Bridge design, part three: fixed-fixed bridgework

By Dr Paul A Tipton, BDS, MSc, DGDP (UK)

Having previously discussed bridge failure and fixed-movable bridgework, Paul Tipton now turns his attentions to fixed-fixed bridgework in the third part of his series

Ante in 1926 proposed his law for bridge design that 'the total periodontal membrane area of abutment teeth should equal or surpass that of the teeth to be replaced'. This law has been used to plan and design fixed-fixed bridgework ever since.

Schwartz (1970), however, was one of the first to question this when he concluded that the introduction of a secondary or double abutment causes a greater incidence of cementation failure.

OCCLUSAL FORCES

Schwartz (1970) looked at the life span of various bridge designs related to the type of opposing dentition. He found that because of the reduced forces of occlusion, bridges lasted longest when opposed by complete dentures (Figure 1), in agreement with Boucher (1964) and Tylman (1965). Lundgren & Laurell (1986), investigating occlusal force patterns during chewing in dentitions restored with fixed bridgework, showed that the choice of chewing side is probably conditioned by the number of teeth and amount of periodontal support between the two sides. During chewing, on average only 37% of the total maximum bite force was utilised. They concluded that periodontal tissues can withstand transient occlusal forces which are much larger than those generally operating during chewing.

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OCCLUSION

In general, an intercuspal holding contact should be incorporated into all units of the bridgework, including a lighter one on the pontic. The pontic, however, should have no lateral or protrusive guidance where possible. These forces should ideally be taken up by the abutment teeth in order to keep the loading nearer to the long axis of the tooth. Where this is impractical the guidance should be placed as near as possible to the abutment teeth to reduce torsional forces even though they may have to be on a pontic.

Figure 1: A 10-unit lower bridge supported by two canines opposed by a complete denture

To comply with this there may be a compromise in aesthetics. Figures 2 to 7 illustrate the case of lower central and lateral incisor and canine pontics retained by the first premolar abutments. The incisal edges are all of a similar length and shorter than the premolars to allow guidance to be taken up by the abutment teeth (first premolars) and the second premolars at the start of guidance and only progressively coming onto the canines (nearest the abutments) and then incisors at the end of the movement. It is known that bruxing forces are greatest at or near the intercuspal position and less towards the extremes of movement and edge-to-edge position.

By designing the occlusion in this way the forces of bruxism can be reduced. A prerequisite of this style of extensive bridgework is that the dentist should have control of the whole occlusion and both dentist and technician should con-

TABLE 1: YEARS OF SERVICE OF VARIOUS LENGTH BRIDGES

Six Unit Canine to Canine	15.3 years
Two Unit Anterior Cantilever Two Unit Splint	14.9 years
Single Crown	9.1 years
Six units or More (Not Including Canine-to-Canine)	8.6 years

Figure 2: Patient wearing partial dentures

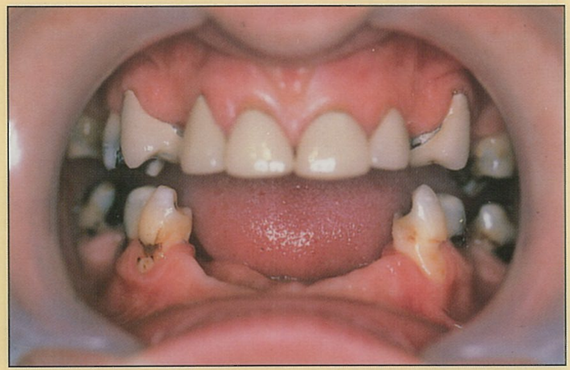


Figure 3: Edentulous spaces

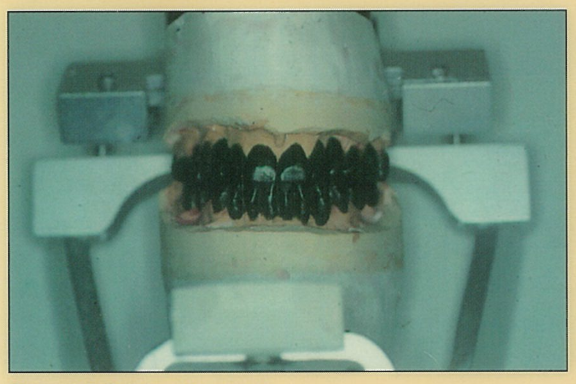


Figure 4: Full diagnostic wax-up

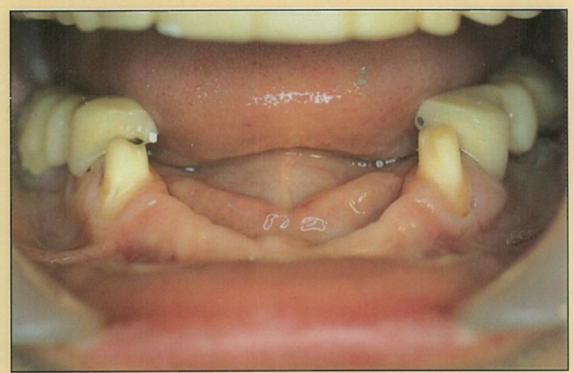


Figure 5: Temporary posterior restorations in place and final preparations for the eight-unit anterior bridge supported by two premolar abutments

Figure 6: Lingual view of final restoration

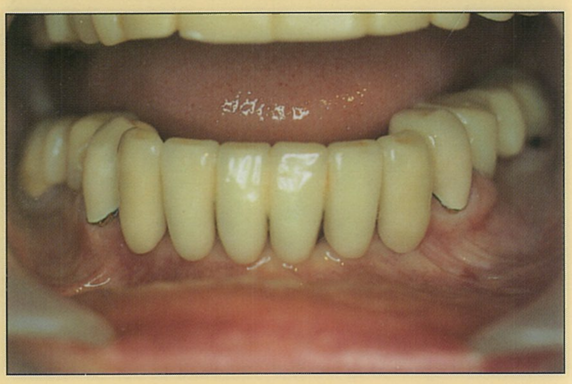


Figure 7: Labial view of final restoration showing occlusal plane lower on the pontics than the abutments in order to gain correct anterior guidance

firm this by a diagnostic wax up.

LENGTH OF BRIDGE SPAN

There appears to be no apparent relationship between years of service and the length of the bridge span. Schwartz (1970) showed that long span bridges averaged at least as many years of service as shorter bridges and often more than single crowns.

His results are summarised in Table 1 (on the previous page).

It would appear then that the two most successful styles of bridge are the six-unit canine to canine bridge and the two-unit cantilevered bridge.

Taking the Schwartz study into consideration and that of Roberts (1970) on the poor success rates of bridgework with posts allows certain criteria for bridge design. This will be further discussed in following articles. In Figures 8 to 13 the root filled lateral incisor tooth is removed rather than having a post incorporated in the bridge and allows successful planning of the longest lasting style of bridge according to Schwartz (six unit canine to canine).

MOBILITY

Care must be taken however if one abutment in the bridge shows increased mobility. If one abutment has increased

Figures 8 to 13: The removal of the upper left lateral incisor which had previously not been filled. This has a poor prognosis if incorporated into a fixed bridge. This tooth was therefore extracted and a six-unit canine to canine bridge inserted with pink porcelain for lip support where the previous denture flange was present. This type of bridge has an excellent prognosis

mobility and is splinted to another abutment of normal mobility, high torquing forces are placed on the cement lute of the less mobile tooth when the mobile tooth is loaded.

This in turn can lead to loss of cementation on the non-mobile abutment. This problem can be overcome by a change in bridge design, increasing the retention on the non-mobile tooth or show the removal of the mobile tooth (Flood, 1989).

RETENTION

Shillingburg has stated in his textbook 'Fundamentals of Fixed Prosthodontics' that the ideal taper for a preparation is 6° (Figure 14). This, however, may be very difficult to achieve and when reviewing his own preparations Shillingburg himself found his average taper to be nearer to 14°. Bridges usually come uncemented due to forces from a mesio-distal direction, as opposed to single crowns, which become dislodged more often by bucco-lingual forces. For increased bridge retention, therefore, grooves, boxes or other forms of extra retention should be placed into the preparations buccally or lingually to resist this mesio-distal dislodgement. The use of mirrors and devices such as the parallel-o-prep (Try-Care) (Figure 15) considerably help the dentist achieve the required retentions. For single crowns grooves should be placed mesially and distally, ideally in tooth tissue. Should the grooves be placed in amalgam then the extra retention gained in the crown is transferred to the retention of the amalgam and often in these cases the retention of the amalgam is poor. This can be increased by 'bonding' the amalgam to the tooth prior to crown preparation.

Tjan (1981) discussed that the premature loosening of the distal retainer in fixed-fixed bridgework was due to the mesial tilting movement seen when teeth are placed under occlusal load. A very slight mesial-angular movement of the anterior abutment under occlusal loading may produce a considerable

Figure 14: The ideal taper for a preparation - 6° (Shillingburg, 1981)

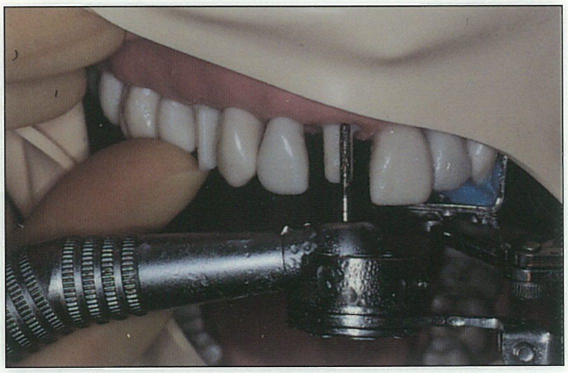


Figure 15: The use of mirrors and devices such as the parall-o-prep (Try-Care) helps the dentist achieve the required retention and parallelism

amount of unseating displacement in the distal retainer. This in turn can produce considerable strains in the cement lute and cause premature cementation failure. This stress will be directly proportional to the length of span and degree of flexure in the bridgework. As span length increases so does the radius of curvature of the unseating force. The longer the span means that the unseating force becomes closer to the vertical. This in turn puts more emphasis on the resistance and retention form of the distal aspect of the posterior retainer. This aspect is often the most difficult surface to prepare with an adequate taper (Kent and Shillingburg 1988). Occlusal loading on the distal abutment causes mesial movement of the bridgework, but the effect on the anterior abutment is compressive, placing considerably less strain on this cement lute. Tjan therefore suggested grooves were essential in the buccal or lingual surfaces of the posterior abutment in fixed-fixed bridgework, to resist these stresses placed parallel to the mesial surface of the preparation (Figures 16 to 20). Added retention can be gained from incorporating mesial, distal, buccal, lingual and occlusal retention features - but seating may now be more difficult (Figure 21).

Figure 16: Preparation for a fixed five unit bridge and model incorporating silver dies

Figure 17 (left): Palatal retention groove to stop unseating forces on the silver plated die

Figure 18 (right): Five unit bridge on the model

Figure 19 (left): Fitted five unit bridge (side view)

Figure 20 (right): Fitted five unit bridge (front view)

MULTIPLE ABUTMENTS

Ante's law suggests the use of 'double abutments' to increase the retention of a bridge. This can lead to increased complications with cementation failure, however, due to complex stress patterns incorporated in the bridgework (Schwartz, 1970) and the introduction of the 'pier' abutment (Shillingburg, 1981). Due to the pier abutment's potential to act as a fulcrum, it sets up considerable and complex stress patterns in neighbouring abutment teeth, often placing the retainers in tension and overstressing the cement lutes. For this reason, where possible, bridge spans should be limited to one abutment at either end (Figures 22 to 26). Incorporating extra abutments requires a great deal of technical expertise on the part of the clinician as retention and resistance form must not be compromised.

CAST AND SOLDERED JOINTS

Bridger (1981) showed that shrinkage occurs during the addition of porcelain onto the metal framework of the bridge. This shrinkage during the porcelain firing cycle can lead to distortion of the metal framework causing open margins on bridge retainers and an increase in bridge failure rates. This is especially relevant in longer span bridgework where this distortion is magnified. The maximum distortion occurs on the distal margin of the posterior retainer and on the mesial margin of the anterior retainer. Most of the warpage occurs during the degassing stage and the glazing stage.

In order to minimise these problems several techniques have been recommended such as post-ceramic soldering, coping bridges, splitting long span bridgework up into smaller fixed-movable sections, thickened metal shoulder bevel margins, metal occlusal surfaces, and all metal bridges. Schiffleger (1985) has also shown that it is very difficult to cast a long

Figure 21 (left): Added retention from mesial and distal boxes, buccal and lingual grooves and occlusal inlay prep

Figure 22 (right): Example of a six unit bridge preparation when only one abutment is used at each end of the span - occlusal view

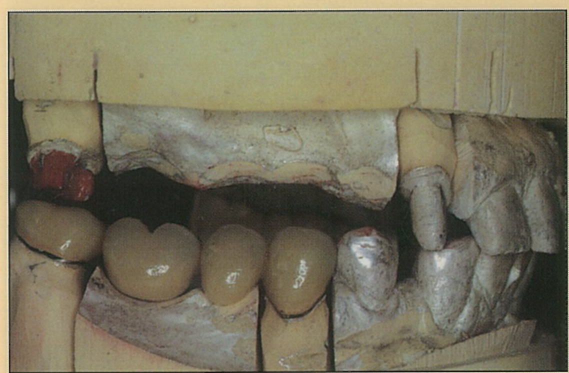


Figure 23 (left): Buccal view

Figure 24 (right): Six unit bridge on the master model

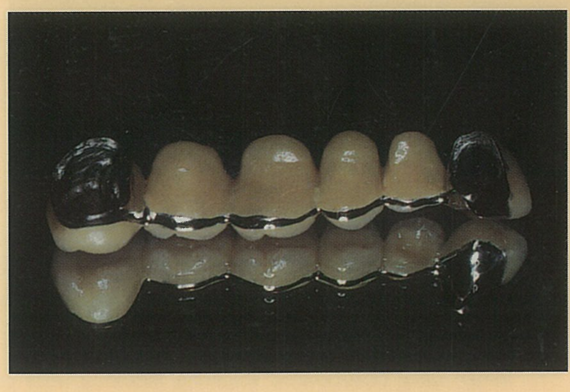


Figure 25 (left): Undersurface of the bridge - showing thickness of metal

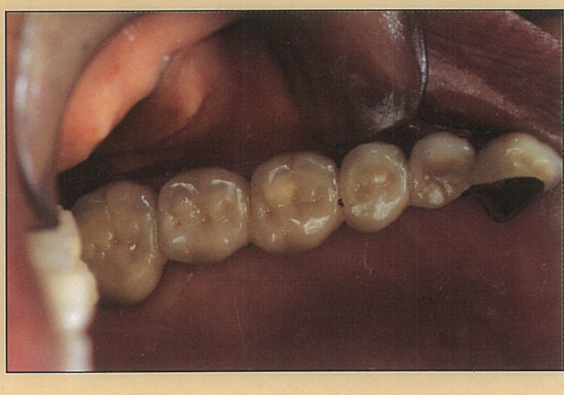


Figure 26 (right): The bridge cemented in situ

Figure 27 (left): Mobile abutments being prepared for full arch bridgework (front view)

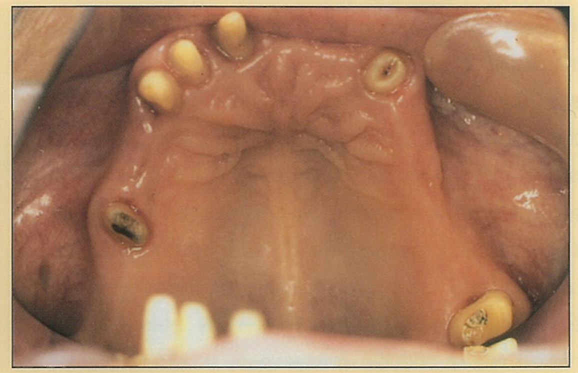


Figure 28 (right): Occlusal view

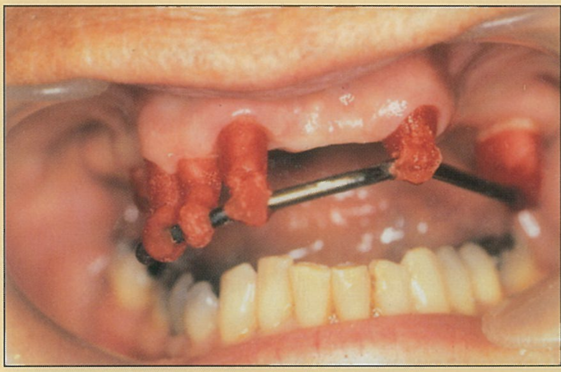


Figure 29 (left): Duralay copings placed and connected with coathanger wire (front view)

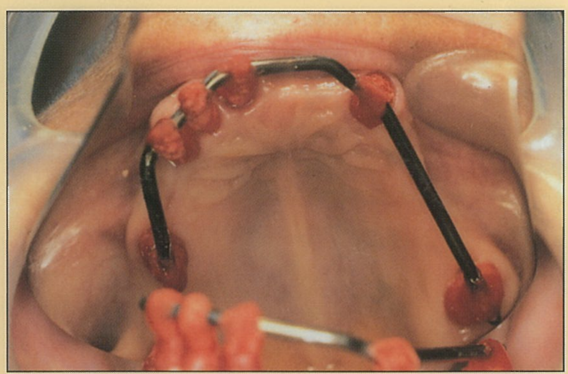


Figure 30 (right): Occlusal view

Figure 31 (left): Pick up impression of the copings and coathanger wire

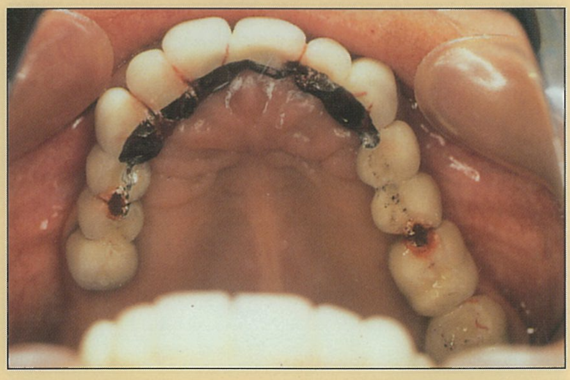


Figure 32 (right): Individual units 'duralayed' together in the mouth

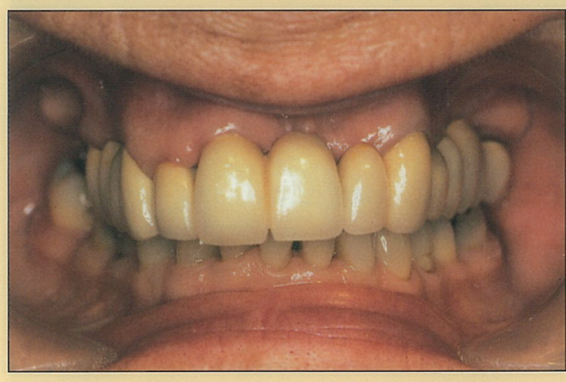


Figure 33 (left): Final fixed bridge (front view)

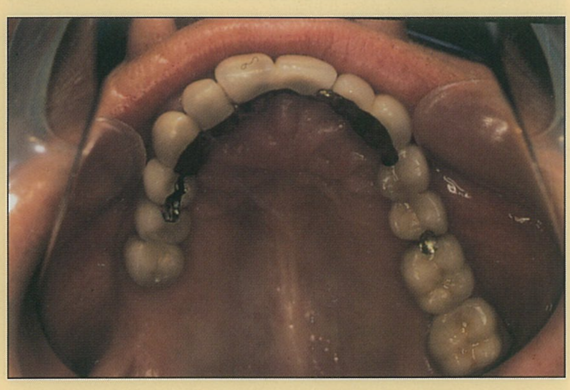


Figure 34 (right): Occlusal view showing soldered joints

span metal casting in one piece and assure accuracy of fit. Sectioning and soldering the metal framework gave more accurate castings. He demonstrated that post-ceramic soldering gave less marginal distortion than cast joints in long span bridgework. Although Smith (1986) suggested that cast connectors were stronger than soldered ones, radiographic examination has revealed possible porosities in the cast joint which could lead to a much weaker joint.

When using post-ceramic soldering, individual units of bridgework are tried in the mouth; fit, retention and occlusion are checked and altered before using an index in the mouth to pick up the bridge and finally solder the units together. In this way porcelain shrinkage and distortion of the metal framework can be kept to a minimum. Figures 27 to 34 show a case where post-ceramic soldering is used in conjunction with duralay copings and a pick-up impression to restore a full arch of mobile abutments. Without the use of the copings and the pick-up impression it would be impossible to take an accurate impression of the mobile abutments.

MATERIALS

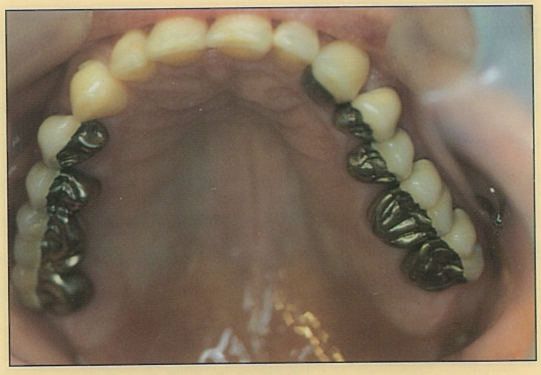
Although it cannot be categorically stated that glazed porcelain is biologically the best material to be placed next to the mucosa, some authors have demonstrated this to be true (Wise, 1975; Clayton, 1970), whilst other studies have been equivocal (Stein, 1966; Podshadley, 1968).

PORCELAIN

Although porcelain produces the optimum aesthetic effect, every restoration also has a functional dimension which is very often overlooked. Porcelain surfaces will limit the clinician's control over occlusal anatomy in certain circumstances, leading to unnecessary wear of the natural or restored opposing teeth. Porcelain is a harder material than tooth enamel and, therefore, if wear occurs between the two opposing surfaces it will be at the expense of enamel. A history of parafunction (Pameijer, 1985) and severe loss of clinical crown height from attrition or erosion may contraindicate the use of porcelain on the occlusal surfaces. The use of porcelain on the occlusal surfaces of bridgework often also results in over contouring of the interproximal spaces, leading to possible periodontal problems (Pameijer, 1985). The use of low fusing porcelain (Ducera) has recently shown better wear characteristics than traditional porcelains.

METAL

As a general rule, if the opposing dentition is natural or metal, the bridge occluding surfaces opposing it should ideally be in metal (Figures 35 and 36). Where the opposing dentition has already been restored in porcelain, the occluding surfaces of the bridge should be restored with the same material. This can be alternated where there are several differing types of opposing tooth material. In the anterior region porcelain must be carried over the incisal edge and onto the palatal surface to allow porcelain support and good aesthetics. This should be kept to a minimum, however, in order to reduce the likelihood of wear taking place on the natural lower incisor as it contacts the porcelain during excursive movements.



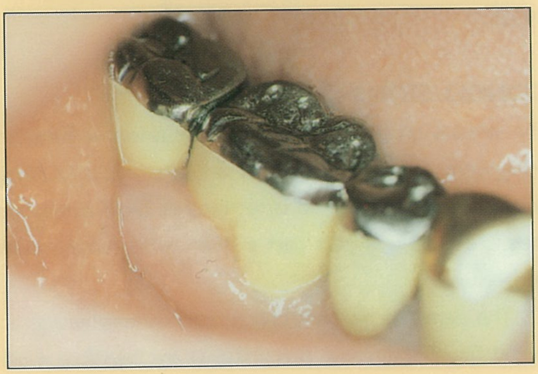


***Figure 35 and 36:** If opposing dentition is natural or metal, the bridge occluding surfaces opposing it should ideally be in metal*

In order to keep the porcelain to a minimum but not to weaken the incisal edge the restoration should first be waxed to full contour and then cut back by the technician to the shape of his desired metal framework. The alternative used by many technicians is to place the die in a bath of moulton wax to give an even thickness of wax for the metal coping. This does not allow for the correct porcelain support before casting.

Foster (1990) showed that an increase in the porcelain content of bridgework, whilst producing a more aesthetic and rigid bridge, can produce additional reasons for bridge failure. These include over-preparation that causes future pulpal problems and technical failures due to poor laboratory techniques. Foster also found that an increase in the gold content of bridgework resulted in an increase in its longevity (Figure 37).

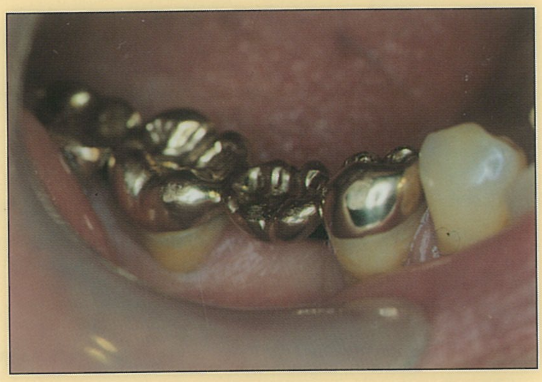


***Figure 37:** Foster (1990) found that an increase in the gold content of bridgework resulted in increased longevity*

ACRYLIC

Nyman and Lindhe's studies on periodontal prostheses used acrylic bonded to gold or metal occlusals as their materials of choice. This combination is also used by many traditional Swedish implant teams as the material of choice when using restorations involving implants as retainers. It is suggested that there is a greater shock absorbency when using acrylic and any detrimental occlusal loading can be dissipated this way. However, porcelain will produce a more rigid bridge which in turn will allow less flexing and less stress on the very important cement lute, especially during static loading or clenching (Davis 1998).

CONCLUSIONS

The stresses on the cement lutes of retainers in fixed-fixed bridgework are far greater than on other types of bridge design because there is no stress breaker. Tooth preparation therefore plays a greater part in the overall success of the bridgework.

The demands on both patient (crown lengthening) and dentist (parallel, retentive preparations) are therefore greater and the overall success rates often poorer.

Fixed-fixed bridgework is the usual choice of bridge design for long-span bridges of five units or over except in certain situations which may include non-parallel preparations, and posts as abutments, where fixed-movable or coping designs may be used.

The next article in this series will concentrate on the aesthetic principles of fixed bridgework.. ■

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