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Occlusal Considerations in Implantology: Good Occlusal Practice in Implantology

Abstract: This article is concerned with implants that are being used for fixed crown and bridgework rather than removable prostheses. The huge increase in the provision of implants over the past two decades is set to continue. Most of the research is related to avoiding failures in implants. This research, in the main, has concentrated on the essential interface between the artificial implant and living bone: osseointegration. The other interface, which is worthy of our full attention, is the one between the implant-supported crown and the antagonist tooth: the occlusion.

Clinical Relevance: This article aims to provide the basis for guidelines for good occlusal practice in implantology.[1] It will consider these under two headings: those which could be considered as basic occlusal principles; and those occlusal considerations that are specific to implants.

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Although the interface between bone and the titanium implant is paramount to the success of the implant, the design of the occlusal interface is also important. This is because the occlusal load can have a profound effect upon the quality of the osseointegration of the implant.[2–10]

This occlusal interface or contact, commonly known simply as *the occlusion,* is part of the articulatory system. This system is itself part of the masticatory or stomatognathic system (Figure 1). The clinician who is considering the provision of implant-supported restorations should carry out an examination of the articulatory system. In fact, it can be argued that all restorative dentists should:

- Have a good understanding of temporomandibular joint, both in health and dysfunction;
- Be able to test the principal muscles of mastication and be able to diagnose myalgia;
- Have a reliable means to examine and record the patient's pre-existing occlusion and jaw relationship.

If these are the requirements for restorative dentists, obviously they pertain to implantologists too. Approved training pathways and Diploma courses in Implantology recognize these basic requirements and teach a *stomatognathic or full-mouth concept*. The reason for this approach in teaching is clear. Temporomandibular disorders can be considered as a disease, dysfunction or discomfort of the articulatory system and very nearly all of restorative dentistry has the potential to change one part of that system, namely the occlusion. It follows, therefore, that it would be ideal if all restorative dentists were able to diagnose the common temporomandibular disorders. If a restorative dentist is unable to diagnose temporomandibular disorders, a patient's treatment plan would be more soundly based if a referral could be made for a pre-restorative TMD screening.

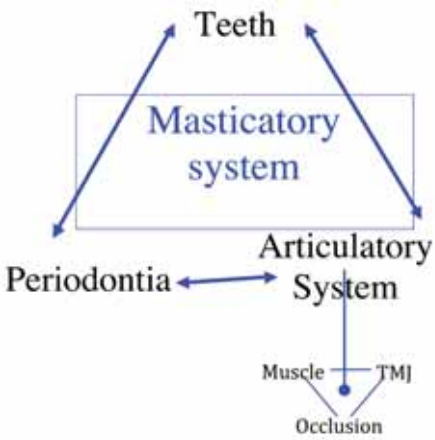

Figure 1. The Stomatognathic Systems.

An inability to diagnose a pre-existing TMD can have devastating consequences to dentist and patient. This was vividly illustrated by a case recently referred to the TMD clinic at the Manchester Dental School. The patient was a 22-year-old with multiple congenitally absent teeth, who was nearing the completion of her implant-supported full-mouth restoration.

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Her treatment was significantly interrupted by the sudden onset of a closed lock due to a TMJ disc displacement without reduction. When a history was taken in the TMD clinic, it became clear that she had presented at the start of her implant/restorative treatment with the signs of TMJ disc displacement with reduction. If this diagnosis had been confirmed before starting her treatment, there would have been much less chance of this developing into the closed lock caused by a non-reducing disc displacement. A simple TMD screening examination might have saved the patient and the dentist the distress of a major interruption to her treatment whilst her disc displacment was resolved. Similarly, there are dangers in providing extensive and complex treatment in a patient who has a masticatory muscle discomfort or dysfunction (TMD diagnosis: myofascial pain). The reason why extensive restorations should not be started in a patient with the signs and symptoms of masticatory muscle dysfunction is related to the necessity of taking an accurate interarch registration ('bite').

A 'bite' is taken either in 'retruded contact position' (centric relation) or, more commonly, in 'intercuspation position' (centric occlusion). Another way of saying the same thing is that the treatment will be provided in either the 're-organized approach' or the 'conformative approach'.[11] In the 're-organized approach', the bite is taken in 'retruded contact position' (centric relation), which is a jaw relationship that is as far as is possible free of the patient's neuro-muscular control. The recording of this position is the starting point of the restorative process under this approach. If the masticatory muscles are dysfunctional (eg tenderness to palpation and hypertonicity), then it will be significantly more difficult for the clinician to find this jaw relationship. On the other hand, if the restorations are to be provided to the 'conformative approach', an ICP or CO bite is needed. The jaw relation in ICP or CO is tooth guided and it is the muscles, under the influence of an engram (a fragment of memory), that provide the guidance to close the jaw into the position of maximal 'intercuspation'. If the muscles are dysfunctional, then the guidance may be affected, especially after a prolonged treatment visit. To illustrate how fatigued muscles do not accurately follow the mouth-closing engram: clench hard on one side only, onto a cotton wool roll, for about 2 minutes. When you then remove the cotton wool roll and try to close your mouth *normally*, your teeth don't fit together.

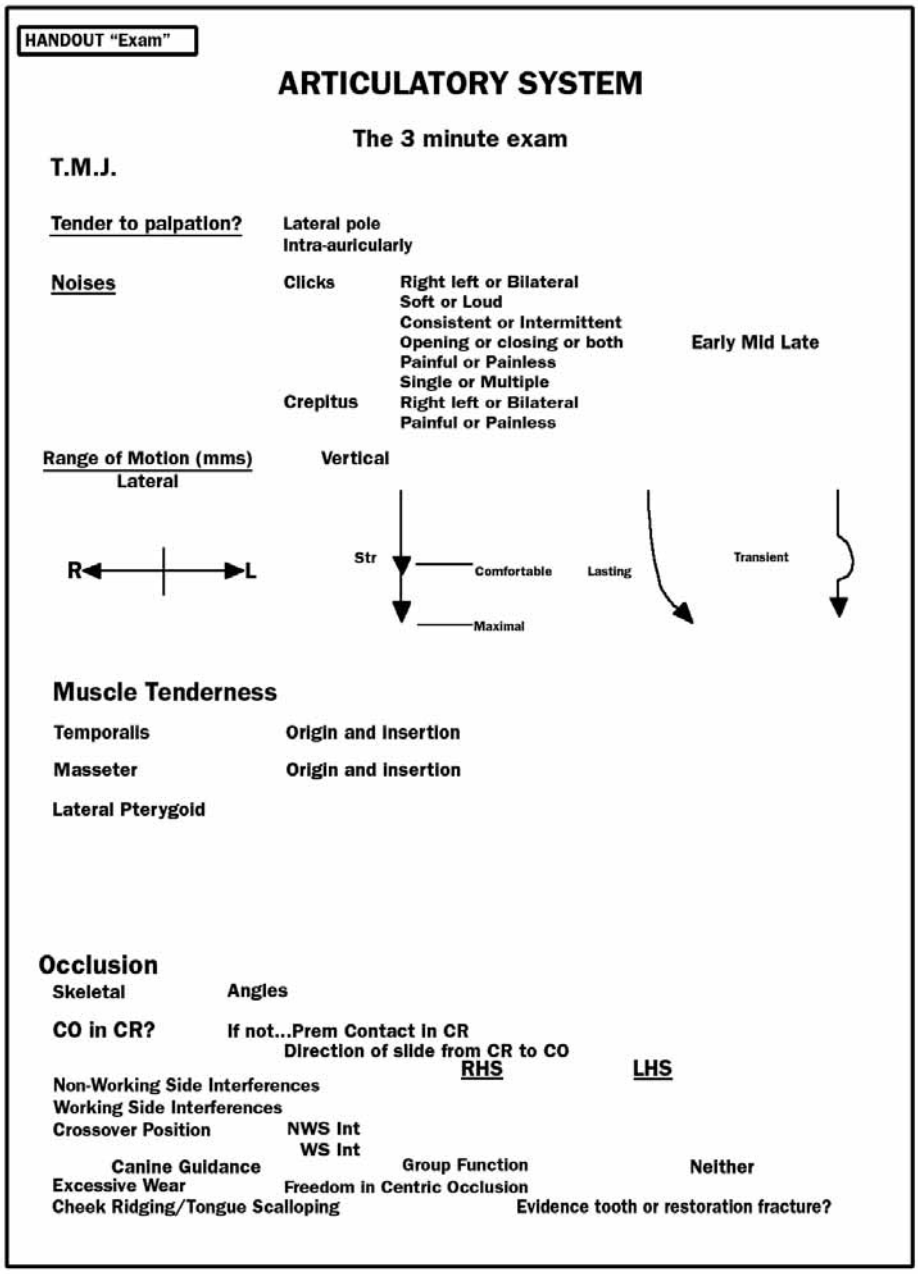

Figure 2. A simple pro-forma.

In conclusion, it is paramount that every dentist providing implant-supported restorative dentistry should be able to:

- Examine the articulatory system;
- Diagnose or have diagnosed a pre-existing TMD;
- Treat or arrange to have treated any pre-existing TMD;
- Have reliable means of examining and *recording* the pre-existing occlusion;
- Maintain the 'conformative approach' throughout treatment, or be able to find and record 'retruded contact position' (centric relation), if the 're-organized approach' is needed.

It is not the purpose of this paper to provide a detailed protocol of the examination of the articulatory system; a simple pro-forma is provided (Figure 2) and this can be supplemented by further study or reading.[12]

Basic occlusal considerations

Whether the 'conformative' or 're-organized approach' is used, the occlusion of our restorations should be prescribed. They shouldn't be the result of a random mix of operator skill, patient reliability and technical reproducibility. Once that prescription has been designed, it needs to be followed. This process should include reliable means of verification, throughout the restorative process. The responsibility for every stage of that process clearly lies with the dentist. Fortunately, not only do patients demonstrate remarkable adaptive capability to occlusal change, but also dental technicians, in the absence of good interarch records, have an uncanny ability to guess well. But these are not the foundations on which dentists want to, or should, base their treatment plans. Patient adaptability is unpredictable at best and, as I will suggest, is likely to be significantly reduced in implantology.

Implicit in the term 'occlusal prescription' is the concept of 'design'. The design of a restoration may be very easy and almost intuitive, as in the case of a simple single restoration. Figures 3a and b illustrate the provision of a very simple restoration. As long as the occlusion is examined before the process, it is an easy matter to ensure that it conforms to the pre-existing state.

Complex cases and those involving the restoration of multiple teeth present greater challenges in the design phase. Multiple restorations are more difficult to provide to the 'conformative approach' because there are fewer occlusal contacts against which to check.

Study models

It may be necessary to mount study models and the value of these is significantly reduced if they are not an accurate representation of the patient's occlusion. So this means that models must be *verified* as being accurate. Figure 4 shows the occlusion marked on some mounted models compared with the occlusion in the mouth. In Figure 4a the differences between the patient's occlusion and that of the mounted models are highlighted. The occlusion of the models in Figure 4b is a more accurate representation of the patient's occlusion.

a  b 

Figure 3. (a) Occlusion marked before restoration of upper first premolar. **(b)** Occlusion marked on restoration six months later.

Diagnostic wax-up

A better name for the *diagnostic* wax-up would be the *design* wax-up, as it is a process that offers the chance to design the occlusion of a proposed restoration. The advantages of a three-dimensional wax representation of the proposed restoration are numerous:

- It will help with deciding tooth preparation or implant location;
- It offers the clinician and technician a 'practice run';
- It enables the patient to see the difficulties and advantages of the proposed restoration (informed consent becomes more robust);
- It is an aid to the construction of the temporary restoration;
- It is the ideal first step in the fabrication of a surgical stent.

Figure 5 shows the stages in designing a wax-up though to the final restoration. It is beyond the remit of this paper to give a detailed explanation of the Broadrick Flag®, which was used as an aid to the construction of this wax-up.[13]

Occlusal considerations which are peculiar to implant-supported restorations

The main difference between an implant and a tooth could be summarized in one sentence. 'It has no periodontal membrane or ligament'. The consequence of this difference is that the adaptive capability of the supporting structure of an implant crown is significantly reduced. It is the view of the author that an occlusion can only be judged by the tissue reaction to it.[14] So, if the adaptive capability of an implant is reduced because of the absence of a periodontal membrane, then the restorative dentist needs to be much more concerned about the occlusal prescription of a crown on an implant than on a tooth.

The adaptive capability is significantly reduced because, in the absence of a periodontal membrane:

- There are no proprioceptive nerve endings;
- The blood supply is less;
- Implants have very limited capacity to displace axially (3–5 μm).[15]

Proprioceptive nerve supply

If the stomatognathic system (mandible and associated structures) is considered to be one of the body's locomotive systems, there is a difference between it and all of the other locomotive systems. The stomatognathic system not only has propreceptive nerve endings in the epidermis, muscles, bone and joints,

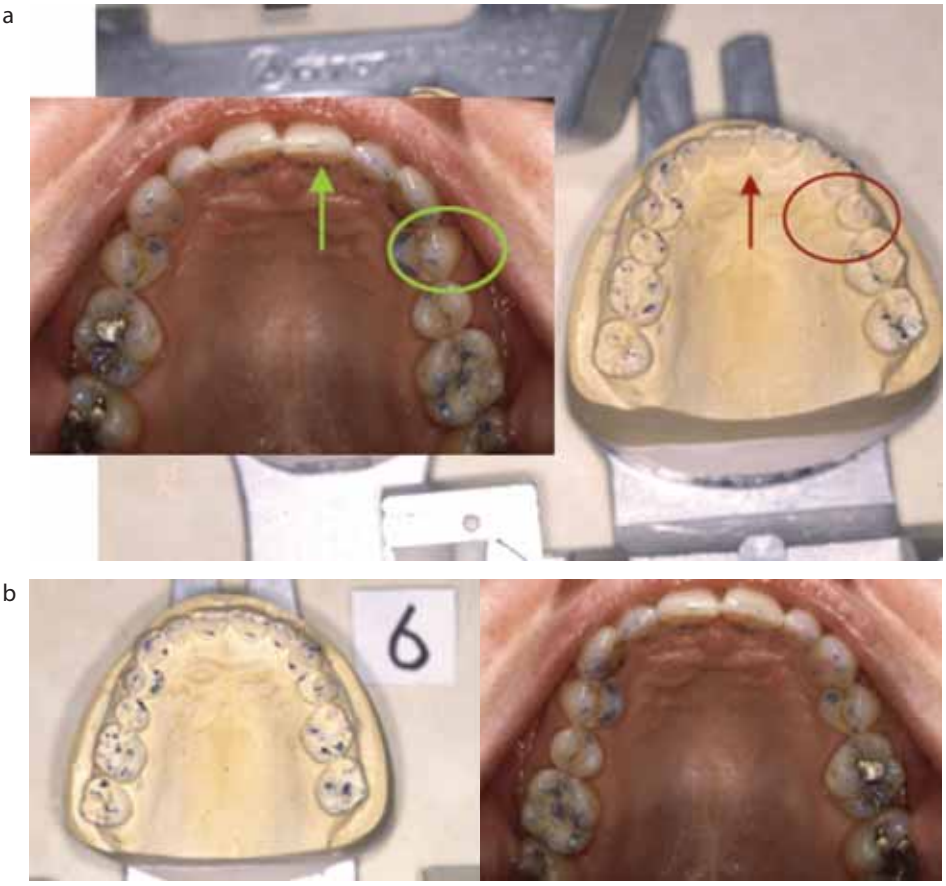

Figure 4. (a) Comparison between clincal occlusion and first mounting of models. **(b)** Comparison between clinical occlusion and correct mounting of models.

as in all other locomotive systems, but in the dentate patient there is an extra layer of proprioception: between the teeth and the bone. This extra connection to the central nervous system allows for an additional layer of reflexes. Its purpose is almost certainly protective, because if a noxious stimulus in the form of excessive occlusal load (excessive force or increased frequency) is applied to a tooth, it will be perceived and an adaptive response is possible. In the case of a crown supported by an implant, this perception will be absent, or very much reduced, as the only nerve endings are in the mucosa, muscles, bone and joints.

Reduced blood supply

The second feature of osseointegration, when compared to a periodontal membrane, is the reduced blood supply. Again, the reactive capability to noxious stimuli is very significantly reduced. Orthodontic movement, a normal reaction to force, is not possible. Neither is a widening of the periodontal membrane possible, which leads to the physiological reaction of hyper-mobility.

Tissue reactions

It is important to consider how reactions may differ in the tissues around an implant as compared to those around a tooth. There is evidence that suggests that implants are more susceptible to occlusal overload than are teeth.[16] When implants are lost, it is often because of the development of peri-implantitis. Although there is an increased proportion of gram negative anaerobic bacteria around an implant with peri-implantitis, there is also evidence that excessive occlusal force is associated with peri-implantitis and bone loss.[17–20]

Tissue reactions do occur around implants, but they are different from those around teeth. It is generally considered that the reactions around implants are likely to:

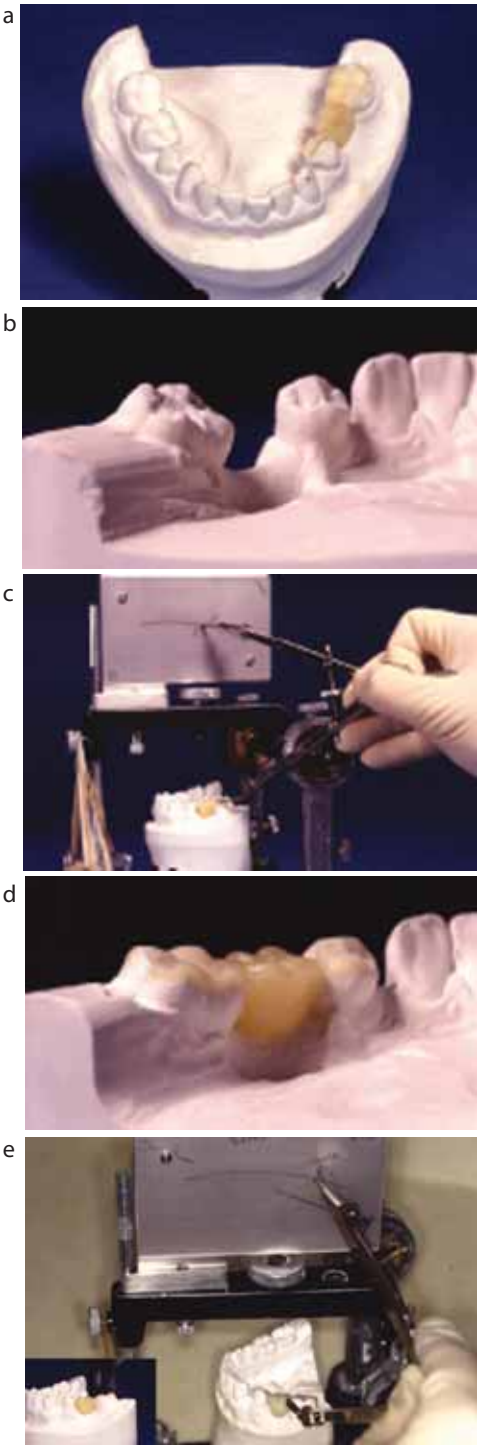

Figure 5. (a) Completed wax-up. **(b)** Pre-operative less than ideal occlusal planes. **(c)** Broadrick Flag® aided wax-up. **(d)** Completed wax-up. **(e)** The completed restoration on the working model, made to the design of the wax-up.

- Be less predictable;
- Happen quicker;
- Occur with less warning;

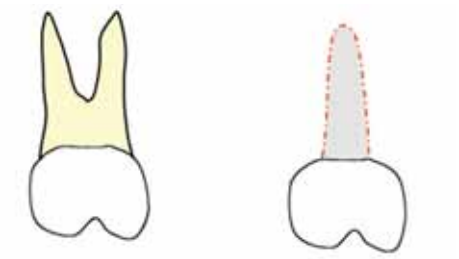

Figure 6. Implants are narrower than the roots of teeth, resulting in greater lateral forces.

a

b

Figure 7. (a) Tongue scalloping. **(b)** Cheek ridging.

- Be catastrophic;
- Be as a result of less load or less frequency of load;
- Be harder for the patient to avoid;
- Be irreversible.

For these reasons, the occlusal prescription of a crown supported by an implant has to be much more carefully designed than that on a tooth. An implant will not be able to react as a tooth can to excessive force or frequency of that force.

Increased load

The second fundamental difference between an implant and a tooth is that the former is much narrower (Figure 6). Simple physics means, therefore, that any occlusal contact which is not directly in line with the long axis of the implant will generate a greater lateral force on the implant than it would do on a wider tooth. The occlusal surface of an implant-supported crown should, therefore, be carefully designed as injudicious placement of the occlusal contact on an oversized occlusal table can easily result in occlusal overload; and there is evidence that this can cause implant failure.[21]

Conclusion

Implants are likely not only to experience greater forces than teeth but have less adaptive capability than teeth.

Occlusal treatment planning in implant-supported restorations

The EDEC principle was designed to provide a broad framework for the prosecution of a restorative treatment plan.[22]

E Examine
D Design
E Execute (that design)
C Check

This protocol can easily be applied and adapted to the particular needs of implant-supported restorations.

E for examine

Although no consideration is given in this paper to the need for an assessment of the bone before the placement of an implant, it is clearly an essential part of the examination process. Is there sufficient volume of bone of suitable quality to be able to withstand the occlusal forces of the implant is an obvious first question.

But, in addition to a bone assessment, all of the articulatory system should be examined during this phase. This is to determine whether there is a pre-existing TMD and whether there are any signs of active parafunction, such as cheek-ridging and tongue-scalloping[23] (Figure 7). A detailed examination and record of the patient's pre-existing occlusion should be made. This can be done in several ways, including the Occlusal Sketch®.[24] Mounted study models can be an important part of the examination stage; that is to say that the models are made *before* the treatment plan is finalized.

As the treatment plan is developed, the decision can be made whether it will be possible to provide the restorations to the 'conformative approach' or whether the more complex 're-organized approach' is needed. The antagonistic occlusal contacts for the potential implant-supported crown will be analysed. A decision may need to be taken that, in order to provide the optimal occlusion, some reshaping of the antagonist teeth is needed. It is the author's experience that it is much easier for a patient to accept the need for this type of adjustment if it is explained at this planning stage rather than after the crown has been fitted.

The design phase (D)

The design phase is of paramount importance in the provision of implant-supported restorations.

There are two considerations in the design phase of implant-supported restorations:

- The placement of the implants; and
- The design of the occlusal prescription.

It may appear that these are two separate phases, one being surgical and the other the restorative stage. It is sometime presented to the patient in those terms: *'the implantologist will place your implants, then I will restore them'.* In order, however, to avoid injudicious placement of the implants, which is an irreversible procedure, it is essential that both of these elements of the treatment are planned and designed before any treatment starts. Irrespective of who places the implants, the design stage of the treatment should be carried out by the restorative dentist.

Surgical placement of the implants – Execute (E)

A surgical stent is needed for accurate implant placement. This is made from the *design* wax-up on accurately mounted study models.

This wax-up is the principal tool used to design the occlusion. It is too late to design the occlusion after the implants have been placed. In the many cases where the surgical and the restorative

Models ⇒ Wax-Up ⇒ Stent ⇒ Implant placement

NOT

Implant position ⇒ Occlusion

Figure 8. Treatment planning sequences.

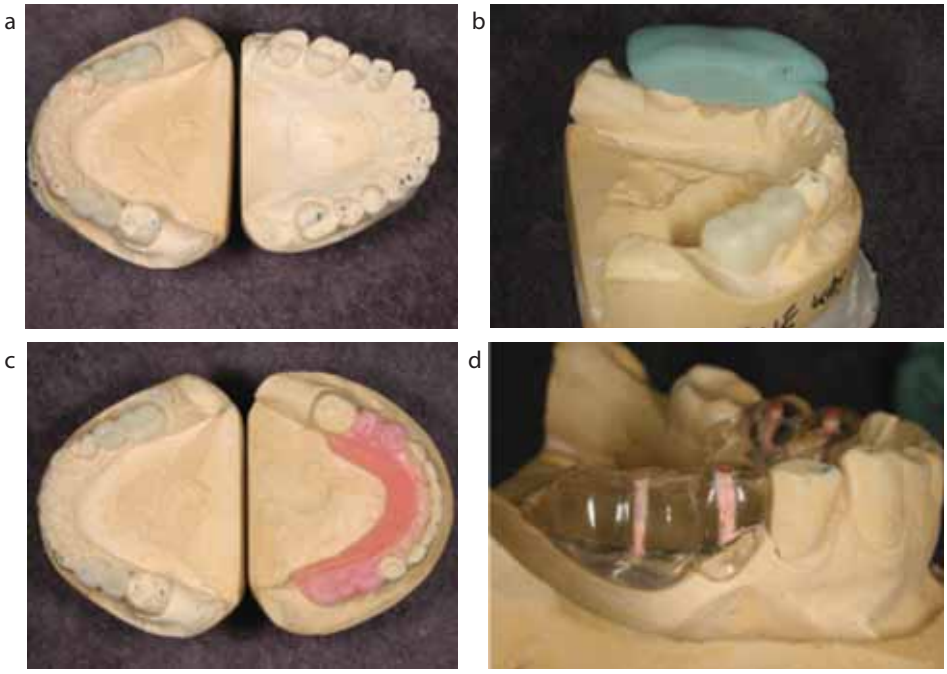

Figure 9. (a) Wax-up. **(b)** Template of wax-up. **(c)** Wax-up of stent. **(d)** Completed stent.

phases are to be carried out by different clinicians, the question of who should take responsibility for the establishment of the ideal implant placement needs to be addressed. It is the author's opinion that it is the restorative dentist who should take this responsibility. In those cases where the surgeon reports that the bone volume is insufficient to allow ideal implant positioning, it will be necessary to return to the wax-up, in order to work out the best compromise. This compromise can then be explained to the patient in advance of treatment. No matter what the constraints imposed by bone volume, establishing the ideal implant position should be the starting point of this pre-surgical stage of the design process (Figure 8).

The construction of the stent involves making a wax-up of the eventual restorations on some accurately mounted study models. A surgical stent is then made from this wax-up as in Figure 9.

The occlusion of the final restoration

Usually this will be provided within the concept of the conformative approach, that is to say the occlusion of the implant-supported restoration(s) should add to the existing occlusion but not change it. If it is impossible or undesirable to conform then the 're-organized approach' will be required.[11] It is difficult enough to re-organize an occlusion in a natural dentition; the problems are much greater if a significant number of the crowns are supported by implants. It is easier to establish the new occlusion on the natural teeth only and then to conform to this new occlusal design when providing the crowns on the implants. If this is not feasible, a period of provisional crowns on the implants will be needed, so that the occlusion can be developed in the provisional restorations.

The recommended features[25] of the occlusion on an implant are:

- Light occlusal load. (It is advised that the occlusal contact on an implant-supported crown is about 30 μm 'lighter' than on adjacent teeth, as a guide, shimstock is 8μm thick.)
- Cusp to fossa occlusal relationship, so avoiding 'incline occlusal contacts' which can exert a lateral force.
- Ideal anterior guidance; ie canine guidance or group function.
- Occlusal force directed down the long axis of the implant.
- The need for axial (occlusal) loading of the implant is the reason for the following often quoted recommendations:

Avoid the following:

- Posterior interferences during eccentric excursions;
- Steep cuspal angles;
- Incline contacts;
- Cantilevers;
- Wide occlusal platforms or contacts on the periphery of the occlusal surface.

Check (C)

It is widely understood that implants need very careful monitoring. It is important that the occlusion is included in this monitoring.

The occlusion needs to be checked as follows:

- Against the record of the pre-existing occlusion; and
- In line with limitations of osseointegration.

It is not only uncommon for the occlusion on an implant-supported crown to change in relation to the heaviness of the contact, but also in relation to the position of the occlusal contact. This is as a result of movement of the antagonistic teeth that is likely because of the light contact build against the crowns at the fit appointment.

Figure 10 (a–e) illustrates how the contact on two implant-supported crowns at sites LR5 and LR6 have become heavier than ideal and in less than ideal parts of the occlusal platform.

Figure 10. (a) Two implants before restoration with lightly occluding crowns in 2003. **(b)** The occlusion on those crowns in 2009; note the heavy incline contact on LR6. **(c, d)** Shimstock can be used to demonstrate the tightness of the occlusal contacts. **(e)** The occlusion adjusted to conform with the guidelines of good occlusal practice in implantology.

Summary

Many of the *rules* of occlusion are based upon the perceived wisdom that has evolved during decades of restoring *natural* teeth. The evidence base for best practice in the restoration of implants is being developed.[26]

In the meantime, this paper has tried to present some simple guidelines for good occlusal practice in implantology by considering the fundamental differences between implants and teeth. It suggests that, by applying these guidelines, dentists can compensate for the limited adaptive capability of the implant-supporting bone, so ensuring that osseointegration is not compromised by an occlusal overload.

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