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Cantilevers Extending From Unilateral Implant-Supported Fixed Prostheses: A Review of the Literature and Presentation of Practical Guidelines

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Cantilevers extending from unilateral implant-supported fixed prostheses

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ABSTRACT

Background. Historically, prostheses involving cantilevered support have resulted in higher complication rates than have fixed dental prostheses (FDPs) without cantilevers. Through the judicious use of contemporary implant protocols, implant-supported cantilevered FDPs (ICFDPs) may provide a method of restoring edentate areas as predictably as do implant-supported FDPs without cantilevers.

Types of Studies Reviewed. The authors searched the dental literature for clinical trials in which investigators appraised the survival rates of and complications (physiological and technical) associated with ICFDPs. Results from workshops have suggested that at least five-year data are needed to enable evaluation of the effectiveness of implant therapy. The authors delineate these data in tables and include additional studies with shorter follow-up periods, as there is a paucity of five-year data addressing survival rates of short-span ICFDPs.

Results. The data indicate that unilateral short-span cantilevered prostheses have an overall estimated survival rate at five years of 94.3 percent (95 percent confidence interval, 84.1-98.0 percent). These prostheses may be associated with minor technical problems—such as abutment or screw loosening, loss of retention and veneer chipping—that do not result in the failure of an ICFDP.

Conclusions and Clinical Implications. An ICFDP can be used in a manner that positions a pontic at a site with a dearth of bone or anatomical structures that preclude placement of a dental implant.

Key Words. Dental implant; dental cantilever; fixed partial prosthesis.
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A fixed dental prosthesis (FDP) can be retained by teeth, dental implants or a combination of both. Implants have been used successfully to support FDPs, but unfavorable situations for implantation can arise, such as a dearth of bone or anatomical structures (such as the mental foramen). In these circumstances, if an implant-supported cantilevered FDP (ICFDP) could be used to restore a problematic edentate area, it would provide a simpler rehabilitation procedure.

A short-span cantilevered bridge has one or more abutments at one end and one or more pontics at the other. Investigators have expressed numerous concerns with respect to potential biological and technical problems associated with cantilevered prostheses used to restore partially edentulous arches, because such prostheses are more vulnerable to the effects of bending moments (torque).[1-5] In this regard, there have been technological improvements in dental implant designs, an increased understanding of biomechanics related to cantilevered bridges and emerging

BOX

Factors affecting biomechanics of dental implants.

- Number and distribution of implants
- Implant size (height and width)
- Implant angulation
- Prosthesis design
- Properties of implant components and connections
- Occlusal forces (normal versus parafunctional)
- Materials (such as titanium alloy)
- Retention of abutments (screws versus cement)
- Superstructure fit
- Loading forces (location, magnitude, direction, duration, cyclic patterns and frequency)
- Status of the opposing arch (such as dentate, complete dentures, implants)
- Properties of bone (quality and quantity)

data indicating a high survival rate for unilateral short-span ICFDPs.[6-13] Therefore, we thought it timely to assess whether cantilevers supported by dental implants are a predictable therapeutic option for partially edentate patients. In this article, we review the biomechanics of short-span, unilateral ICFDPs and address clinical trials concerned with their survival. In addition, we suggest practical guidelines with respect to avoiding biological and technical complications associated with this type of construct.

BIOMECHANICS ASSOCIATED WITH AN IMPLANT-SUPPORTED CANTILEVERED FIXED DENTAL PROSTHESIS

Numerous factors can affect the biomechanics of an implant-supported restoration (Box). In the discussion section of this article, we address ways in which to mitigate many of these issues. Here, we review the forces that act on a cantilever and the subsequent stresses and strains they induce.

Forces acting on a cantilever. An FDP with a cantilever is a type 1 lever.[14] For example, a three-unit ICFDP is composed of a cantilevered pontic at one end, an implant adjacent to the cantilever that acts as the fulcrum and a remote implant that provides resistance to displacement of the prosthesis (Figure 1). The force exerted on the prosthesis is computed by multiplying the biting force times the length (the mesiodistal dimension) of the cantilever. The cantilever arm generates torque on the prosthesis, and these bending moments can form in three clinical axes (occlusoapical, mesiodistal and faciolingual).

Results of several studies indicated that bending moments induced by load-bearing cantilevers can increase forces on the supporting implants by two to three times compared with stresses normally detected on a single implant.[15,16]

Brunski[14] indicated that if two implants support a prosthesis with a cantilevered pontic, the moment (force over a distance) generated by the cantilever results in a compressive force (pushing down) on the abutment closest to the cantilever and a tensile force (pulling up with a tendency to separate components) on the more distant abutment. He also noted that increasing the mesiodistal length of the cantilever relative to the interimplant distance increases tensile and compressive forces.[14] Therefore, increasing the interimplant distance, shortening the mesiodistal length of the cantilever or adding more implants provides a safety margin in the construction of a prosthesis with a cantilever.

Stress and strains. All cantilevers under a load produce stress (force acting on an object) and strain (deformation or elongation in response to stress). The correlation between stress and strain establishes the modulus of elasticity (stiffness) of a material. In biomechanics, strain is expressed in microstrains: 1,000 microstrains in compression shorten bone by 0.1 percent.[17] The fracture strength of lamellar bone is 25,000 microstrains or 2.5 percent deformity.[17] According to Frost,[18] a certain amount of stress is needed to maintain bone homeostasis. Too little stimulation results in bone atrophy and too much causes microfractures and bone loss. The suggested relationship between bone microstrain and physiological responses is as follows:

- microstrains 0 to 50, atrophy;
- 50 to 1,500, normal bone modeling;
- 1,500 to 3,000, overload;
- more than 3,000, destructive.

Therefore, forces on an implant that exceed the physiological response of bone may result in osseous resorption at the bone-implant interface.

Forces beyond biomaterial tolerances can cause technical problems (for example, screw loosening, cement failure and framework fracture). If a force exceeds two-thirds of the stress limit of a material (such as metal), it fatigues and eventually fractures.[19] Consequently, a bridge should be made as

ABBREVIATION KEY. FDP: Fixed dental prosthesis. **ICFDP:** Implant-supported cantilevered fixed dental prosthesis.

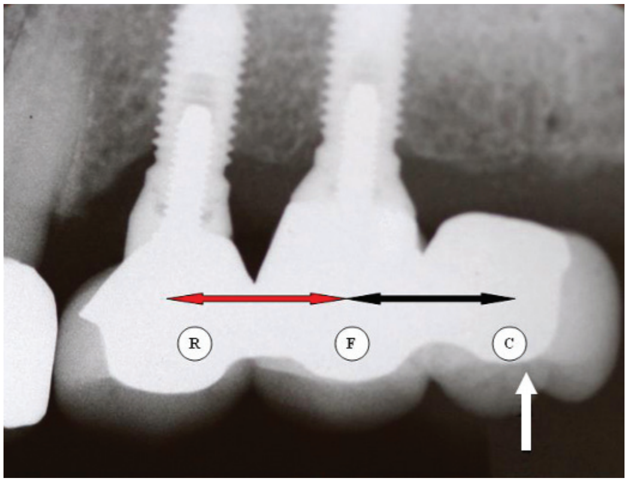

Figure 1. Periapical radiograph depicting an implant-supported cantilevered fixed dental prosthesis on teeth nos. 13 through 15. There are two implants supporting a prosthesis with a premolar-sized cantilever (C). When a force is applied to the cantilever by an opposing tooth (vertical white arrow), the approximate center of the terminal implant acts as a fulcrum (F), and the approximate center of the mesial implant acts as the resistance (R). The effort arm is depicted by the black horizontal arrow, and the resistance arm is depicted by the red horizontal arrow. In this figure, the implants are 4.1 millimeters in diameter and externally hexed, and the abutments are prefabricated titanium alloy retained by gold alloy screws. The prosthesis is cement retained and was fabricated by using porcelain fused to palladium-gold alloy.

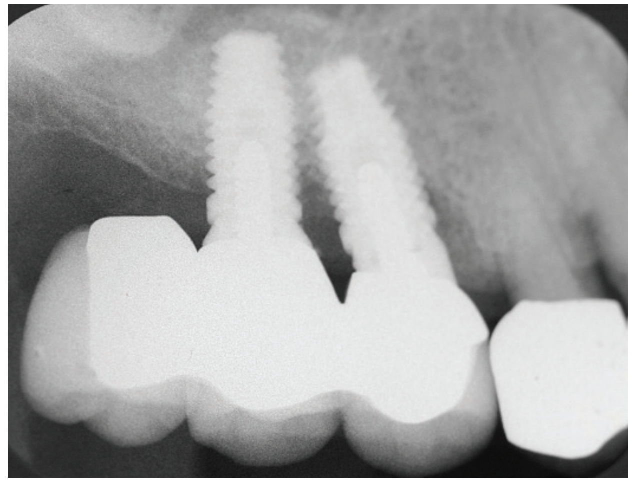

Figure 2. Periapical radiograph of a cantilevered bridge (teeth nos. 3-5) with two 4.1-millimeter–diameter implants (teeth nos. 4 and 5) supporting the prosthesis. The pontic is over the sinus, where there was too little bone to place an implant. This radiograph was obtained at a three-year follow-up appointment. Components and prosthesis design are similar to those shown in Figure 1.

strong as possible to reduce cantilever deformation and possible fracturing of the luting media, porcelain, retaining screws and so forth.

CONSIDERATIONS ASSOCIATED WITH IMPLANT-SUPPORTED CANTILEVERED FIXED DENTAL PROSTHESES

Advantages. The major advantages of using an ICFDP are that it broadens treatment options and may simplify prosthetic rehabilitation. Using a cantilevered pontic over an area in which there is a dearth of bone obviates the need to regenerate osseous support for an implant fixture (Figure 2). This would circumvent additional cost and reduce therapeutic time and potential morbidity associated with surgical procedures. Similarly, to avoid anatomical structures, such as the maxillary sinus or the mental foramen, placement of a cantilever may be advantageous.

Disadvantages. Studies that address forces around prostheses with and without cantilevers indicate that bone adjacent to cantilevered prostheses experiences increased stresses.[20-23] The greatest forces are at the crest of the bone at the implant surface facing the cantilever. The size of the force is related to the length of the cantilever. Negative aspects of increased torquing forces can result in breakdown of the bone–implant interface, bone loss around the prosthesis, screw loosening or implant and prosthesis fracture.[6-10,24]

Biological complications. Investigators in two controlled clinical trials compared the amount of bone loss that occurred adjacent to implant-supported prostheses that did and did not have a cantilevered pontic.[6,7] In both studies, the researchers concluded that there was no statistically significant difference in the amount of bone loss around a prosthesis with or without a cantilever (0.49 millimeters versus 0.38 mm[6] and 0.23 mm versus 0.09 mm[7]). In another study, Tawil and colleagues[25] noted that mesial and distal cantilevers did not affect peri-implant bone stability adversely (mean follow-up, 53 months).

SURVIVAL RATES OF IMPLANT-SUPPORTED CANTILEVERED FIXED DENTAL PROSTHESES: HUMAN CLINICAL TRIALS

Studies in which investigators evaluated the functionality of ICFDPs across many years provide strong evidence supporting their usefulness (Table 1).[6-13] Aglietta and colleagues[24] conducted a systematic review of estimated survival rates for five studies[6-10] that lasted at least five years. The overall estimated survival rate for ICFDPs at five years was 94.3 percent (95 percent confidence interval [CI], 84.1-98.0 percent), and after 10 years it was 88.9 percent (95 percent CI, 70.8-96.1 percent).[24] They did not include three additional

TABLE 1

Studies addressing survival of implant-supported cantilevered fixed dental prostheses (ICFDPs).

AUTHOR	IMPLANT MANUFACTURER	NO. OF PATIENTS	NO. OF ICFDPs	LOCATION OF ICFDPs	YEARS OF FOLLOW UP	NO. OF FAILED IMPLANTS	NO. OF FAILED ICFDPs	ICFDP ESTIMATED FIVE-YEAR SURVIVAL RATE
Wennström and Colleagues[6]	Astra Tech, Waltham, Mass.	28	26	16 maxillas 8 mandibles	5	2	2	92.6*
Hälg and Colleagues[7]	Straumann, Andover, Mass.	27	27	13 maxillas 14 mandibles	5	2	3	89.5*
Eliasson and Colleagues[8]	Brånemark System, Nobel Biocare, Zürich-Flughafen, Switzerland	Not reported (NR)	61	NR	10.5	1	0	100*
Kreissl and Colleagues[9]	Biomet, Warsaw, Ind.	20	23	Maxillas and mandibles (no. NR)	5	1	1	95.7*
Brägger and Colleagues[10]	Straumann	14	18	11 maxillas 7 mandibles	9.4	1	3	91.5*
Becker and Colleagues[11]	Straumann	35	60	54 maxillas 6 mandibles	10	0	0	100
Romeo and Colleagues[12]	Brånemark Straumann	38	8 41	7 maxillas 42 mandibles	1 to 7	3	1	98
Johansson and Ekfeldt[13]	Brånemark	83	65	NR	4.1	NR	0	100

* Survival rate computed by Aglietta and colleagues.[24]

studies concerning ICFDPs in the systematic review because those three did not meet all the inclusion criteria (such as a five-year time span and specific data regarding ICFDPs); however, those studies demonstrated survival rates ranging from 98 percent[12] to 100 percent[11,13] (Table 1).

INDIVIDUAL STUDIES ADDRESSING SURVIVAL RATES OF IMPLANT-SUPPORTED CANTILEVERED FIXED DENTAL PROSTHESES

Controlled clinical trials. Researchers in two retrospective investigations planned deliberately to evaluate and compare implant-supported FDPs with and without cantilevers.[6,7] After five years in function, the ICFDPs' survival rates compared with those of FDPs supported by implants were 92 percent (24 of 26) versus 96 percent (26 of 27)[6] and 89.9 percent (24 of 27) versus 96.3 percent (26 of 27).[7] Both studies also reported high survival rates for implants in the groups with and without cantilevers.

Noncontrolled clinical trials. In five noncontrolled retrospective[8,13] and prospective[9,10,12] studies, researchers derived data pertaining to ICFDPs that consisted mostly of implant-supported FDPs without cantilevers. The investigators estimated survival rates for ICFDPs to be 91.5 to 100 percent (Table 1).[8-10,12,13] In a case report, Becker[11] noted that after 10 years, 60 placed ICFDPs were functioning without any major technical problems. The survival rate was 100 percent[11] (Table 1).

SYSTEMATIC REVIEWS ASSESSING SUCCESS OF FIXED PROSTHESES

In a systematic review, the authors use a meta-analysis to compare similar studies to determine if clinically relevant trends can be identified. Findings from a systematic review by Aglietta and colleagues[24] indicated that ICFDPs had a high survival rate (Table 1).[6-10] However, to determine the critical relevance of these data, one needs to evaluate them in light of findings from other systematic reviews in which investigators addressed the same outcome variables but included different prosthetic constructs (Table 2).[24,26-30] These comparisons revealed that the survival rate of ICFDPs was similar to that of bridges supported by teeth[26] or implants without cantilevers.[27] Furthermore, the prosthesis sur-

TABLE 2

Meta-analyses for prostheses and implant survival rates after five and 10 years.

AUTHOR	NO. OF STUDIES ANALYZED	ABUTMENTS USED	SURVIVAL RATE (PERCENTAGE)			
			Prostheses		Implants	
			Five years	10 years	Five years	10 years
Aglietta and Colleagues[24]	5	Implant-supported cantilevered fixed dental prostheses (ICFDPs)*†	94.3	88.9	98.5	91.7
Tan and Colleagues[26]	19	Teeth	NR‡	89.1	NR	NR
Pjetursson and Colleagues[27]	21	Implants	95.0	86.7	95.4	92.8
Pjetursson and Colleagues[28]	13	Cantilevers/teeth	NR	81.8	NR	NR
Lang and Colleagues[29]	13	Implants/teeth	94.1	77.8	90.1	82.1
Zurdo and Colleagues[30]	3	ICFDPs	91.9§	NR	NR	NR

* Short-span prostheses.
† Estimated five- and 10-year survival rates. Not all studies lasted 10 years.
‡ NR: Not reported.
§ Systematic review with only three trials. Weighted five-year survival rate was 91.9 percent (range, 89.9-92.7 percent).

vival rate after 10 years was greater for ICFDPs than it was for cantilevered bridges supported by teeth[28] or for prostheses that connected teeth to implants.[29] In one other recent systematic review that addressed the retention of ICFDPs, researchers reported a five-year survival rate of 91.9 percent (Table 2).[30] This systematic review included three[6,7,9] of the five studies[6-10] that Aglietta and colleagues[24] assessed in their review. Overall, the above data clearly underscore that an ICFDP with a cantilever of limited mesiodistal dimension has a high survival rate and is a predictable therapeutic option.

TECHNICAL PROBLEMS ASSOCIATED WITH IMPLANT-SUPPORTED CANTILEVERED FIXED DENTAL PROSTHESES

Pjetursson and colleagues[27] suggested that complications should be separated into three categories: major (implant fracture and loss of superstructures), medium (abutment, veneer or framework fracture) and minor (abutment or screw loosening, loss of retention, veneer chipping or fracture). Table 3 lists a variety of technical complications associated with ICFDPs.[6-10] The five-year and 10-year complication rates reflect a low level of minor technical complications (Table 3). These findings are within the 20 percent technical complication rate for implant-supported FDPs reported in the systematic review by Berglundh and colleagues,[31] in which 24 percent of patients had technical problems. Technical complications do not necessarily endanger the survival of ICFDPs; however, they do indicate that maintenance is needed. For example, Hälg and colleagues[7] found that there was an 18.5 percent (five of 27 ICFDPs) chance of a technical problem with ICFDPs. However, these problems were minor: four instances of porcelain chipping and one failure of luting cement.

Fracture of a dental implant is a serious technical problem that can result in the loss of an ICFDP. In this regard, Hälg and colleagues[7] reported that three implants fractured during their study. Two were 3.3 mm wide, and one was a hollow-cylinder implant. They mentioned that directions from the manufacturer (Straumann, Andover, Mass.) indicated that 3.3 mm–wide implants should not be used with an ICFDP. Romeo and colleagues[32] also reported the fracture of two 3.3-mm implants that supported ICFDPs. Apparently, 3.3-mm implants carry a higher risk of fracture than do wider implants, and clinicians should try to avoid using them in ICFDPs. In an article by Brägger and colleagues,[10] the fractured implant was a hollow cylinder, indicating that implants designed as hollow cylinders also may not be suitable abutments in ICFDPs.

In a systematic review, Aglietta and colleagues[24] noted that a small number of veneer fractures had been reported in all the studies they included in their review and that no framework fractures had been reported in any of the included studies (Table 3). Abutment screw fractures, screw loosening and lost retention of crowns all were relatively uncommon findings (Table 3).

Table 3 does not include four articles[4,12,13,33] in which investigators addressed prosthetic compli-

TABLE 3

Technical complications associated with implant-supported cantilevered fixed dental prostheses.*

AUTHOR	NO. OF IMPLANT FRACTURES	NO. OF VENEER FRACTURES	NO. OF FRAMEWORK FRACTURES	NO. OF ABUTMENT SCREW FRACTURES	NO. OF CASES WITH SCREW LOOSENING	NO. OF CASES WITH LOSS OF RETENTION
Wennström and Colleagues[6]	NR†	1	0	0	2	NR
Hälg and Colleagues[7]	2	4	0	0	NR	1
Eliasson and Colleagues[8]	0	2	0	3	7	NR
Kreissl and Colleagues[9]	0	8	0	1	5	NR
Brägger and Colleagues[10]	1	1	0	1	0	2
Five-Year Rate	1.3 percent	10.3 percent‡	0	2.1 percent	8.2 percent	5.7 percent
10-Year Rate	2.5 percent	19.6 percent‡	0	4.1 percent	15.7 percent	11.1 percent

* Source: Aglietta and colleagues.[24]
† NR: Not reported.
‡ Estimated rate of veneer fractures (per 100 patients per year).

cations associated with ICFDPs because the articles lacked specificity with respect to the types of problems encountered. Results from two studies indicated there was a high rate of prosthetic complications; however, we could not determine if complications were minor (screw loosening, recementation) or major (loss of a prosthesis or an implant).[4,33] Nedir and colleagues[4] indicated that when they compared fixed prostheses with and without cantilevers across eight years, they found a greater incidence of complications associated with ICFDPs—respectively, five (29.4 percent) of 17 versus 18 (8.6 percent) of 210. De Boever and colleagues[33] reported that prosthetic complications occurred in four of eight patients treated with ICFDPs (they monitored patients for up to 40 months after prosthesis placement). In another study, Johansson and Ekfeldt[13] found that a greater number of implants supporting ICFDPs experienced screw loosening when compared with implants supporting FDPs without cantilevers (12 percent of gold screws and 17 percent of abutment screws versus none; the difference was not statistically significant). However, it was unclear how many prostheses were affected. Similarly, Romeo and colleagues[12] mentioned that a few prosthetic failures occurred in their study, but they did not delineate the types of technical complications that were involved.

In general, investigators who provided specific data concerning technical problems associated with ICFDPs reported that these complications frequently were minor (Table 3). These difficulties usually were manageable and did not result in the loss of a prosthesis. However, technical complications occurred at a greater frequency among ICFDPs than among FDPs.[30] On the basis of three studies,[6,7,9] Zurdo and colleagues[30] indicated that minor technical problems occurred more often among ICFDPs (weighted mean, 20 percent; range, 13-26 percent) than among FDPs (weighted mean, 9.7 percent; range, 0-12 percent).

DISCUSSION AND RECOMMENDATIONS FOR PROSTHESIS CONSTRUCTION

There are a limited number of clinical trials in which investigators specifically addressed the usefulness of a short-span, unilateral ICFDP (Table 1). However, the data we reviewed for this article consistently demonstrated that fabrication of a unilateral, short-span ICFDP is a practical and predictable procedure for restoring a partially edentate area of the mouth (Tables 1-3). This conclusion is in agreement with a recent consensus statement by the European Association for Osseointegration,[34] which indicated that "an implant-supported fixed partial dental prosthesis with a short extension (one unit) is an acceptable restorative therapy, and might be considered as an alternative to procedures that require more advanced surgery (e.g., sinus graft, etc.) or for esthetic reasons." It also is in accord with the findings of Aglietta and colleagues,[24] who stated that ICFDPs are a reliable treatment for the replacement of missing posterior teeth in partially edentulous patients.

Nevertheless, cantilevers are subjected to forces that vary according to three design characteristics: apico-occlusal height, buccolingual width and mesiodistal cantilever length. These forces can result in increased stress on a prosthesis and on the surrounding bone.[23,35] Accordingly, it is advantageous to reduce forces on ICFDPs.

Recommendations for treatment with ICFDPs. We make the following suggestions for reducing stresses on ICFDPs and, thereby, decreasing biological and technical complications associated with them and increasing their survival rate.

Number, diameter, length and position of implants. The number, diameter, length and position of dental implants affect the transmission of stress to bone. Alteration of these four factors can provide increased resistance to bending moments. The ideal number, diameter or length of implants to provide the optimal support for a cantilevered prosthesis is unknown. However, data in the literature indicate that FDPs using two to three implants (see the appendix in the supplemental data to the online version of this article at "http://jada.ada.org") to support a cantilever are highly successful and predictable (Table 1). With regard to spacing implants, a span of at least 8 mm between the centers of implants seems appropriate.[5] It should be noted that stress on the prosthesis increases rapidly when interimplant spacing decreases or cantilever length increases.[14] Concerning the diameter of an implant, whereas increased surface area contributes to improved bone-to-implant contact, a main advantage of increased diameter relates to preventing the implant fracture that has been reported with 3.3-mm implants.[7,32]

Mesiodistal length of the cantilever. The length of a cantilever usually is computed on the basis of the supporting implants' anteroposterior spread—the distance between parallel lines drawn through the most anterior and most posterior implants. The anteroposterior spread can be affected by several factors: number and length of implants supporting the prosthesis, presence of cross-arch stabilization and masticatory forces generated by the patient (such as parafunctional forces). At present, there is no consensus as to the optimal cantilever length as a function of implant length.[21,36]

Figure 3. Intraoral left lateral view of metal assemblage of an implant-supported cantilevered fixed dental prosthesis. The interproximal connectors are larger than usual to provide additional strength for the cantilevered prosthesis (6-millimeter height and 4-mm buccopalatal width). The size of the casting's embrasure can be modified before porcelain application depending on the type of interproximal cleansing technique that the clinician will recommend (such as an interdental brush or a floss threader). This prosthesis rests on implants that are 4.1 mm in diameter and internally connected.

With respect to unilateral short-span cantilevers, the clinician must pay attention to the interimplant distance.[14] He or she should avoid overflexion of cantilevers and keep the length of cantilevers to a minimum.[37] The law of beams indicates that if a cantilever is extended, the length of a beam, similar to its height, will flex to the cube power (x^3).[38] Eraslan and colleagues[39] suggested keeping the size of the cantilever to the mesiodistal dimension of a premolar, which is similar to values recommended by other investigators.[6,20,40-43]

Dimensions of the connector. To determine the rigidity of a beam for occlusal loading, the clinician can use the following formula proposed by English[38]: I (rigidity) = $WH^3/12$. This relationship indicates that doubling the buccolingual width (W) of the metal connection doubles the strength, but doubling the occlusogingival height (H) increases the strength eight times.[38] To increase the stiffness and resistance to deformation of the metal substructure of the cantilever, the clinician can increase its thickness in height and width (Figure 3). In general, the metal connector adjacent to the cantilevered pontic should be unit-cast and be designed for maximum strength.

Preloading. Preloading refers to tightening of a screw, which deforms it slightly and thus places it under a tensile force. However, if the clamping force between an implant and the abutment is exceeded by forces placed on the prosthesis as a result of occlusal load, the screw will loosen. To avoid this dilemma, we suggest that the clinician do the following:

- routinely retighten abutment screws several minutes after the initial torque applications;
- use torque value for abutment screws according to the manufacturers' recommendations.[44]

Technological improvements to implant components and design. The design of an implant affects the way it responds to forces. Historically, screws used to keep components assembled were subjected to forces that tended to loosen them. The clinician can prevent this loosening by using a system with precisely fitting components, an abutment screw capable of accepting a preload and a longer implant-abutment connection (such as an internal connection).[11,45,46]

Implants with rough rather than smooth dental surfaces provide better retention to bone and a greater surface area to transmit stresses to the bone.[47,48] Wider-diameter implants have a greater surface area for bone-to-implant contact and also reduce the incidence of implant fracture.[49] In addition, elimination of "stacked" components[11] (such as multiple screws securing the abutment and the crown) when feasible, use of UCLA-type prosthesis designs (that is, screw retained without an abutment) and cementing of prostheses on abutments[11] can reduce problems such as fracturing or loosening associated with restorations that include abutment screws and small occlusal (prosthesis) screws.

Occlusion and occlusal prosthesis material. The clinician can modify the occlusion to reduce occlusal stress in a number of ways: place the cantilever in infraocclusion (0.1-0.2 mm),[50] use low cuspal inclines,[19] use a narrow occlusal table[19] and provide vertically directed centric contacts in the prosthesis.[19] In addition, the patient can wear a nightguard to buffer forces applied while sleeping. Stresses are applied via occlusal surfaces (whether acrylic, porcelain or metal) to the bone when forces are applied to a cantilever.[51] In this regard, Sahin and colleagues[46] reviewed the literature and concluded that the data were inconclusive as to which material is better. Therefore, metal and ceramic occlusal surfaces, which supply improved wear resistance and esthetics, typically are used with implant restorations.[52]

Retention of abutment crowns. To enhance the retention and resistance form when creating a cantilever on teeth or a dental implant, the clinician should ensure that abutment preparations have maximum axial wall length with minimal taper (convergence angle).[53] This aids the cement luting medium, which is the weakest biomechanical link,[54] especially for abutments adjacent to the cantilever. In this respect, an increased abutment height of 2 mm can amplify retention as much as 40 percent. In addition, if there is a lack of space to increase abutment height, vertical grooves in the abutments placed parallel to the prosthesis insertion path will reduce the risk of cement failure.[55]

Crown-to-root ratio. Clinical crown height (abutment plus restoration) creates a vertical lever arm, which can be interpreted as a vertical cantilever on an implant. For every 1 mm of additional crown height compared with normal anatomical height, force may increase 20 percent.[56] Therefore, if the crown-to-implant ratio is excessive, the clinician should consider either providing wider implants to resist bending moments or adding additional implants for strength. Because the greatest stresses are located in the coronal aspect of the bone, wider implants are better than longer implants in reducing stress on the bone.[21]

Fit of prosthesis. A prosthesis must fit passively. A substantial mis-fit might create both biological and technical complications.[14]

Precautions regarding patients with bruxism. Parafunctional forces are destructive and can result in metal fatigue; therefore, it is prudent to avoid placing ICFDPs in patients with bruxism.[57] However, if an ICFDP is fabricated for a patient with bruxism, the clinician should overengineer it and use additional implants to support the prosthesis. The clinician can consider using metal on occlusal surfaces to reduce the incidence of porcelain chipping. In addition, it is sensible to recommend that a patient wear a nightguard and that the clinician avoid using narrow implants.

CONCLUSIONS

The findings in the literature we reviewed were consistent in indicating that a unilateral, short-span ICFDP is a predictable and dependable solution for the restoration of a partially edentulous area of the mouth when there is a lack of bone to support an implant or there are anatomical structures that need to be avoided. ■

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