

Practical implantology, part two

IN THE SECOND PART OF HIS SERIES ON IMPLANTOLOGY, SIMON ALLUM CONSIDERS THE LEADING IMPLANT SYSTEMS



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It is interesting to note that there currently appears to be only one major healthcare insurer – Cigna (Figure 1) - that offers a formal warranty scheme for dental implant cases in the UK. This service is available for treatments provided by approved practitioners via Cigna's Dental Implant Plus policies. However, Cigna will only issue such policies on cases that have been restored by any of the following six major implant systems - Astra (Astra Tech), Branemark & Replace (Nobel Biocare/Steri-oss), Frialit 2 (General Medical), ITI (Straumann) and Osseotite (3i).

For the purposes of these articles I have limited my discussion to these mainstream systems. I am advised that in the future Cigna may consider adding to this list if alternative systems satisfy the company that such products can reliably perform to their required standards.

As well as these mainstream implant systems a number of alternative systems are also available on the market. In the course of time it may be shown that many of these can perform well. However, it should also be noted that many minor implant systems are promoted with little published data to support them, and lesser-known systems may struggle to provide follow-up support into the future. The availability of parts to service

completed cases could become an issue if companies drop out of the market at some future date.

DIFFERENT NUTS AND BOLTS

The worldwide market is extremely competitive, with companies keen to promote any perceived advantage over rival products. New developments and product ranges are constantly being introduced.

Some of the key features that will be considered and discussed in the course of this series include:

- Bone to implant interface and the effect of surface technology
- Single stage vs two stage surgery systems
- Abutment connection devices

- Implant and component ranges.

BONE TO IMPLANT INTERFACE AND THE EFFECT OF SURFACE TECHNOLOGY.

This subject has certainly been a big topic in the world of implantology over the past few years and is one that has brought about huge changes in clinical case planning and treatment possibilities. It is now widely acknowledged that the surface anatomy of an implant at the bone/implant interface has a direct bearing on the 'bond strength' between the living bone and the artificial implant surface and will also have a direct effect upon the rate and degree of osseointegration.

From the first days in the

Figure 1: Cigna can offer your patients a formal warranty on cases restored with any of the six major implant systems discussed in this article



Figure 2: A smooth (machined) surfaced implant with external hex connection



Figure 3: 3i osseotite implant. This implant has a hybrid surface. The endosseous part features the roughened osseotite surface. The coronal part of the implant is similar to the machined surfaced implant shown in Figure 2

evolution of modern dental implantology protocol, the significance of bone quality and density at the osteotomy site were recognised as important factors, which influenced clinical considerations. Bone with larger marrow spaces and thin cortical plates (such as often found in the posterior maxilla) was recognised as being less favourable to implant success than bone of higher density with a thicker cortical plate (such as often found in the anterior mandible). In view of such variables, in the 1970s Branemark suggested a range of integration times, usually set at three months for fixtures placed in the anterior mandible, and up to six months for sites in the posterior maxilla. This delay was deemed necessary to allow the implant fixture to form a firm union with the surrounding bone before it was ready to become a load-bearing fixture.

Branemark implants, which became a worldwide market leader from the 1970s, have traditionally been manufactured with a straightforward 'machined' surface - basically a smooth, lathe-turned surface finish (Figure 2). It is now generally accepted that a smooth and highly polished surface affords the optimum soft

tissue response at the gingival margin since such a surface is more hygienic with a lesser tendency to harbour plaque and other deposits. However, a whole raft of clinical data and studies has established the considerable clinical advantages of using alternative surface finishes on the endosseous part of the implant fixture.

Many studies have been published on a range of implant systems which clearly show that implants produced with suitably textured endosseous surfaces can generate a greater 'bone-to-implant contact' as determined by a number of parameters, including histological analysis. Such variations in surface anatomy significantly increase the surface area available for osseointegration. Perhaps it is therefore not surprising that stronger bond strength to the surrounding bone is achievable in this way. Bond strengths can be determined experimentally by measuring removal torques - the forces required to remove an osseointegrated implant.

Various researchers have shown that an appropriate micro-roughened surface will engage and hold the fibrin strands which are formed during the initial clotting process following insertion of the implant fixture. In

contrast, fibrin strands are said to contract and loose contact with the endosseous surface of a traditional machined type implant. The stabilisation of the initial clot is important as the fibrin strands form a bridge for the migration of osteoblastic cells from the surrounding osteotomy onto the implant surface. Clinically, one can see the increased wettability of a roughened implant surface as it is offered up to the osteotomy site and the concept seems only common sense. The science behind such concepts has been mounting up over the past few years and the clinical advantages of using implants with appropriately roughened surfaces are evidence-based.

Favourable surface characteristics have also been shown to aid the absorption of proteins, accumulate and activate platelets in providing platelet derived growth factors (promoting angiogenesis) and help differentiate progenitor cells into mature osteoblasts. The clinical benefits of all these factors result in quicker and more extensive osseointegration - even in sites with poor

quality bone.

For healthy patients with adequate bone quality, loading times for ITI* implants featuring the SLA surface treatment (Figure 4) is said to be possible following successful osseointegration after only six weeks.

Similarly the current data from 3i approximates the ITI research, suggesting that 3i implants can be ready to load only two months after surgery. Using implants with higher bond strengths to supporting bone can not only increase the reliability of the final construction, but can also allow the use of fewer or shorter implants to restore any given case because the implant forms a more secure bony union. The possibility of using shorter implants opens up the treatment options for more demanding cases, and reduces the risk of damaging vital structures.

These concepts of the enhanced healing processes associated with roughened implants along with their other associated benefits are now widely accepted. Over the past few years particularly, the very real benefits of such implant surfaces have become

* The International Team for Oral Implantology. The ITI is an international non-commercial research foundation. Implants are manufactured commercially by the Swiss company, Straumann to ITI specifications

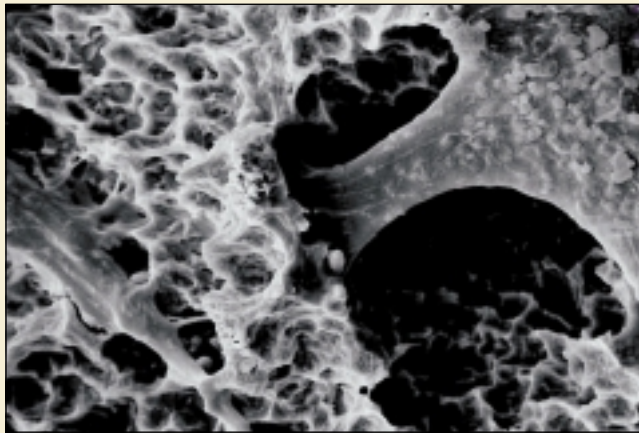


Figure 4: SEM view of the SLA surface manufactured by Straumann. In favourable sites this surface is functionally osseointegrated only six weeks after fixture placement

undeniable. Literature on, for example the 3i system now describes ‘contact osseogenesis’ around the fixture, as opposed to ‘distance osseogenesis’ which occurs with traditional machined surface implants.

In contrast, Branemark implants have long been seen as the archetypal Machine surfaced implants. It has appeared to many of my contemporary colleagues that Branemark have previously been reluctant to alter their product in this and other respects, preferring to market a product which the company felt had a long-established pedigree.

However, over the past ten years or more, the science behind alternative endosseous implant surfaces has become overwhelming, and many clinicians in implantology practice have come to regard the use of such smooth surface implants as an outdated concept. In response to scientific research, and no doubt also to market forces, a new rough surface Branemark implant has recently been launched featuring their own new roughened ‘Ti-Unite’ surface.

Researching, developing

and the publishing of clinical trials to substantiate claims on implant surface performance are time consuming and costly to undertake. Major companies are understandably proud of the virtues of their own implant surfaces. For example, Astra Tech claim that ‘TiO blast (Figure 5) is the only enhanced implant surface backed by comprehensive documentation and long-term follow-up studies.’ In this age of ‘evidence-based practice’ such claims are to be carefully considered. However, it should be noted that rival companies make similar claims. Appropriate research and development should ideally include theoretical modelling, pre-

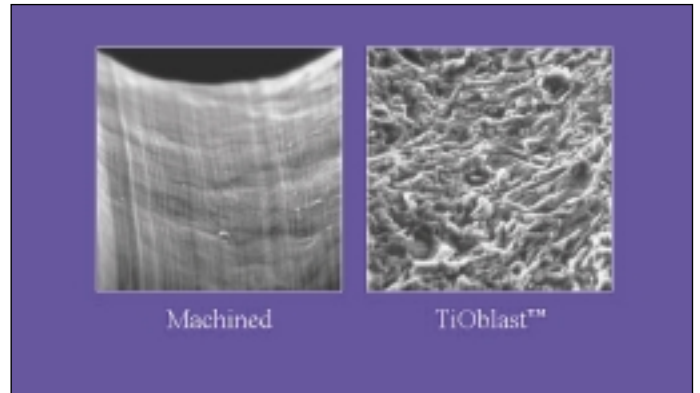


Figure 5: A comparison of a machined surface and the Astra Tech TiO blast surface

clinical in vivo and in vitro documentation, human histology and clinical documentation.

VARIATIONS IN ROUGHENED SURFACES

During manufacture, following production of the implant ‘blank’, the endosseous section of the implant fixture is carefully processed to achieve the desired implant surface anatomy. The fine details of the procedures used to achieve each patented surface are closely guarded industrial secrets. Such surfaces are therefore often mimicked by lesser companies, but are by definition not exactly the same.

Mainstream companies argue that the effect of ‘similar’ (but not identical) surface treatments by

imitation systems, which are not backed by significant clinical trials, cannot be held to trigger the same response at a cellular level, and therefore their long-term performance is often only speculative.

ADDITIVE ENDOSEOUS SURFACES

The endosseous surface of a dental implant can be classified as an additive or a reductive surface.

When an additive technique is employed, the finished surface is applied onto the appropriate section of the implant blank. For the purposes of this article, TPS and Hydroxyappetite surfaces fall into this category.

TITANIUM PLASMA SPRAYED (TPS)

During the manufacturing process, pure titanium particles are sprayed onto the implant blank through a plasma flame at 20,000°C. The resulting globules of titanium oxide are visible on the implant surface when viewed under the SEM (Figure 6).

This process can increase the surface area of the implant surface by 6-10 times by the apposition of a porous layer 20-50 microns

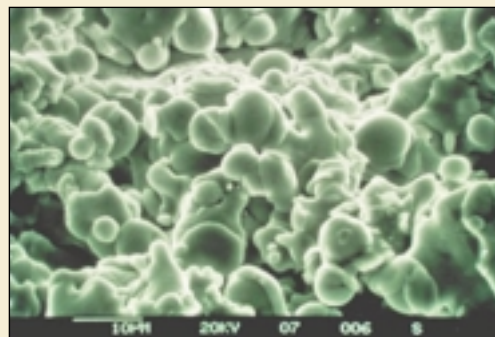


Figure 6: TPS surface as manufactured by Straumann

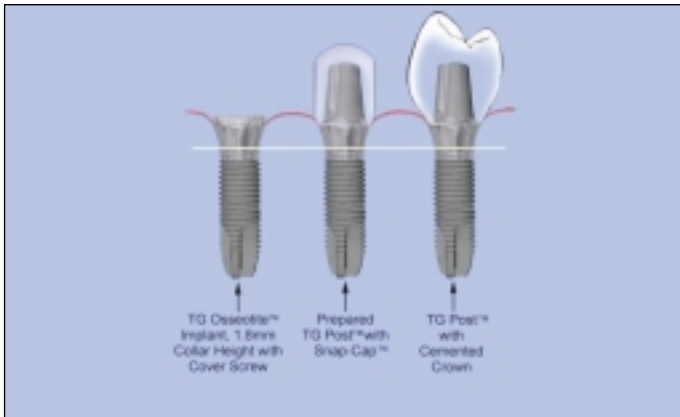


Figure 7: TG Osseotite implant

thick. Examples of Titanium Plasma Sprayed surfaces (TPS) are in use in various implant systems including Frialit 2 push-fit implants. Replace implants (Nobel Biocare) are currently available in this format if requested. ITI implants had TPS surfaces since their inception more than 20 years ago, but this surface has been superseded by their reductive SLA surface, which is discussed below.

One disadvantage of an additive surface is the risk of eventual surface detachment, at least in degrees. Titanium oxide particles have been found in regional lymph nodes in cases treated with TPS implants, although to date, no detrimental health risks have been identified.

HA COATING

Hydroxyapatite is another surface additive that has been tried by a number of manufacturers and has been included as an option in the popular Replace system from Steri-oss. The use of a hydroxyapatite surface has been shown to accelerate the process of osseointegration and has also been thought to be helpful in the treatment of patients with osteoporosis. However, the concern with such surface modification is

again the risk of eventual detachment with subsequent peri-implantitis. I certainly know of colleagues who have had this experience with Calcitec implants coated with hydroxyapatite. Implants with hydroxyapatite surfaces are not in common use in the UK today seemingly for this reason, but are apparently quite popular in the USA.

REDUCTIVE SURFACES

Reductive surfaces are manufactured by exposing the implant 'blank' to some sort of corrosive element to produce the desired surface morphology. This commonly involves some sort of acid etching, grit blasting, or a

Figure 9: The Astra fixture range comprises four basic implant types available in varying lengths. The TiOblast surface extends to the full length of the endosseous part

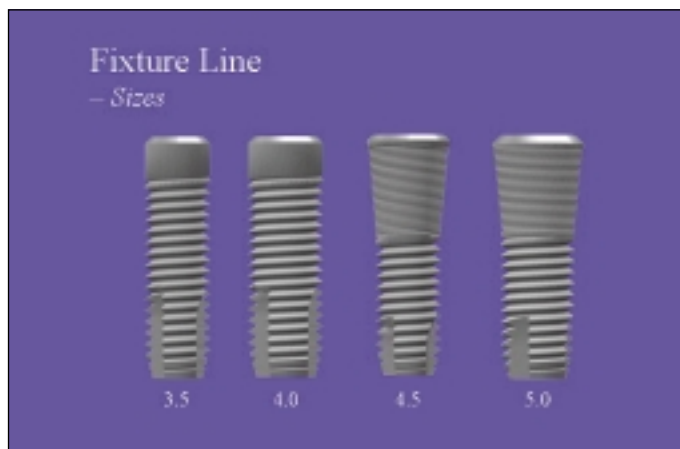


Figure 8: Restoration of two premolars on TG Osseotite implants by 3i. The Morse taper connection system on the TG range make these implants particularly easy to restore. Note the fixture heads are supragingival favouring a good soft tissue response. This implant design is especially suited to areas of the mouth where the emergence profile and gingival aesthetics are not paramount

combination of the two procedures, whilst the new 'Ti-Unite' surface from Nobel Biocare is manufactured using an electrolytic process.

During production of a reductive surface, the risk of inclusion of foreign bodies must be avoided. Generally speaking, it is believed that the risk of eventual surface detachment is minimised or avoided when a reductive technique is used.

ELECTROPOLISHING

The newly introduced 'Ti-Unite' surface from Nobel

Biocare (marketed as 'the most significant breakthrough in osseointegration today') is produced by an electrolytic procedure which is said to produce a controlled thickness of Titanium Oxide which has 'a structure very similar to human cancellous bone' (i.e. when viewed via an SEM).

The degree of roughness is graduated along the length of the implant. Long-term studies on this surface do not yet appear to be available.

To many of my colleagues, the previous lack of a rough surface fixture in the Branemark range meant that the system was beginning to look very dated. It will be interesting to see how successful and popular this surface turns out to be.

Whilst Branemark implants by Nobel Biocare have previously been available only with the machined surface finish, Replace system implants from the sister company Steri-Oss have always been available in the UK with a choice of finishes - machined surfaced, titanium plasma sprayed and hydroxyapatite.

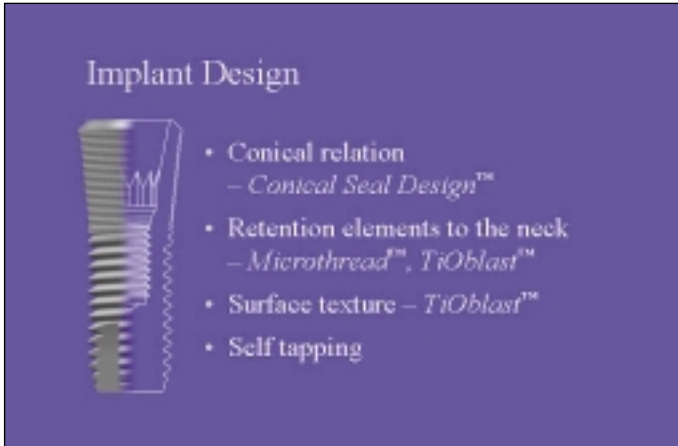


Figure 10: The neck of the Astra implant featuring the microthreaded design that is said to optimise conditions for maintaining crestal bone levels

The Ti Unite surface is now a further option for Replace system users.

ACID ETCHED SURFACES

The Osseotite surface by 3i is achieved by thermo-etching the pure Titanium surface with a combination of Sulphuric and Hydrochloric acids. Successful osseointegration for all bone types is now said to be achievable in less than two months with this surface. The roughened Osseotite surface is applied to the level of the second thread of the implant fixture (Figure 3) but short of the crestal bone position. 3i also produce their TG range (Figure 7). The fixture head of the TG implant is situated well above the top of the Osseotite surface, making this appear to be an implant which is well suited to transmucosal use (Figure 8).

BLASTED SURFACES

The TiOblast surface, as featured on Astra implants, is produced by blasting the implant surface with titanium dioxide particles to produce the required micro-topography without contaminating the implant

surface (Figure 9). Compare this fixture design to the 3i range and notice the very different philosophies re: the maintenance of the crestal bone height. The rough surface of the Astra implant is carried right to the top of the crestal bone. The purpose of this design, combined with the micro-threaded feature at the implant neck (Figure 10) is to maintain crestal bone position by providing a favourable surface for bone physiology. In contrast, the 3i philosophy is to provide a smooth titanium surface at *and* below the bone crest, allowing an optimum soft tissue response in the event that crestal bone is lost.

Figure 12: Push and Screw fit Frialit-2 implants. Ideally, the polished collar is positioned just above the crestal bone margin

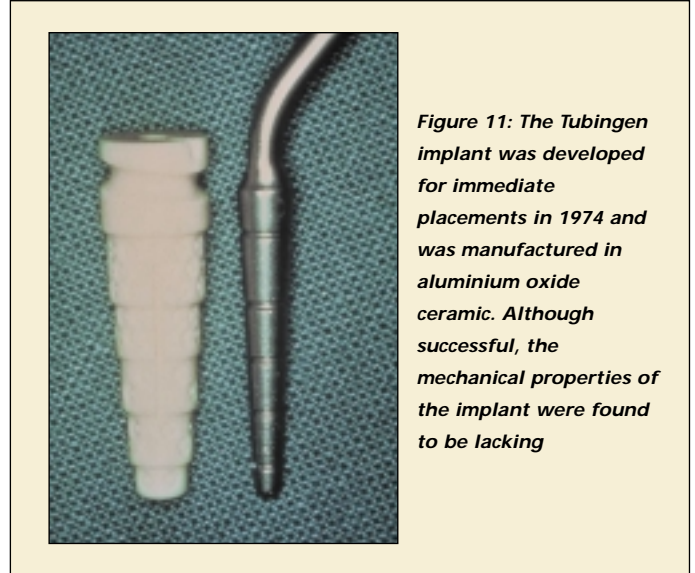


Figure 11: The Tubingen implant was developed for immediate placements in 1974 and was manufactured in aluminium oxide ceramic. Although successful, the mechanical properties of the implant were found to be lacking

BLASTED AND ETCHED SURFACES

ITI implants by Straumann were all produced with the TPS surface from 1974, but testing on the new SLA surface (Sand blasted Large grit Acid etched) began in 1990. The macro roughening of the implant surface is produced by the grit blasting procedure, while the subsequent thermo-etching procedure gives the surface its micro-etched 'double roughness'. The reduced osseointegration times associated with this surface have already been discussed.

Frialit-2 implants are

available in the UK via General Medical, manufactured by Friadent. The company began the development of the Frialit-1 implant (the Tubingen implant) in 1974 (Figure 11). The Frialit-2 implant was introduced to the market in 1992 following two decades of research and clinical testing. Frialit-2 implants (Figure 12) have been available in a choice of Grit Blasted/Acid etched surface, TPS, and hydroxyapatite coated since their inception.

IMPLANT SURFACE CHARACTERISTICS AND THE TREATMENT OF SMOKERS

The treatment of smokers with dental implants is a potentially controversial area and a number of studies have shown that smokers can expect an increased fixture failure rate. Patients may face early problems arising as a result of failed osseointegration, or later problems should a peri-implant infection develop.

Wallace recently published a retrospective study of Branemark implants, reporting an extremely-high 16.7% failure

rate in smokers, concluding that smoking was a significant risk factor. All his failures occurred within the first year of treatment with this type of machined surface implant.

Conversely, there have also been quite a number of studies apparently showing no significant difference in the treatment of smoking patients, certainly in the shorter term. Evidence exists that the enhanced healing characteristics of roughened surfaces may account for the fact that studies on implants with, for example, the Osseotite surface or SLA surface often do not show a problem with osseointegration in smokers with good bone volume (however, the success of associated procedures such as Guided Bone Regeneration in these patients is another matter).

It is interesting to note that Cigna will offer what basically amounts to a full warranty on smokers, if the patient wishes to take out a financial warranty on their valuable implant treatment.

This having been said, in practice, the counselling of smokers can be more complex. 30-40% of the European population carries a genotype (in the Interleukin-1cluster) which some authorities believe to have an adverse synergistic effect in combination with heavy smoking. Some patients may be at a higher risk of periodontal disease and peri-implant disease in the longer-term and more strict

maintenance protocols may be appropriate for these higher-risk patients if implant treatment is provided.


Patients will need to be made aware of the various issues involved. Ideally, the patient would give up any smoking habit prior to undergoing treatment. My personal experience to date is that I have treated quite a few lighter smokers selectively using roughened implants, and without incidence to date. However, I feel that as well as the extent of the patient's smoking habit, it is important to take into account their overall oral and general health and the nature of the work requested.

As a practitioner in private practice it must be borne in mind that even where the patient apparently accepts such risks, and written documents underlining these issues are signed, if problems do unfortunately arise, the patient will return to the treating practitioner to resolve the situation.

IN CONCLUSION

Over the past few years, the industry has been placing great emphasis on the development of improved endosseous surfaces, changing treatment protocols for the better. The benefits of these micro-roughened surfaces are perhaps reaching their limits, certainly in terms of the reduced osseointegration times and the extent of implant to bone

contact that will be achievable by surface modifications alone. The issues that I have covered are by no means exhaustive, and surface characteristics of implant fixtures will have a bearing on other important factors, such as peri-implantitis - both in terms of its development, and the subsequent host response to treatment of this condition.

It is currently anticipated by the industry that future advances in the enhancement of the osseointegration process are likely to come from techniques such as the use of bone morphogenic proteins, perhaps in combination with implant surface treatments, resulting in accelerated bone growth and enhanced bony union. 

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