Adrian Rollings FBIDST

The selection and use of dental laboratory materials to create passively fitting cast alloy frameworks supported by dental implants

The need for creating an extremely accurate passive fit when constructing cast metal frameworks for implant borne restorations is well documented and understood, however the fact remains that there are many variables that must be optimised within the dental laboratory if a predictably satisfactory outcome is to be attained, in particular for larger cases. In order to create this predictability it is first necessary to review the most basic processes and take a ground up approach. The following article is not intended to be exhaustive and it should also be borne in mind that it would be extremely unwise for any individual to claim that a framework will never need sectioning; our aim is therefore to highlight various 'basic success' factors that should influence the selection and use of materials for the construction of these structures.

Selection of Die Stone and Model Construction

The working model is of course the basic foundation of any restoration and here all too often economic grounds can be the arbiter of which material that we select rather than suitability for purpose, yet this is probably the single most important product that we use. The properties required for an implant stone differ only very slightly from those for regular crown and bridgework and there is no reason why one material cannot suffice for both. The specific factor most important to implant restorations is a low setting expansion as in many instances a full arch rather than sectional model is created, increasing the bulk of material and consequent risk of inaccuracy. It is therefore important when selecting a die stone for this purpose that you have complete confidence in the manufacturers' production and batch testing processes. Fuji Rock EP (GC Europe) fulfils these criteria particularly well by combining a short setting time with an expansion of only 0.08% and eight minute working time. Consistency is ensured by the fact that the raw material gypsum is first refined to an exceptional degree of purity prior to the addition of a range of specially engineered property enhancers to guarantee optimal mechanical and thixotropic properties.

In the laboratory we also have our role to play, in order to guarantee consistency with the manufacturers testing process we should use distilled water with our Type IV stone and strictly follow the manufacturers mixing instructions without exception, weighing and measuring the volumes of powder and liquid. Here it is interesting to make comparison with a casting investment; if we misuse this material the consequences are visible, often catastrophic and relatively instant. Whilst an inaccurate die stone model may well appear to be perfectly satisfactory in the dental laboratory with the problem not appearing until the final fit stage. At which point it will be even more catastrophic, yet the source of the problem will be difficult to trace and become a potential source of conflict between dental surgeon and technician.

Additionally it should be noted that there is a definite economic advantage to accurately dosing the material as the exact amount of die stone can be prepared, minimising any wastage and allowing the laboratory to precisely monitor its unit cost.

Storage of die stone should always be in an airtight container as its physical properties can be adversely affected by humidity, given that these effects will increase over time it is sensible to only purchase larger packages if there is a rapid turnover of material.

The method for creating the soft tissue model, whether directly in the impression or indirectly from a matrix is a decision for the individual operator. However it is important that the implant fixture replicas are embedded in a sufficient bulk of material to guarantee their stability. Here stainless steel replicas offer a significant advantage when compared to anodised aluminium items which are inherently less stable for obvious reasons.

The most accurate technique for the production of the model is a matter open for discussion; but the basic principle must always be that during the setting process no displacing force can be placed on the implant fixture replicas. Such a force may come from sources such as an excessive mass of fluid die stone or being inverted unsupported onto a model base. Here we have used a modified model tray technique (Tricodent) which can work extremely well (figure 1). The fixture replicas are inserted and the impression poured, taking care to avoid any interference the impression is then inverted into the model tray. The key is that the impression must be supported by the rim of the tray and the die stone must still be fluid. The advantages are a reduced volume of die stone, a model that has the option of being sectioned and also the creation of a 'self contained tray' to store implant components during subsequent stages.

(Fig 1 Model trays can provide useful storage)

Constructing the Pattern

In order to provide the correct support for the veneering ceramic or in the case of a denture ensure that a bar will be correctly accommodated it is essential to construct silicone indices to define the final contour of the planned restoration. This can be achieved in many ways, including the use of a diagnostic wax up, wax try in, study cast of provisional restoration or full contour wax up (figures 2 & 3).

 

(Fig 2 & 3 Indices of provisional restoration)

Obviously it is dependant on the particular implant system used and its individual nuances, in this instance we will look at a case utilising preformed plastic burnout screw retained copings (Institut Straumann AG) which are very popular due to their cost advantage and flexibility of use when compared to components containing platinised gold elements (figure 4). However it must be understood that the fit at the interface with the implant will be inherently inferior with a laboratory casting when compared to a precisely engineered factory produced part, the choice of a highly accurate investment material is therefore extremely important.

Where screw retained components are utilised it is important not to over tighten the plastic patterns as there is a tendency for them to flex and introduce unwanted stresses and create an inaccurate framework.

In order to gain stability the use of resin material such as Pattern Resin (GC Europe) is highly recommended. It should be noted that in most instances the resin will not bond chemically with the preformed plastic components and it is necessary to create some form of mechanical retention (figure 5). Pattern Resin is best manipulated by wetting the tip of a brush in the monomer and then picking up a small amount of powder which will then become wet and can be applied to build the pattern up incrementally. The consistency must not be too fluid as this will increase polymerisation shrinkage. A good tip is to select a brush of similar in size and shape to the type that you normally use for your ceramic work.

Figure 4 Plastic burnout cylinders in position


Figure 5 A mechanical bond is created with the pattern resin


Figure 6 The connectors are formed

The process is highly intuitive as the material has a relatively quick set and is therefore highly resistant to slumping; once the ideal contour has been achieved it is best to allow the material to set for an extended period, ideally overnight (figure 6). Bridge connectors should be sectioned with a thin diamond disc ahead of this setting period in order to allow them to fully polymerise in a tension free manner (figure 7), reducing the risk of distortion when the framework is removed from the model. Once this extended setting period has occurred the connectors are rejoined with a little more resin and allowed to polymerise (figure 8).


Figure 7 The connectors are sectioned and allowed to polymerise for an extended period


Figure 8 The connectors are rejoined

During the burn out process there is a tendency for plastic components and resin to expand prior to their elimination risking the mould cracking; it is therefore always advisable for them to be covered with a layer of wax to allow for this expansion (figures 9 & 10). Likewise the rapid burnout technique should not be used as this makes the expansion of the resin more volatile and therefore increases the likelihood of the mould cracking (figure 11).

Figures 9 & 10 The final form is contoured in wax

Figure 11 Rapid expansion of plastic components can cause investment material to fail

Fig 12

Fig 13


Fig 14 Fig 15

Figure 12, 13, 14, 15 Here exactly the same rationale is used for a compromised placement utilising a cast to abutment (Astra Tech Dental)

The Spruing Technique

The technique that we have found the most reliable method for spruing larger frameworks involves the use of an indirect 'runner bar' technique, however this bar is always split into a number of individual segments dependent on the span of the pattern. This is intended to minimise the risk of a warping force as the alloy in the 'runner bar' contracts on cooling (figure 16). The runner bars have a diameter of 4-5mm and the sprues to the cross bar are normally 3.0 mm in diameter, with the pattern a distance of approximately 3.0mm from the crossbar.

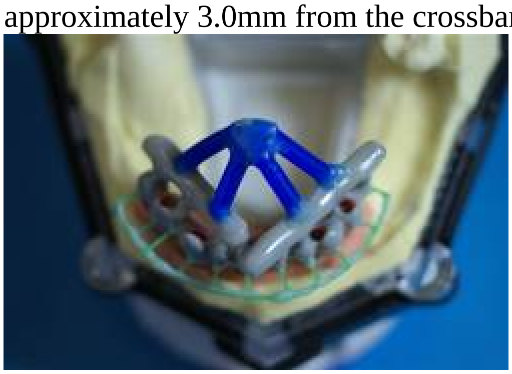

Figure 16 The spruing technique utilises a segmented runner bar to help prevent warpage

If large volumes of alloy are used it is important to provide venting channels on the buccal/labial surface to allow gases to escape from the mould.

Additionally it is important to calculate the exact amount of alloy required to fill the mould with only the excess necessary to create a reservoir that will eliminate the risk of porosity. Under no circumstances should the mould be filled to the point that a casting button is created joining the reservoirs together as once again there is a risk of creating a force that will warp the casting.

Investing Technique

Screw retained castings create a number of extra risk factors for the dental technician at the investing stage. This is because the screw housing must be reproduced accurately, there is not the benefit of a cement gap and the pattern will often incorporate expensive components.

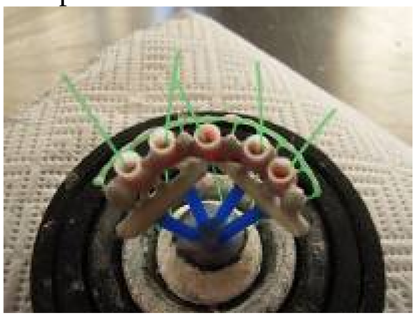

Figure 17 A thin gauge sprue wire is inserted into each cylinder

Here a good option is to insert a thin gauge (0.6mm) sprue wire into each plastic burnout cylinder (figure 17) which extends above the height of the casting ring; the investment material should then be poured in a thin stream to avoid trapping air. This is best achieved by allowing the investment material rise inside each individual cylinder at exactly the same rate as the material surrounding their outer surface; they should not be filled from above. Once completely full the thin gauge sprue wire will protrude from the mould and must be removed before the investment material sets (figures 18, 19). Upon removal a minute vacuum is created within each cylinder which will help eliminate any remaining air voids.

Figures 18 & 19 The sprue wires are removed once the mould is filled

Figure 20 Once set the investment material should be roughened to allow the escape of gases

When utilising semi burnout components (those containing non oxidising platinum gold cylinders) there is the possibility that castings will be incomplete if the mould is not 'heat soaked' for an adequate period of time. This is caused by the molten casting alloy 'freezing' as it comes into contact with the 'cold' platinum gold cylinder Whilst conversely elevating the mould temperature excessively may encourage alloy to 'flash' onto the critical surfaces of the manufactured components rendering them unusable, additionally this flashing can be caused by the use of a wetting agent.

GC Fujivest Platinum investment (GC Europe) makes an ideal choice for precious and semi precious alloys because of its fine grained structure which eliminates the need for a wetting agent and also means that the investment removal is a much less arduous task than with coarser harder material. This also has the benefit of reducing the risk of damaging either manufactured or cast components by the use of excessive or harsh abrasion techniques.

Figures 21 & 22

We will discuss later the merits of various alloys, but if non precious alloys must be used it is advantageous to use a more robust investment material with a higher capacity for expansion such as GC Fujivest Premium (GC Europe).

The key components of phosphate bonded investment are quartz, cristobalite, ammonium phosphate and magnesium oxide which are refined and combined with specially engineered additives. As the basic ingredients are of natural origin controlling the purity of the incoming raw material is of equal importance to the quality control of the production process. Whilst this may seem academic it is the only way of guaranteeing consistency for the end user in the dental laboratory.

When calculating the ratio of expansion liquid to distilled water the presence of plastic or resin components must be taken into consideration. On setting investment material produces a 'green' expansion ahead of any thermal expansion; however as resin is less flexible than wax this 'green' expansion can be restricted resulting in tight castings which require internal adjustment, this problem can be eradicated quite simply by using a higher concentration of expansion liquid.

An often overlooked factor influencing this critical liquid ratio is the choice of casting ring liner (New Casting Liner, GC Europe) which should be impervious to the absorption liquids.

During the setting process the mould should be kept away from the vibrating table to avoid the risk of the liquid separating out to the top of the investment mould which will compromise the powder liquid ratio.

Alloy Selection

The selection criteria for alloys used for casting implant borne supra structures should be viewed pragmatically. Firstly we must make clear that any alloy that is suitable for implant borne castings should also be suitable for your regular crown and bridgework, as in essence they are doing the same job. But it is not safe to assume that your regular crown and bridge alloy will be suitable for your implant work.

The reasons for this are manifold; the dental implant is screwed rigidly into bone without the benefit of a periodontal membrane. It is therefore only advisable to use type IV alloys, as type three alloys do not have the rigidity to withstand the focused loading of an implant. Given that the interface between restoration and implant is often metal to metal means that there is far less tolerance for inaccuracy than with conventional restorations. This increases the risk that a framework may need to be sectioned and either laser welded or soldered.

The alloys that meet these criteria are not necessarily the most expensive, indeed there is a very strong case to make for a number of palladium based and reduced gold alloys. However these alloys cannot be generalised as it is often their minor constituents and trace elements that guarantee their suitability. Tin for example even in small quantities can have an adverse effect if laser welding is undertaken, causing the joint to be brittle.

If the semi burnout components described earlier are used it is essential that the casting alloy is compatible with and can create an inter metallic bond with the pre manufactured component. The melting temperature of the casting alloy and mould temperature are therefore critical, if too high there is a risk of melting the pre manufactured component, if too low either an incomplete casting or no inter metallic bond. Endurance 52 (Skillbond, Argen Corp) is particularly suitable for this purpose as its formulation has similarities with an industrial brazing alloy.

The volume of alloy used tends to be greater than that used for regular PFM work due to the size and placement of the implant and the contour necessary to support the veneering ceramic. Additionally the risk of a galvanic reaction between the titanium implant and casting alloy must be taken into consideration; this is most likely to occur when non precious alloys are in close contact with titanium.

When using precision attachments with nylon retention components they must not engage a gold alloy surface as it will be worn away. It is far better to use a high palladium alloy such as Argelite 76 SF+ (Argen Corporation) which is particularly suitable for bar type restorations due to its combination of strength and corrosion resistance. Silver palladium alloys are better avoided as they can be susceptible to corrosion if cold sterilisation procedures are undertaken.

However there really are no magic numbers and the final arbiter must be the integrity of the alloy manufacturer, the level of technical support offered and not least your own experiences. The Endurance range (Skillbond, Argen Corp) of implant alloys has been specifically developed to fulfil these criteria by identifying suitable alloys and backing them with marketing and educational courses that put the practical needs of the dental technician first.

Devesting and verifying

Once cast the ring should be allowed to bench cool, the investment mould is then removed from the casting ring and soaked in water to avoid the inhalation of dust. The fine grained nature of GC platinum allows the majority of material to be carefully removed with normal hand tools (figures 23 & 24). When blasting the remaining material away great care should be taken to avoid damaging the areas of interface with the implant and screw housing. If pre manufactured gold cylinders have been used under no circumstance should they be blasted and it is wise to protect them as the other areas are abraded. If plastic burnout cylinders have been used the majority of material should be carefully removed by hand and then only blasted at low pressure with glass beads. Any areas that are to veneered with ceramic should then be blasted with aluminium oxide.


Figures 23 & 24 No casting ‘button’ is formed, note that the direction of casting force is marked into the investment prior to burn out

The casting should then have its sprues removed and be visually inspected for any imperfections which can be removed with a tungsten cutter or reamer (figure 25). The framework can then be verified for passivity on the master model by the insertion of a screw at one extremis (figure 26).

Figure 25 The framework is inspected and any slight imperfections removed

Figure 26 The framework is tested for passivity

Figure 27

Figure 28

Figure 29

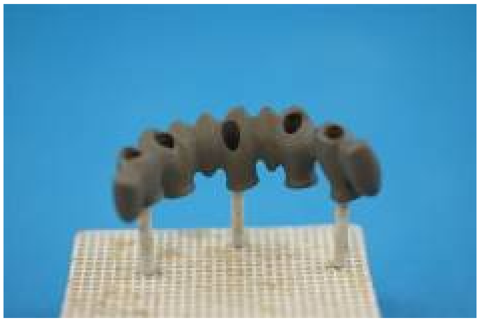

Figure 30

Figure 27, 28, 29, 30 The framework is then trimmed with a range of tungsten cutters taking into account the occlusion and final contour required prior to alloy manufacturers degassing procedure.

Summary

The construction of large implant borne castings introduces significant risk factors to the dental laboratory with the potential for financially disastrous consequences. As said from the outset it is impossible to cover every possibility and completely guarantee that a framework will never need to be sectioned and rejoined. However it can be seen that by carefully evaluating and refining the individual processes that are undertaken and selecting materials primarily for their suitability you will significantly increase the probability of success.

Acknowledgements

Paul Cascone of the Argen Corporation for his expert advice on the subject of dental alloys.
Diederik Hellingh of GC Europe for his expert advice on dental materials.

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Adrian J Rollings FBIDST
183 Great Hampton Row
Hockley
Birmingham B19 3JP
United Kingdom