgrowth.

The general term Guided Bone Regeneration (GBR) has been applied to procedures that attempt to regenerate bone, either prior to or at the same time as the placement of dental implants. GBR is accomplished using bone graft materials such as autogenous bone, xenografts, human donor grafts, as well as various synthetic ceramic materials, usually also in association with a bio-compatible membrane.

As already mentioned, the use of a membrane ensures that competitive cells do not invade the area where we want new bone to regenerate. The mechanical barrier provided by the membrane offers a means of excluding mucosal tissue and epithelial cells that would interfere with bone healing from the clot. This permits the slower bone-producing osteoblasts to facilitate clot organization and produce undamaged osteoid healing.

GBR membrane materials must maintain the integrity of their barrier function long enough to allow new bone to migrate into the wound. Both resorbable and non-resorbable membranes have been used as a GBR barrier. However, non-resorbable membranes such as e-PTFE, although effective, must be surgically removed after the healing period. A resorbable membrane that transmits tissue fluid, but excludes undesired cells from the clot, has the advantage of not requiring surgical removal.

Examples of resorbable membranes include bovine and porcine collagen, PLLA-PGA polymers and calcium phosphate.

The science, application and clinical effectiveness of the various bone graft materials, whether autograft, allograft, xenograft or allopast, is currently one of the most controversial in implantology and periodontology. Autografts may still be considered by many surgeons to be the graft of choice for specific indications, but there is no current consensus regarding the most appropriate materials for each clinical situation.

There is still much work to be done in this field and we still await the production of good quality randomised controlled trials. Recent years have seen more development of synthetic based bone augmentation materials and a decrease in the prescription of human derived bone substitutes.

The ideal graft material should preferably be gradually resorbed and fully replaced by vital bone that is subsequently remodelled into a natural bone structure that is capable of supporting implants repositioned into the occlusion. If the implanted material does not fully resorb, as is the case with some hydroxyapatites, the incorporation is restricted to bone apposition to the material surface, but no substitution occurs during the remodeling phase. This may be desirable for cases where simple ridge preservation or augmentation is required, eg to help stabilize conventional removable prostheses or improve soft tissue outcomes around conventional pontics, but is not so desirable in implantology.

As clinicians, we have a professional duty to discuss treatment options with our patients and only undertake those procedures which have a reasonable likelihood of a favourable outcome. This is particularly true of elective surgery such as dental implantology and associated bone augmentation procedures.

The gold standard for evidence supporting clinical practice is the randomised controlled trial. Unfortunately in dental implantology, as in many other branches of clinical practice, we are faced with a relative lack of high quality trials of this type. Around the world, researchers are working towards this goal, and we still await the important evidence that is still to emerge.

Before prescribing materials and treatments for bone augmentation, clinicians need to arrive at their own conclusions from the available information regarding the suitability of these materials and their limitations.

In recent years I have come to the conclusion that it is no small challenge to assimilate this information in an impartial way and free from commercial influence. Discussion with colleagues and reading of the literature only really extends to anecdotal information and small groups of case studies or presentations. For some time I have nurtured a desire to put together a special meeting dedicated to reviewing the choice of materials available as bone substitutes.

One of my first initiatives, therefore, on recently taking over the presidency of the Association of Dental Implantology was to organise the forthcoming meeting—Focus on Bone Substitutes—to be held at the Manchester Conference Centre on Monday 20th April, 2008.

This full day symposium will examine both the biological basis, as well as the evidence supporting the clinical use of the currently available bone augmentation materials. During the day, seven renowned experts will present the evidence for both xenografts and synthetic materials. Specifically, the performance of these materials in both alveolar ridge reconstruction and sinus augmentation will be highlighted.

Following this meeting, clinicians should be in a better position to critically evaluate the evidence supporting the bone substitutes currently available for bone regeneration in day to day clinical practice. The truth is certainly out there to be discovered.
Dentistry has become so exciting and challenging since predictability has been recognized for long-term dental implant and restoration success. As the number of patients selecting dental implants as a treatment option continues to grow, the dental team must accept the challenges of maintaining these sometimes complex restorations.

Proper monitoring and maintenance is essential to ensure the longevity of the dental implant and its associated restoration through a combination of appropriate professional care and effective patient oral hygiene. The value of using conventional periodontal parameters to determine peri-implant health is not clearly evident in the literature. Therefore, it is paramount that the dental implant team understands the similarities and distinctions between the dental implant and the natural tooth. Subsequently, by examining the similarities and differences between a natural tooth and a dental implant, basic guidelines can be provided for maintaining the long-term health of the dental implant.

Direct anchorage of alveolar bone to a dental implant body provides a foundation to support a prosthesis and transmits occlusal forces to the alveolar bone. This is the definition of osseointegration. With the increased acceptance of dental implants as a viable treatment option for the restoration of a partially edentulous or edentulous mouth, the dental team is faced with maintaining and educating those patients.

Recently, the focus of implant dentistry has changed from obtaining osseointegration, which is highly predictable, to the long-term maintenance health of the peri-implant hard and soft tissues. This can be achieved through appropriate professional care, patient cooperation, and effective home care. Patients must accept the responsibility for being co-therapists in maintenance therapy, as the dental team essentially must screen the potential implant patient. Diagnosis and treatment planning based on a risk-benefit analysis should be performed subsequent to a thorough medical, dental, head-and-neck, psychological, tempromandibular disorder and radiographic examination.

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