Clinical methods for evaluating implant framework fit

Joseph Y. K. Kan, DDS,[a] Kitichai Rungcharassaeng, DDS, MS,[b] Khaled Bohsali, DDS,[c] Charles J. Goodacre, DDS, MSD,[d] and Brien R. Lang, DDS, MS[e]
School of Dentistry, Loma Linda University, Loma Linda, Calif., and School of Dentistry, University of Michigan, Ann Arbor, Mich.

Statement of problem. *Passive fit* of implant-supported–prosthesis frameworks has been suggested as a prerequisite for successful long-term osseointegration. However, there are no scientific guidelines as to what is *passive fit* and how to achieve and measure it.
Purpose. The purpose of this article is to discuss passive fit and to review the various clinical methods that have been suggested for evaluating implant framework fit.
Methods. The dental literature was reviewed to identify the clinical methods that have been used to evaluate implant framework fit.
Conclusions. The suggested levels of passive fit are empirical. Numerous techniques have been advocated to evaluate the prosthesis-implant interface, but none individually provides objective results. It is suggested that clinicians use a combination of the available methods to minimize misfits. (J Prosthet Dent 1999;81: 7-13.)

CLINICAL IMPLICATIONS

Implant components and bone appear to tolerate a degree of misfit without adverse biomechanical problems. The level of this misfit has yet to be determined. In the absence of such quantitative fit guidelines, it seems appropriate to optimize fit by using the available clinical methods described in this review to evaluate implant framework fit.

Achieving a *passive fit* between implant frameworks and underlying structures is critical for successful long-term osseointegration.[1] Ill-fitting implant frameworks may cause mechanical failures of the prostheses, implant systems, or biologic complications of the surrounding tissue.[2] Mechanical complications may include loosening of the prosthetic and abutment screws or fracture of various components in the system (Fig. 1).[3-6] Biologic complications may include adverse tissue reactions, pain, tenderness, marginal bone loss, and loss of integration (Fig. 2, *A* and *B*).[7-11]

As in conventional fixed prosthodontics, the cause of fixed implant-supported framework misfit is usually multifactoral.[12-14] Distortions can occur in the x-, y-, and z-axis dimensions,[15,16] and may be introduced by one or more of the following factors: implant alignments, impression techniques and materials used, process of framework fabrication, framework design and configuration, and clinician/technician experience.[16-19] Moreover, distortions tend to increase with increasing prosthesis span length.[20] One-piece castings of multiple-unit conventional fixed partial dentures (FPDs) are technique sensitive and a certain degree of distortion (approximately 100 μm) is inevitable.[14,21] Therefore the use of different impression techniques,[22-24] verification jigs,[17,25,26] low fusing metal casts,[27] casting frameworks in sections, and master reference casts[28] have been suggested to mini-

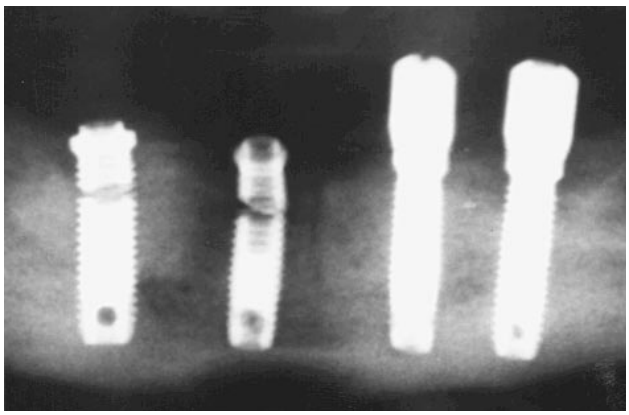

Fig. 1. Radiograph of mechanical implant fractures.

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[a]Assistant Professor, Department of Restorative Dentistry, School of Dentistry, Loma Linda University.
[b]Assistant Professor, Department of Restorative Dentistry, School of Dentistry, Loma Linda University.
[c]Former Resident, Advanced Education in Implant Dentistry, School of Dentistry, Loma Linda University.
[d]Professor and Dean, School of Dentistry, Loma Linda University.
[e]Professor, School of Dentistry, University of Michigan Ann Arbor, Michigan.

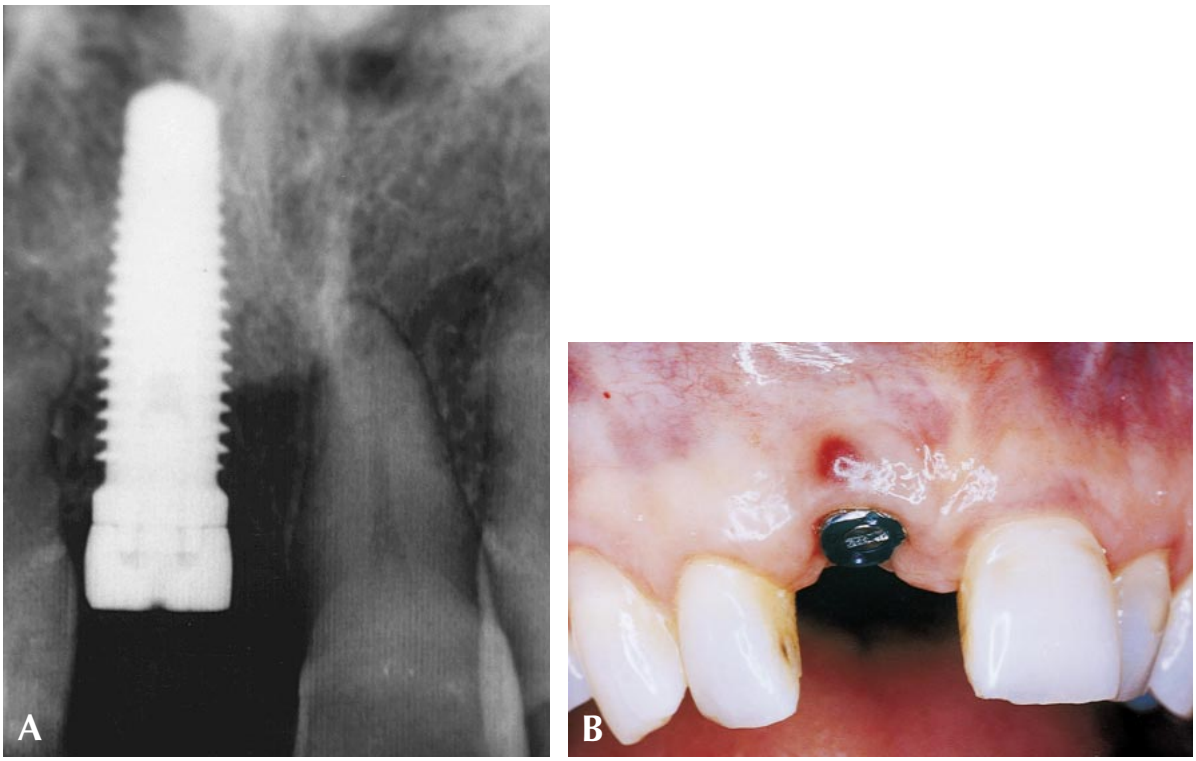

Fig. 2. A, Radiograph of incompletely seated provisional component that caused **B**, adverse tissue reaction.

mize misfits during framework fabrication. Sectioning and soldering the framework can improve some discrepancies, but still may not create an absolute fit.[14] Some clinicians have suggested using the KAL technique (Attachments International, San Mateo, Calif.)[29,30] or the Preci-disc prosthetic system (Alphadent, Antwerp, Belgium),[31] in which a cement medium is used to compensate for any misfits. Recent laboratory studies had shown that intraoral luting of frameworks may decrease the strains produced in the bone around implants[32,33]; however, there is no documentation of long-term success for such treatments. Therefore the final clinical fit of a framework depends on the methods used and the experience of the technician/clinician team.

The purpose of this article is to attempt to define *passive fit* and to review the various clinical methods that have been suggested for evaluating implant framework fit.

ACCEPTABLE LEVELS OF FIT

Many authors have attempted to define an acceptable level of implant prosthesis fit.[1,34,35] In 1983, Brånemark was the first to define *passive fit* and he proposed that it should exist at the 10 μm level to enable bone maturation and remodeling in response to occlusal loads.[1] In 1985, Klineberg and Murray[34] suggested that castings with discrepancies greater than 30 μm over more than 10% of the circumference of the abutment interface were unacceptable. In 1991, Jemt[35] defined passive fit as a level that did not cause any long-term clinical complications and suggested misfits smaller than 150 μm were acceptable. It was proposed that an unacceptable level of framework misfit existed when greater than half-a-turn was needed to completely tighten the gold screw after its initial seating resistance was encountered.[35] Although the preceding values were reported and subsequently highly quoted, they are of empirical origin.

FACTORS AFFECTING FRAMEWORK FIT EVALUATION

The accuracy and validity of clinically evaluating framework fit can be affected by factors such as implant number and distribution, framework rigidity, ability of the screw to close the gap, and/or margin location. Clelland et al.[36] demonstrated that marginal gaps up to 500 μm for 2-implant frameworks were not detectable with an explorer when the framework screws were tightened to 10 Ncm, which suggests that passive fit may appear to be present because screw tightening has closed a gap. However, the fit of the casting becomes more critical as the number of implants and framework rigidity increases, and the prosthesis span decreases.[11] A significant force can be induced when a framework with clinically acceptable fit is connected without functional

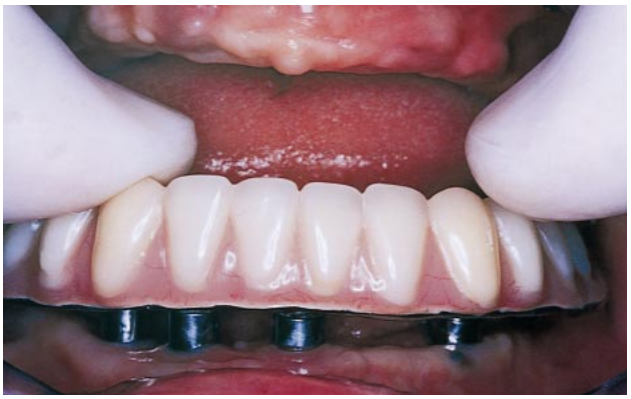

Fig. 3. Alternate pressure technique. Pressure applied in apical direction, alternately to one thumb and then other to determine if rocking movement occurs with prosthesis.

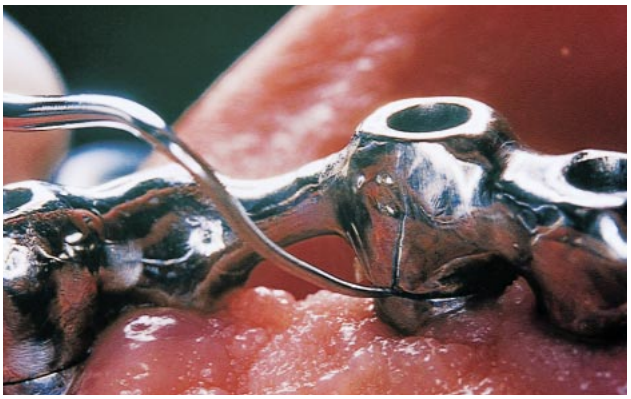

Fig. 4. Direct vision and tactile sensation with explorer being used to validate difference in fit of component or framework.

load.[37] This force may be related to the fit and to the stiffness of the framework, and a rigid casting may cause higher stress levels than a flexible framework for exactly the same degree of misfit.[35] Millington and Leung[38] introduced 55 μm discrepancies in an intermediate abutment in a model with 4 implants and showed that the screw joint failed to close at 10 Ncm. Anterior restorations that, more often than not, demand subgingival margins for maximum esthetics may also hinder the effectiveness of framework fit evaluation.

The keenness of eyesight, lighting, magnification, angle of vision, background, and level of experience of the clinician can also attribute to errors in fit assessment.[16] In addition, the ability to discriminate different levels of misfit varies between clinicians.[39,40]

METHODS FOR EVALUATING FRAMEWORK FIT

Methods for evaluating implant framework fit can be categorized according to the assessment method.

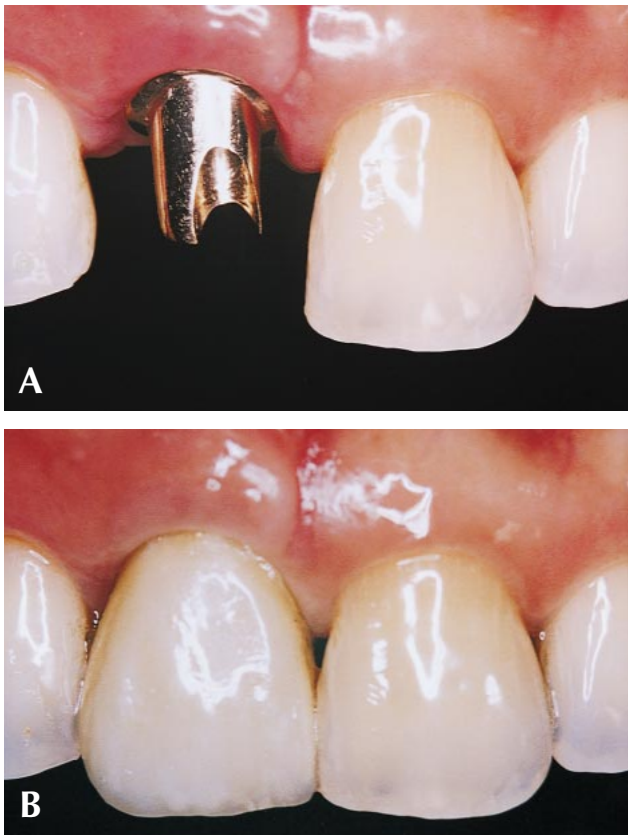

Fig. 5. A, Restoration of single implants in patients with high smile lines requires placement of subgingival finish lines for esthetic reasons. **B**, Provisional restoration has been cemented. Finish line location makes marginal fit assessment more challenging than frameworks with supragingival interface.

Alternate finger pressure

Henry[26] suggested a quick and simple method for initial macroscopic assessment of implant framework fit by manually seating the prosthesis with finger pressure applied alternately over 1 terminal abutment and then the other (Fig. 3).[11,16,41] This alternate pressure helps divulge any fulcruming that may be present. Adell et al.[42] suggested that the effectiveness of the alternate finger pressure technique can be enhanced if used in conjunction with observation of saliva movement at the prosthesis-abutment junction. Finger pressure applied across the arch of the framework can be used to check for lift or distortion. Any detected rocking and/or saliva movements between the framework abutment interface is considered a misfit. This method can be difficult to interpret short span multi-implant–supported prostheses or where subgingival margins are present.

Direct vision and tactile sensation

Direct vision in conjunction with tactile sensation through an explorer is a method commonly used to evaluate the implant framework fit (Fig. 4).[11,43] This method

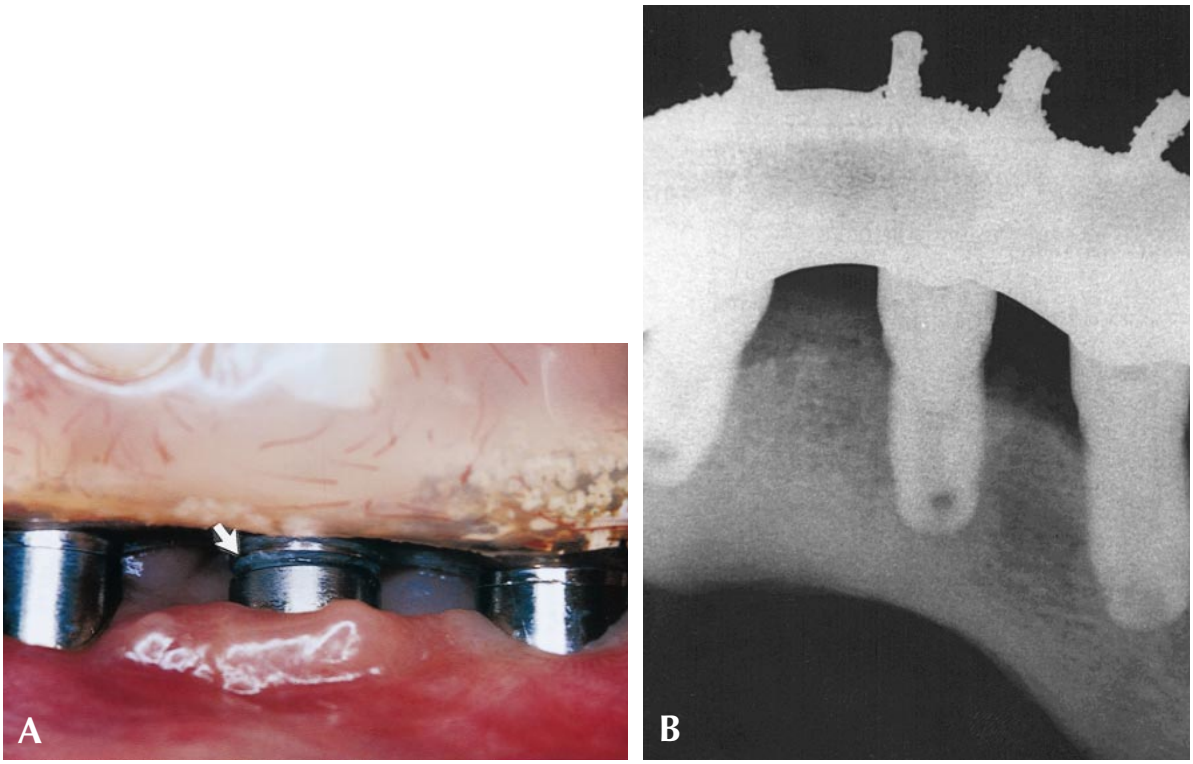

Fig. 6. A, Clinical view of framework misfit (*arrow*). **B**, Because of difficult radiographic access from high floor of month, radiograph failed to show misfit apparent in A.

can be enhanced when used with ample lighting and magnification.[11,26,43,44] However, the sensitivity of this technique is limited by the size of the explorer tip, the location of the margin and the clinician's discriminatory ability. The tip of a brand new explorer is approximately 60 μm, making a misfit smaller than this dimension difficult to detect.[45] Clinical evaluation of fit may also be obscured by soft tissue at the joint to be tested. Furthermore, anterior reconstruction often requires placement of subgingival finish lines for esthetic reasons (Fig. 5, *A* and *B*). Christensen[46] showed that average clinicians would consider supragingival marginal opening as high as 51 μm and subgingival marginal opening as high as 119 μm to be acceptable. Dedmon[39] reported a great disparity in clinicians' ability to discriminate what is deemed acceptable marginal openings. In his study, clinicians considered marginal openings between 32 to 230 μm horizontally and 43 to 196 μm vertically to be acceptable. In addition, Carr and Toth[47] also reported inconsistency in clinicians' ability to discriminate implant framework misfits of less than 95 μm.

Visual and tactile inspection alone may not be sufficient to determine framework misfit, especially with subgingival margins. Also, the finishing and polishing process may round marginal edges of implant components, making the correlation of tactile "catch" and degree of misfit rather tenuous. Therefore this method is often used to complement other techniques.

Radiographs

Periapical radiographs are often used to evaluate framework fit,[11,48,49] especially with subgingivally located margins. These radiographs should be made as perpendicular as possible to the long axis of the implant-abutment junction to optimize accuracy. However, anatomic limitations may prevent proper alignment, resulting in overlapping of components that mask misfits and mislead clinicians into believing that a passive fit has been achieved (Fig. 6, *A* and *B*).[11]

One-screw test

Jemt[35] suggested the 1-screw test for evaluation of framework fit, and Tan et al.[16] further described the test in detail where 1 screw was tightened at 1 terminal abutment and discrepancies observed at the other abutments (Fig. 7). This technique is especially effective for long span frameworks, in which vertical discrepancies tend to be magnified at the opposite terminal abutment. The 1-screw test can be used in conjunction with direct vision and explorer when the margins are supragingival or with periapical radiographs when the margins are subgingival. However, the discrepancies are often masked if the distortion occurred in the neg-

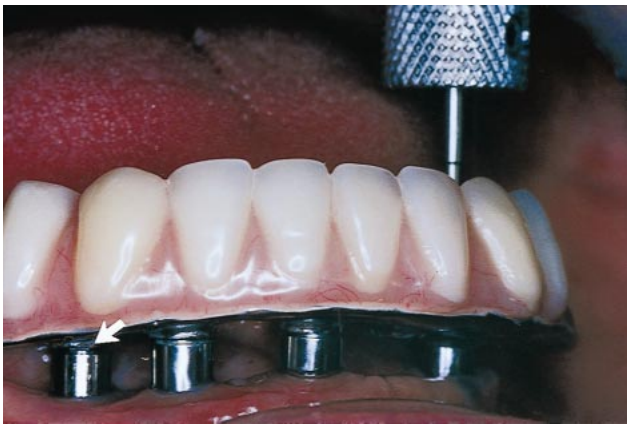

Fig. 7. One-screw test. One screw is tightened at 1 terminal abutment and discrepancy observed at other abutments (*arrow*).

ative z-axis direction to result in a "bottoming out" phenomenon.[16]

Screw resistance test

In 1991, Jemt[35] introduced the screw resistance test based on his experience that a clinically acceptable level of misfit was 150 μm, which corresponded to half the distance between the Nobel Biocare prosthetic gold screw (DCA 074, Nobel Biocare USA, Chicago, Ill.) threads. Gold screws are tightened one by one, starting with the implant closest to the midline until initial resistance between the head of the screw and the framework is encountered. A maximum of one half turn (180 degrees) was then allowed to completely seat the screw and achieve a torque of 10 to 15 Ncm. A misfit was considered when more than a half turn was needed to achieve the desired screw seating and torque measurement. Absence of mechanical fatigue fractures in a 5-year follow up with a group of edentulous patients provided with fixed prostheses suggests this test is clinically adequate for fit assessment.[19,50]

The screw resistance test can be enhanced by using the "Flag" technique described by Rochette (personal verbal communication, 1994, Nice, France), in which a tape is placed around the shaft of the screwdriver in the form of a flag. This flag will serve as a marker for the clinician to identify the degrees a screw has turned when attempting to achieve maximum screw seating. Furthermore, Wicks et al.[51] used the torque/turn analysis technique to demonstrate that gaps or impingement at the prosthetic/implant interface can be recognized by using "altered screw turns limits." Framework misfits can be measured as over or under rotations proportional to the magnitude of the gap. Nevertheless, radiographs, direct vision, or disclosing media are usually needed for verification of framework fit. The presence of persistent pain, pressure, and discomfort during the tightening of the screws may also indicate an unacceptable level of framework misfit.[11]

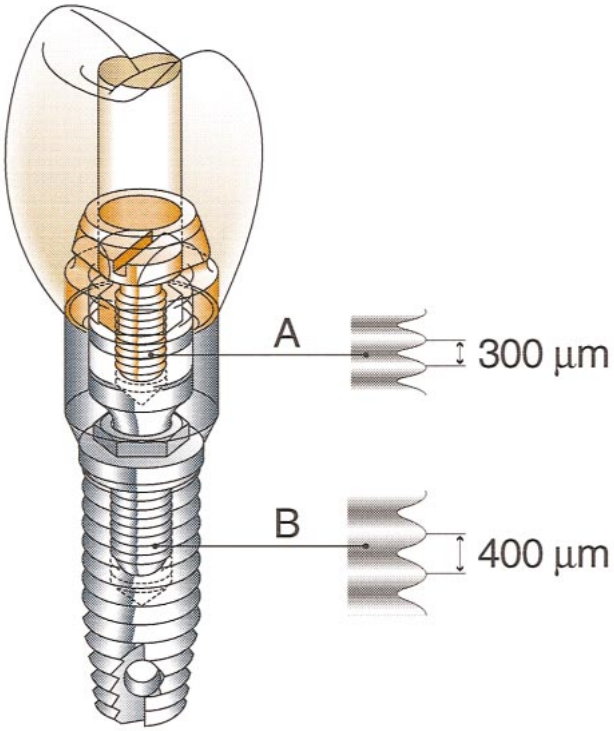

Fig. 8. Diagram illustrates different dimensions between **A**, prosthetic screw and **B**, abutment screw.

The ability to close a 150 μm gap under 10 to 15 Ncm torque may be an acceptable gauge of fit versus misfit, but it can only be applied when Nobel Biocare prosthetic gold screws are used. The distance between the threads of the abutment screw threads for Nobel Biocare and its compatibles is 400 μm, whereas those of other systems' prosthetic screws* vary between 300 to 350 μm (Fig. 8, *A* and *B*). Furthermore, the recommended torque for each screw design and system varies from 10 to 45 Ncm.* The question then is: should the acceptable level of misfit be considered as 150 μm or half-a-turn of the screw thread (150 to 200 μm) and should 10 to 15 Ncm be routinely applied regardless of the implant systems used?

Disclosing media and other materials

Disclosing media such as Fit Checker (GC America, Alsip, Ill.), pressure indicating paste and disclosing wax have been used to complement the screw resistance test for evaluation of framework fit.[11,17,43] The presence of disclosing media at the mating surface of the framework indicates misfit (Fig. 9). These disclosing media can be used for both supragingivally and subgingivally placed margins.

Materials of measurable thickness like unwaxed floss (12 μm), polyester film strips (40 μm), and shim stock

*Source from manufacturers.

Fig. 9. Fit Checker (GC America) was used to evaluate fit of 2 components. Metal visible through silicone medium on 1 of cylinders but not other (*arrow*).

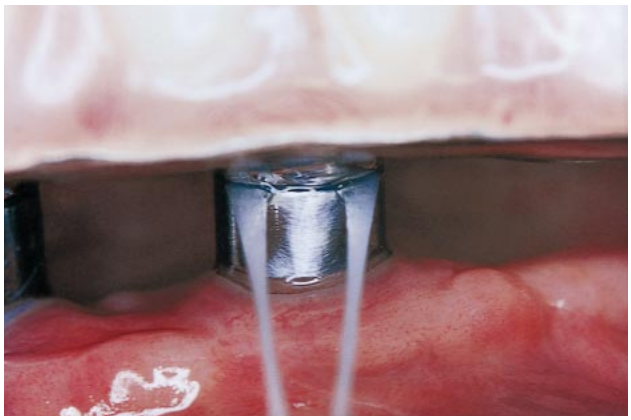

Fig. 10. Unwaxed floss being used to check framework fit. Framework that approximates implant abutment by less than thickness of floss will grasp floss and impede it from slipping between 2 surfaces.

(10 to 12 μm) have also been suggested as tools to verify framework fit (Fig. 10).[11] However, these methods are of limited applications for subgingival situations and difficult for lingual discrepancy evaluation.

INSTRUMENTS

Jemt et al.[52] described 4 systems that quantify framework misfit 3-dimensionally: the Mylab, University of Washington, 3-D photogrammetric, and University of Michigan systems. Discrepancies can be accurately measured to the nearest 10 μm. However, these systems are technique sensitive, expensive, and require special equipment. Furthermore, except for 3-D photogrammetric, these systems can only be used extraorally and therefore limit their clinical applications.

An in vitro study by May et al.[53] suggested that the Periotest instrument is capable of differentiating misfits equal to or greater than 100 μm. They also implied that there might be a positive correlation between the Periotest values and the levels of misfit. Although the initial results are promising, further studies are needed to demonstrate the objective potential of this method.[53,54]

BIOLOGIC TOLERANCE

In 1994, Kallus and Bessing[10] retrospectively evaluated 236 patients who were wearing implant-supported prostheses for at least 5 years. Although there appeared to be a clinically significant correlation between prostheses discrepancies and loose gold screws, neither clinical nor radiographic findings indicated that these misfits affected the long-term osseointegration or maintenance of the bone level.

Recent studies were designed to correlate degrees of framework misfit and bone response. Assuming the length of the study was sufficiently long enough to effect required bone changes, Carr et al[55] showed no significant difference in bone response in baboons when comparing 2 levels of misfit; 38 and 345 μm, without functional loads. Michaels et al.[56] found no histomorphometric differences in the mean percentage area of bone integration with up to 400 μm of misfit after 12 weeks. Jemt and Book[57] reported the 1-year prospective and 5-year retrospective in vivo human studies with functional prostheses and showed that there was no statistical correlation between marginal bone loss and framework misfit with an average gap of 111 μm and maximal discrepancies of 275 μm. The results of these studies suggest that some form of biologic tolerance may exist between the implant and its surrounding bone that allows for a certain degree of misfit. However, no studies have yet scientifically defined or quantified the minimal threshold of biologic tolerance.

CONCLUSIONS

On the basis of what is known, the relative misfit with the available fit evaluation methods cannot be accurately assessed and determined. In the absence of such quantitative fit guidelines, achieving passive fit may be of emotional reasons rather than of evidence-based science. However, implant components and bone appear to tolerate a degree of misfit without adverse biomechanical problems. The level of this misfit has yet to be determined. Therefore improving clinical techniques such as the use of rigid impression materials, custom trays, cementable superstructure, and a combination of the available evaluation methods described in this review may be relied on to optimize fit or compensate for misfit.

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Reprint requests to:
DR JOSEPH Y. K. KAN
DEPARTMENT OF RESTORATIVE DENTISTRY
SCHOOL OF DENTISTRY
LOMA LINDA UNIVERSITY
LOMA LINDA, CA 92350

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