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Creating Complete Dentures that are Stable in Function

Abstract: Many edentulous people can experience difficulty in carrying out functional activities when wearing complete dentures. This may be due to a number of factors, one of which is the ability to control the dentures effectively during mastication and speech. For this reason, it is critical when constructing complete dentures to incorporate features in their design which will aid stability in function. Usually, the challenges are greater in constructing a prosthesis to replace the missing mandibular teeth. It is recognized that the use of osseointegrated implants offers considerable advantages for people who have to wear complete dentures, and the contribution of implantology to the provision of stable complete dentures will be explored. However, many people will not have the opportunity to experience the benefits of this approach. Furthermore, for people who need to wear conventional dentures, age and other factors may impact on their ability to control the prostheses effectively during oral function. In this paper, the ways in which design features may impact on the stability of complete dentures will be discussed.

Clinical Relevance: This paper considers how complete dentures can be designed and constructed so that they are stable in oral function, and can be worn comfortably without causing damage to the intra-oral tissues.

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It is known that dental health is improving and the proportion of edentulous people in the UK is falling. In the last Adult Dental Health Survey, only 13% of adults were found to be edentulous,[1] a proportion which has dropped considerably over the last 30 years. At first sight these figures appear encouraging. However, in the age group over 75 years, approximately 58% of people are still edentulous[1] and there may be over 4 million people in this age group in the UK. Clearly, there remains a large number of edentulous people, many of whom will not be in the position to have access to more sophisticated options such as dental implants to replace their missing teeth. Furthermore, as people are keeping their natural teeth for longer, they may now become edentulous at a much later age than previously. There is a perception that the ability of these individuals to adapt to this change in dental state could potentially be much more difficult at a later stage of life. However, this is almost certainly an oversimplification since, amongst edentulous people, there may be a wide range of denture wearing abilities. Nevertheless, many people have particular difficulties in relation to the mandibular prosthesis and some may also have problems in wearing the maxillary denture successfully.

People who wear complete dentures will understandably have expectations in relation to function, comfort, aesthetics and self-esteem. Edentulous people who need to wear a set of complete dentures will have to acquire the necessary oro-motor skills to ensure that they can control the dentures during normal functional activities such as mastication and speech.[2] Many edentulous people may experience difficulties in carrying out functional activities when wearing complete dentures. It should be recognized that it is not always possible to understand why some people seem able to manage to control complete dentures much more effectively than others, even when the morphology of the alveolar ridges appear compromised. Furthermore, many clinicians have observed patients who appear to have technically very well constructed dentures that they find difficult to function with, whereas others may still be able to function adequately with dentures that show signs of gross deterioration and which are supported by a poor denture bearing foundation. These observations suggest that there is a wide variation of denture-wearing skills in the population as a whole.

Notwithstanding the observations relating to the wide variation of people in being able to acquire denture-wearing skills, it is nevertheless important when constructing complete dentures to incorporate as many features as possible in their design so that they can be stable in function. In this paper, the ways in which design features may impact on the stability of complete dentures in function will be discussed.

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What is denture stability?

Denture stability has been defined as 'the resistance of a denture to displacement by functional forces'.[3] This statement makes

Poor ridge morphology due to resorption of alveolar bone or surgical removal for conditions such as malignant disease
Fibrous changes in the supporting tissues of the denture bearing area
Localised areas of anatomy which might require special consideration
Compromised muscle control due to ageing or neurological disease

Table 1. Factors that may affect the stability of complete dentures or the ability of a person to function with them successfully.

no reference to how such forces could cause displacement of a prosthesis. Some definitions have suggested that stability relates specifically to lateral (horizontal) or rotational forces causing displacement of the dentures, as opposed to vertical displacement.[4] Indeed, the resistance of a denture to vertical movement away from the tissues has been the usual accepted definition of denture retention.[3] However, during function, there may be forces which act to displace complete dentures away from the tissues in a number of directions. For this reason, it seems reasonable to accept that a functional force, which might displace a denture in any direction relative to the supporting tissues, needs to be considered in relation to designing prostheses that remain stable in function. Therefore, the design of a prosthesis that has satisfactory retention could be considered to be an essential part of constructing a denture which will be stable in function. This will be considered along with other design factors that are essential for denture stability. It is accepted that the factors that contribute to retention and stability are related. Indeed, some authors have suggested that the interaction between stability and retention makes the factors indistinguishable.[5] Furthermore, the underlying support of the denture may also impact on how stable a denture will be in function. Denture support has been defined as the resistance of a denture to occlusally directed loads.[3] For the edentulous patient, such support is derived from the soft tissues of the denture-bearing area and the underlying bone. Again, some of these factors can impact on functional stability. For example, a denture may be well retained owing to an effective border seal. However, this may be easily compromised on occlusal loading during masticatory function when there is a fibrous anterior maxillary ridge, because the post-dam seal can be broken by the tipping of the prosthesis. Therefore, when considering how to design complete dentures that are stable in function, it is necessary to consider all of these factors together.

Factors that affect the stability of complete dentures

There are many factors which might affect the stability of complete dentures in function.[6] Some of these could be related to the design features and overall shape of the prostheses. Other factors may be related to the anatomical form of the denture-bearing area (Table 1). Some of the factors outlined in Table 1 relate to the anatomical features of the mouth and these will be discussed in the context of designing the dentures appropriately to ensure maximum stability.

Design of the prostheses

When considering the management of an edentulous patient in which there may have been problems with an existing set of dentures during function, it is important to have collected sufficient information that should lead to an appropriate diagnosis of what features may be contributing to the real or perceived lack of stability. Therefore, before embarking on treatment, it is necessary to have recorded a succinct history of how the person has managed with any existing dentures. If a set of dentures has been worn successfully, this should indicate to the dentist that at least some of the design features are favourable. Some factors in the medical history (eg neurological conditions such as a previous stroke) may impact on the prognosis for providing a set of complete dentures that can be stable in function (Table 1), as muscle control may be compromised.

A careful inspection of the

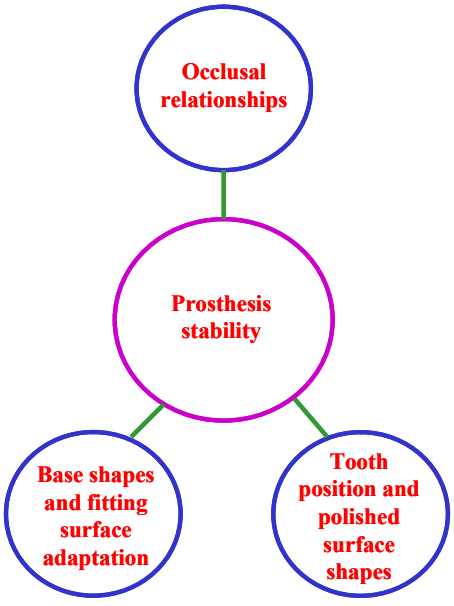


Figure 1. The surfaces of a complete denture where appropriate design may create greater stability.

Labial fraenum
Root of zygomatic arch
Buccinator
Hamular notch
Vibrating line
Palatal rugae
Incisive papilla
Remnants of palatal gingival vestige

Figure 2. Anatomical features related to the maxillary complete denture. A diagram to show the maxillary denture-bearing area and tissue landmarks superimposed on a silicone master impression to indicate how the surrounding muscles may affect the border shapes of the prosthesis. The colour-coded labels indicate the different muscles and tissue landmarks.

patient's oral tissues, as well as the existing dentures themselves, is required. If the patient has previously had complete dentures, it is particularly helpful to identify features that could be incorporated into the new ones (eg an acceptable form to the base shapes).

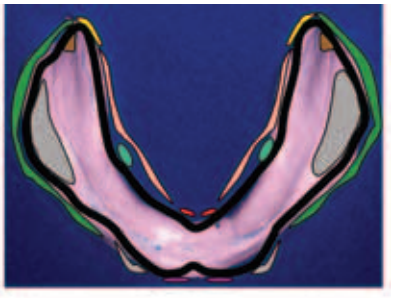
Similarly, attention should be directed to the features of the dentures to which modification may be required. On occasions, it might be necessary to carry out further special investigations such as radiographs or imaging. However, these sorts of investigations would be most likely used when considering additional ways by which prostheses can be made more stable during function, eg dental implants. This will be discussed later. Once the examination has been completed, and a diagnosis has been made in relation to any features which might be contributing to a lack of stability in function, a treatment plan can be formulated. It will be necessary to resolve any localized areas of pathological change in the mouth before the new dentures are constructed, eg the management of conditions such as denture-induced stomatitis.

When thinking about the design of the prostheses, one approach is to consider the different surfaces of the denture, ie base shapes and fitting surfaces, tooth position and polished surface shapes, as well as the occlusal relationships (Figure 1). Features related to each of these surfaces may impact on stability during function and these will be considered separately.

Base shapes and fitting surface adaptation

The fitting surface of the denture is that part which lies in direct contact with the tissues of the denture-bearing area. The shape of the base is also influenced by the soft tissue attachments which might affect the periphery. It follows from this that the master impressions are critical to achieving these objectives. The impression materials themselves should be able to record good surface detail. The impression trays for the master impressions should be optimally extended over the whole of the denture-bearing area. Figure 2 shows the important tissue landmarks in relation to the maxillary denture-bearing area and how these relate to the master impression. A number of muscle attachments may affect the shape of the border and these should be allowed for when the special tray is assessed in the mouth. The posterior border of the maxillary denture is critical for denture retention and is incorporated in the design as a post-dam. The posterior border of the denture should extend to the vibrating line. This is defined as 'the line of junction between the moving tissues of the soft palate and the static tissues anterior to them'.[3] If the posterior border lies short of the vibrating line, an insufficient posterior seal often results. If it extends too far beyond the vibrating line, the seal can be broken when the soft palate lifts during function. For this reason, the vibrating line (sometimes called the 'ah-line') should be examined carefully and the clinician should be satisfied that it has been correctly prepared on the master cast, taking into account the displaceability of the tissue. It should be stated that the use of the term 'line' to describe this region of the tissues is not strictly accurate; it is better described as an 'area'.

The important tissue landmarks in relation to the mandibular denture-bearing area and how these relate to the master impression are shown in Figure 3. Because it is not possible to extend the base across the floor of the mouth, the prosthesis can be more easily displaced in function, and therefore mandibular dentures create greater challenges in relation to achieving stability in function compared to maxillary dentures.



Buccinator
Depressor labii inferioris
Mentalis
Genioglossus
Mylohyoid
Sublingual salivary gland
Superior pharyngeal constrictor / Palatoglossus
Anterior border of retromolar pad
Buccal shelf

Figure 3. Anatomical features related to the mandibular complete denture. A diagram to show the mandibular denture-bearing area and tissue landmarks superimposed on a zinc oxide/eugenol master impression to indicate how the surrounding muscles may affect the border shapes of the prosthesis. The colour-coded labels indicate the different muscles and tissue landmarks.

The retention of a maxillary complete denture may be affected by a number of factors related to the fitting surface. It may not be possible to extend the denture base optimally because of gagging problems that some patients experience. This often affects the posterior seal. Alternatively, anatomical factors may place limitations on what can be achieved. Figure 4 shows the denture-bearing area of a patient with a fibrous ridge in the anterior region of the maxilla. Even though it is possible to achieve a well extended denture base, this tissue may displace on occlusal loading, which would commonly result in the posterior seal of the denture being compromised as the denture sinks anteriorly. There have been techniques described to record an impression of these tissues in specific ways, [7,8] but even then, good stability can still be very difficult to achieve.

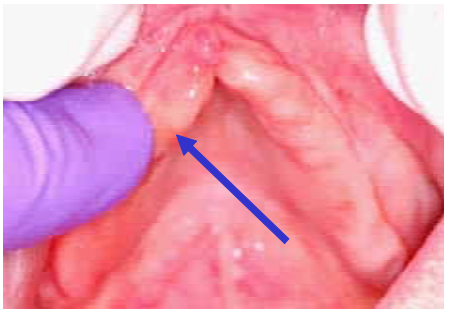


Figure 4. A fibrous ridge results in a decreased stability of the prosthesis because of the lack of support when occlusal loading is applied. Light pressure to the tissues results in considerable displacement (arrowed).

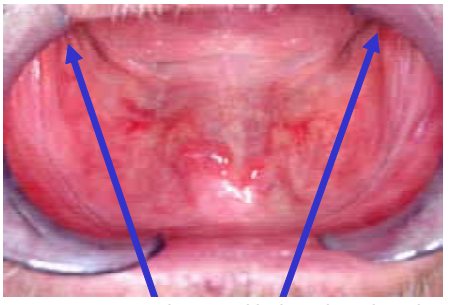


Figure 5. An atrophic mandibular ridge. There has been a large amount of resorption of the alveolar bone which has resulted in the residual ridge becoming very flat. It would be critical to extend the base of the prosthesis into the retromylohyoid fossae (arrowed) to assist the stability of the prosthesis against horizontal displacing movements. Extension of the prosthesis on to the retromolar pads, where the mandible begins to ascend, will also help the denture to remain more stable in oral function.

Stability Feature	Factors to consider
Appropriate level of occlusal table for efficient tongue function	Level of occlusal planes in relation to anatomical landmarks e.g. vermillion border of the lip, retromolar pad. Occlusal vertical dimension and freeway space
Appropriate siting of teeth to allow the tongue to stabilise the mandibular denture	Position of mandibular teeth in relation to the underlying ridge Posterior shelf of the denture
Appropriate siting of teeth to avoid displacement of the denture during masticatory function	Position of teeth to harmonise with muscle function Neutral zone
Contact of occlusal surfaces of the teeth in closing and in lateral and protrusive movements of the mandible	Even and reproducible contact during mandibular closure Balanced occlusion and articulation in eccentric movements of the mandible

Table 2. The ideal features to consider in relation to creating maximum stability by factors related to the tooth position and occlusal surfaces of the complete dentures.

The stability of a mandibular complete denture in function is often not as favourable as the maxillary denture. It has been reported[2] that the mean area of the edentulous maxilla is 22.96 cm^2, whereas in the mandible it is only 12.25 cm^2. The area of support available may be reduced further if there has been a large amount of resorption of the alveolar ridge (Figure 5). The denture may be displaced much more easily by the movement of the tongue and the floor of the mouth in function. Furthermore, other muscles, such as the mentalis, may cause denture displacement when the ridge is atrophic. It is critical that an optimum base shape is therefore achieved. The retromylohyoid fossae (also referred to as the lingual pouches) may be a critical area to extend the lingual flanges to aid the denture stability (Figure 5). Furthermore, it is important for optimal stability to extend the prosthesis on to areas of the tissues that are most able to support occlusal loading. For the mandibular denture, the buccal shelf area (Figure 3) is critical for this.

Tooth position and polished surface shapes

The correct positioning of the

artificial teeth will be critical to achieving stability in function.[9] Inappropriate siting of the denture teeth can result in the prostheses being displaced easily during function, particularly the mandibular denture. Some of the factors that are important in achieving maximum stability by correct positioning of the teeth are shown in Table 2.

To optimize efficient tongue function, the occlusal planes of the dentures should both be positioned at an appropriate level.[10] The positioning of the upper occlusal plane is usually carried out by modification of an occlusal rim so that the appropriate amount of tooth is shown and the occlusal plane orientation is parallel with the inter-pupillary and ala-tragal planes. For the mandibular denture the assessment of the height of the occlusal plane often needs to be looked at very specifically. The tongue should be able to rest on the occlusal surfaces of the mandibular denture which aids stability. Clearly, the height of the occlusal planes of both of the dentures must also be related to an assessment of the occlusal vertical dimension and the need to create an adequate freeway space.

Inappropriate positioning, particularly of the mandibular denture teeth, can result in instability. For example, if wide posterior teeth are overhanging the lingual aspect of the ridge, the prosthesis can be easily displaced by the action of the tongue in oral function (Figure 6a). Simply reducing the bucco-lingual width of the posterior teeth can help in achieving improved stability. In relation to the anterior teeth, when there has been significant alveolar resorption, the necks may have to be sited close to the crest of the residual ridge so that the prosthesis will not be easily displaced by the action of the lips or a prominent mentalis muscle. The angulation of the anterior teeth will also need to be considered so that there is not a restricted area created for the tongue to move in function without the prosthesis being easily displaced. The posterior teeth should be placed in a region where there is no danger of them being lifted by the lateral border of the tongue during function. Furthermore, the omission of one or more of the posterior teeth allows the creation of a posterior shelf on which the tongue can rest to help stabilization of the denture (Figure 6b).

The polished surface of the denture extends from the borders of the base to the artificial teeth. It includes the shape of the palate as well as the buccal and lingual surfaces of the acrylic in contact with the lips, tongue and cheeks.[6] For this reason, these parts of the prostheses should be appropriately shaped to allow the action of the surrounding muscles to harmonize with the denture shapes. Areas such as the labial (eg mentalis muscle) or lingual (muscles of the tongue) polished surfaces of the mandibular denture may need to be shaped specifically to allow muscle function to take place in a way that will not result in displacement of the prosthesis. Other areas of the polished surface shape may impact on different functions, eg the palatal vault of the maxillary denture in relation to speech.

The term 'neutral zone' is often used to describe the siting of the artificial teeth in an area in which stability is optimized. This can usually be achieved by the clinician and technician following the guidelines outlined above. However, on occasions it may be necessary to record an impression of this zone to allow optimal positioning of the artificial teeth and the correct shaping of the polished surfaces.[11] This can be carried out by constructing a rigid denture base with occlusal stops placed at the correct vertical dimension. A tissue conditioner (*Coe Comfort*, GC America Inc, Alsip, IL 60803, USA) is a suitable material to record a functional impression which will indicate the size of the neutral zone. The denture teeth are then shaped and sited to harmonize with this, and the polished surfaces are also shaped so that they lie within this defined zone. The resulting teeth may well be very narrow but as they are placed in an optimum position for stability, the patient may be able to control the denture during function more effectively (Figure 7).

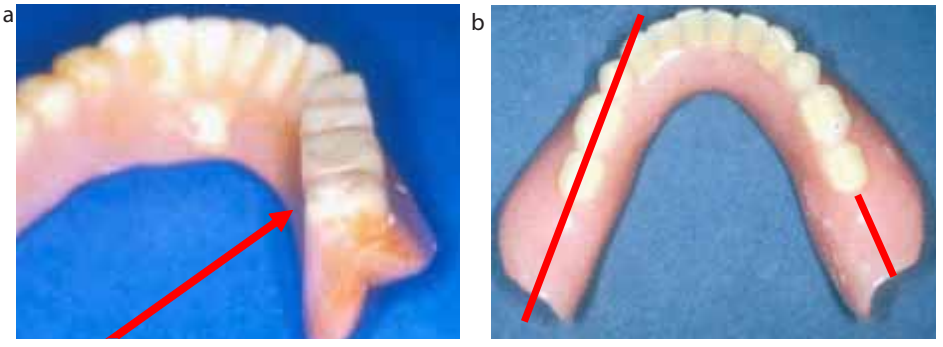


Figure 6. The effect of tooth width, position and polished surface shape on the stability of a mandibular complete denture: **(a)** the arrow shows wide posterior teeth that overhang the lingual aspect of the alveolar ridge making the denture susceptible to displacement during mastication by the action of the tongue; **(b)** the use of narrow posterior teeth placed on the crest of the ridge shown by the line on the left side. The creation of a posterior shelf shown on the right side allows the tongue to assist with the stability of the denture.

Occlusal relationships

The occlusal surface of the denture is the part which makes contact with the same surface of the opposing denture.[6] For optimum function the dentures should be constructed at the correct vertical dimension, ensuring that an adequate freeway space is present. The vertical dimension of the dentures in occlusion is dependent on how the artificial teeth are sited and therefore the level of the occlusal plane on each prosthesis is related to this. This has been discussed in an earlier section.

It is important that, on normal closure of the mandible, the contacts of the teeth are even on both sides and there are no localized interferences in the occlusion. Furthermore, an occlusal scheme in which there is a balanced contact of the posterior teeth on both sides during lateral and protrusive movements of the mandible has usually been considered desirable.[7] A detailed discussion of how such schemes are established cannot be covered in depth in this article and so the reader is referred to a further source of reference where this is explored in more detail.[12] It should be stated, however, that a view has emerged from reviews of the published literature that occlusion does not necessarily have a major role in the success or failure of complete dentures, since other psycho-social factors have been considered to be more important.[13]

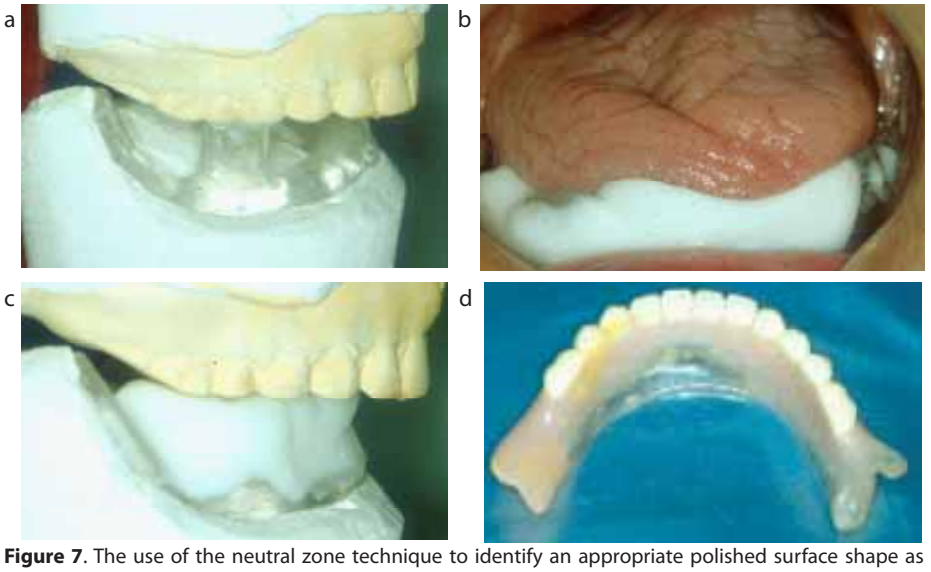


Figure 7. The use of the neutral zone technique to identify an appropriate polished surface shape as well as the area in which the teeth should lie to optimize the stability of the prosthesis. This might be indicated in patients who may not be suitable for implant treatment and who have compromised tongue function: **(a)** a rigid base on which occlusal stops have been placed to ensure the impression is recorded at the correct vertical dimension; **(b)** the impression material in the mouth; **(c)** the completed impression outlining the zone where teeth can be placed; **(d)** the completed denture showing the very narrow width of the neutral zone and the polished surface shape that has been defined.

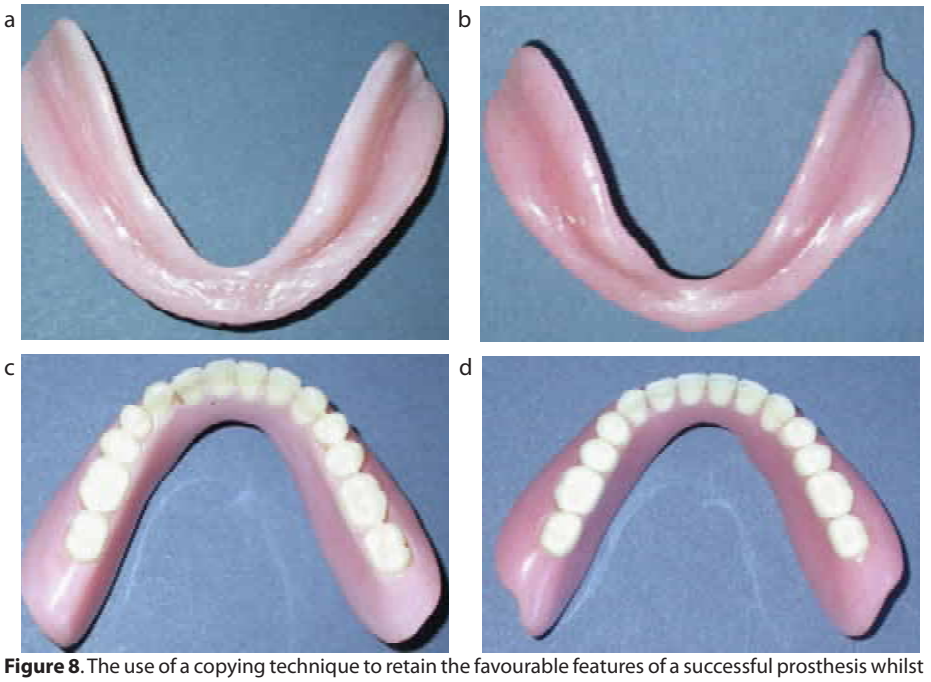


Figure 8. The use of a copying technique to retain the favourable features of a successful prosthesis whilst addressing the design features that need to be changed to optimize the stability of the replacement prosthesis: **(a)** the base shape of the original denture; **(b)** the base shape of the replacement denture; **(c)** the occlusal and polished surfaces of the original denture; **(d)** the occlusal and polished surfaces of the replacement denture.

Change and adaptation

When replacing complete dentures that have been worn successfully it is important to give some thought as to how the patient will adapt to any new shapes or design features. This involves an assessment of the changes that need to be made to overcome some of the limitations or deterioration that has taken place with the original dentures. However, making large changes to specific design features may result in the patient not being able to control the new dentures as effectively as the originals, which will lead to instability. One way in which some design features can be retained on replacement dentures is by the use of copying techniques. These permit favourable features to be incorporated into the replacements and the dentist can also make controlled modifications to those features that are judged to be unfavourable. These are described in detail elsewhere.[14-18] The construction of complete dentures that are similar in many features to those that have been successfully worn may mean that the patient adapts more readily to these and this may help with the stability (Figure 8).

Osseointegrated implants and complete dentures

The rapid development of dental implantology has had significant impacts on edentulous people who experience problems functioning with complete dentures. These can be placed in conjunction with prostheses that are removable (Figure 9). Indeed, so successful is this treatment modality judged to be that an international consensus statement has recommended that two implants and a removable prosthesis (as shown in Figures 9a, b) should be used as a first line approach for the management of patients with an edentulous mandible.[19] Fixed bridgework supported on dental implants is an alternative line of treatment but this will not be considered further in this article.

A removable implant-supported denture will be more stable than a conventional prosthesis because of the opportunity to have direct mechanical retention with the implant itself. This can be achieved by means of studs, bars or magnets of a variety of designs. Some attachment systems are likely to offer better stability than others in relation to forces that might displace a denture in a horizontal direction (eg bar and sleeve – Figures 9c,d). However, a decision on the type of attachment system used will not just be made on this factor as there are many other issues to be considered here, such as the type of implant system and long term maintenance. It should be emphasized that,

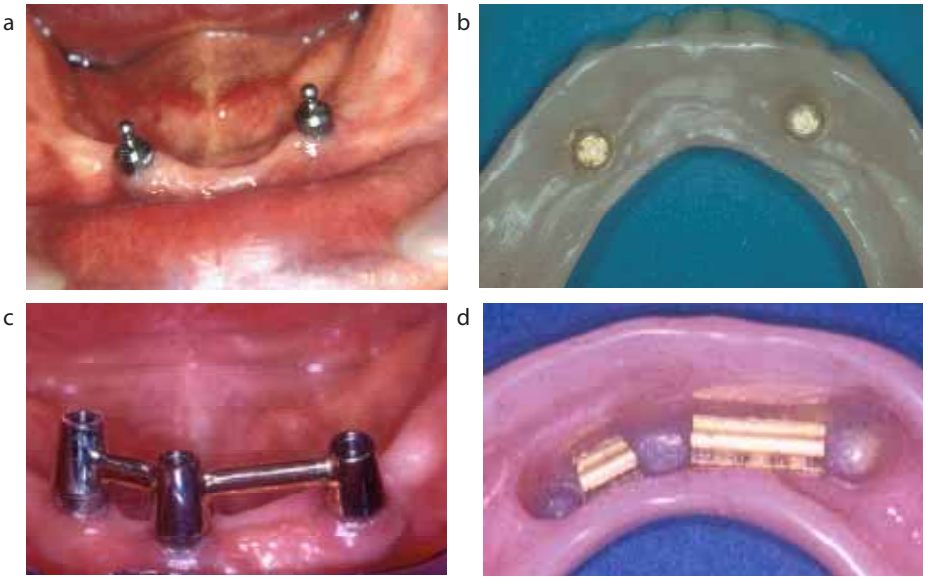


Figure 9. The use of osseointegrated implants has had a major impact on assisting people who have difficulties in controlling complete dentures: **(a)** mandibular implants carrying retentive anchors (studs) to which the denture is attached; **(b)** the clips in the mandibular prosthesis; **(c)** mandibular implants and a bar to which the denture is attached; **(d)** the sleeve in the mandibular prosthesis.

although the use of implantology will mean that the fitting surface of a denture will be optimally stabilized, it is important that the features of the other surfaces of the denture are designed appropriately for maximum stability during function. The reader is referred to other sources of reference for an introduction to these procedures.[20]

Conclusions

It is important to consider the features required to create optimum stability for a patient who has to wear a set of complete dentures. One of the challenges in considering an area such as denture stability is the availability of evidence to support the concepts discussed. Carlsson has stated that there are real limitations when attempting to find strong evidence from randomized controlled trials for the most appropriate methods that are used in complete denture fabrication.[13] However, it would seem sensible that careful attention is required in relation to identifying the critical aspects of denture design to achieve optimum stability during function. Although dental implantology has the potential to improve the stability of complete dentures dramatically, in reality many edentulous people will never have the opportunity to experience this because of health or financial constraints. For this reason, and because there remains a significant number of elderly edentulous people who are living longer than in the past, there is still a place for designing and constructing complete dentures that can be as stable as possible during masticatory function.

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