Confronting Controversial Issues in Dental Implant Therapy, Part 1

Authored by
Gary Greenstein, DDS, MS; John Cavallaro, DDS; and Dennis Tarnow, DDS

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LEARNING OBJECTIVES
After participating in this CE activity, the individual will learn:

• That there are abundant data to indicate that despite increased stress associated with certain types of prosthetic constructs, the survivability, technical issues and biological responses are not deterrents for employing cantilevers and increasing crown to implant ratios within certain limitations.

• Recommendations for enhancing success with these types of prostheses.

ABOUT THE AUTHORS

Dr. Greenstein is clinical professor, Department of Periodontology, College of Dental Medicine, Columbia University, New York, NY. He maintains a private practice in Surgical Implantology and Periodontics in Freehold, NJ. He can be reached via e-mail at the address ggperio@aol.com.

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Dr. Cavallaro is director of the implant fellowship program and associate clinical professor of prosthodontics, College of Dental Medicine, Columbia University, New York, NY. He maintains a private practice in surgical implantology and prosthodontics in Brooklyn, NY. He can be reached at docsamurai@si.rr.com.

Disclosure: Dr. Cavallaro reports no disclosures.

Dr. Tarnow is director of dental implant education and a clinical professor, Department of Periodontology, College of Dental Medicine, Columbia University, New York City. He maintains a private practice in New York City. He can be reached at dennis.tarnow@nyu.edu.

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INTRODUCTION
Confronting controversies in implant dentistry is necessary in order to develop clarity with respect to choices clinicians have when treatment planning dental prostheses. As new information appears in the literature which conflicts with ingrained ideas, therapists may be left in a quandary concerning which facts should be applied to patient management. Therefore, it is essential to assess current data from multiple studies to determine the status of therapeutic options.

In this 2-part article, 5 subjects related to implant dentistry are addressed to help clarify certain controversial issues. Part 1 discusses the topics of cantilevers off of dental implant-supported prostheses, and increased crown-to-implant ratios (CIRs). Part 2 will discuss the topics of angulated abutments, connecting teeth to implants, and bone adaptation to stress. Each subject was previously reviewed by the authors.1-5 This 2-part series summarizes the critical salient facts and provides clinical guidelines to enhance patient outcomes.

First, background information is provided to help understand bone tolerance levels with respect to stresses applied to dental prostheses.

FORCES ACTING ON PROSTHESSES
Cantilevered prostheses, increased crown-to-implant ratios, angulated abutments, and connecting teeth to implants are prosthetic constructs that experience increased stresses and strains.6-9 Stress is the force acting on a prosthesis, and the biologic response is referred to as strain (deformation or elongation of bone).10 Forces beyond biomaterial tolerances
can cause technical problems (e.g., screw loosening or breakage, implant fracture, and disruption of cement retention) and biological problems (e.g., bone loss). Bone deformation is expressed in microstrains (ue), where 1,000 ue in compression shortens bone by 0.1%. The fracture strength of lamellar bone is 25,000 ue or 2.5% deformity. According to Frost, a certain amount of stress/strain 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 are listed: 0 to 50 ue—atrophy, 50 to 1,500 ue—normal bone modeling, 1,500 to 3,000 ue—overload, > 3,000 ue—destructive.

Forces exceeding the physiological bone tolerance around an implant can result in bone resorption and deosseointegration at the bone-implant interface. However, it is not possible to identify a precise force threshold that initiates bone loss around an implant because there are many confounding variables: loading conditions, prosthesis type (unsplinted or splinted), abutment angulation, bone type, duration of destructive overload, etc. With these concepts in mind, various types of prosthetic constructs that experience increased stress during function are examined with respect to several perspectives: long-term survivability, biological, and technical issues.

**UNILATERAL SHORT SPAN CANTILEVERS OFF DENTAL IMPLANTS**
An implant-supported cantilevered fixed dental prosthesis (ICFDP) consists of one or more abutments at one end of the prosthesis and one or more unattached pontics at the other end. Concerns were expressed regarding potential biological and technical problems associated with cantilevers, because they experience increased bending moments. However, emerging data indicate that unilateral implant-supported fixed dental prostheses with a cantilever have a high survivability rate (Table 1).

**Forces on a Cantilevered Prosthesis**
The stress on implants supporting an ICFDP is 2 to 3 times greater than found on single implants that do not support a cantilever. The increased stress is mainly located at the bone crest adjacent to the surface of the implant facing the cantilever, and as the cantilever becomes longer the stress increases on the prosthesis and bone.

**Potential Benefits Associated With Implant-Supported Cantilevered Fixed Dental Prostheses**
The primary benefit provided by an ICFDP is denoted by its ability to expand therapeutic options, which could simplify prosthetic restorations. Its employment may allow placing a cantilevered pontic over a site that had a lack of bone (e.g., sinus, mental foramen), thus circumventing the necessity to restore bone to support an implant. This would avoid additional cost, decrease treatment time, and reduce morbidity related to surgical endeavors.

**Potential Shortcomings Linked to Implant-Supported Cantilevered Fixed Dental Prostheses**
Increased torque may potentially induce biological problems (bone-implant interface deterioration, bone resorption) and mechanical issues (screw loosening, implant and prosthesis fracture, porcelain fracture).

**Clinical Trials Evaluating Bone Resorption Around Implant-Supported Cantilevered Fixed Dental Prostheses**
Concerning bone loss, 2 prospective controlled investigations found no statistically significant difference with respect to bone resorption around prostheses with or without a cantilever (0.49 mm versus 0.38 mm, 0.23 mm versus 0.09 mm).

**Human Clinical Trials: Survival Rates of ICFDP—**
Investigations that assessed the utility of ICFDPs (one pontic cantilevered off 2 implants) demonstrated a high survival rate (Table 1). Five studies that spanned 5 years were included in a systematic review. The survival rate for ICFDPs at 5 years was 94.3% (95% CI: 84.1 to 98%) and after 10 years, it was 88.9% (95% CI: 70.8 to 96.1%). Three other investigations, not included in the systematic review because they did not meet all the inclusion criteria, exhibited survival rates of 98% to 100% (Table 1).
Systematic Reviews: Comparison of Survivability of Implant-Supported Cantilevered Fixed Dental Prostheses to Other Types of Fixed Prostheses

The 10-year data indicate that the survivability of ICFDPs with a cantilever of limited mesiodistal dimension (one premolar sized tooth) is 88.9%, which is comparable to fixed dental prostheses retained by teeth (89.1%) or implants without cantilevers (86.7%).

Technical Problems Associated With Implant-Supported Cantilevered Fixed Dental Prostheses

Complications can be divided into 3 different 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). The prevalence of technical complications related to ICFDPs are within the range for implant supported prostheses. In general, these complications do not jeopardize the survivability of ICFDPs, but they do underscore that maintenance is required.

Conclusions and Recommendations

The data indicate that short span ICFDPs are a predictable technique to restore partially edentate areas of the mouth. This finding is in accord with the European Association for Osseointegration. The suggestions in Table 2 are provided to reduce stresses on ICFDPs, which should decrease biological and technical complications and increase their survivability.
INCREASED CROWN-TO-IMPLANT RATIOS

Patients with reduced alveolar bone often present for implant supported restorations, and the final prostheses may demonstrate increased CIRs. Consequently, vertical cantilevers are created and will increase stress, which can affect clinical outcomes. Therefore, the literature was evaluated to determine if increased CIRs have a deleterious effect on prostheses.

**Vertical Cantilevers**

Bidez and Misch calculated that when a crown's height is increased from 10 to 20 mm, there is 100% more force on an implant. However, the central question concerning this theoretical calculation relates to how this affects clinical outcomes.

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**Table 2. Clinical Recommendations for Restoring Teeth With Cantilevers**

1. **Number of Implants**—Fixed dental prostheses utilizing 2 to 3 implants to support a cantilever are successful.
2. **Spacing of Implants**—A span of at least 8 mm between the centers of implants seems proper. Stress on the prosthesis increases when interim implant spacing decreases or cantilever length increases.
3. **Width of Implants**—Increased diameter avoids implant fracture that was reported with 3.3-mm implants.
4. **Mesiodistal Length of the Cantilever**—Keeping the size of the cantilever to the mesio-distal dimension of a premolar.
5. **Dimensions of Connector**—To calculate the rigidity of a beam for occlusal loading, the following formula can be used: $I (rigidity) = \frac{WH^3}{12}$. This formula shows that doubling the buccolingual width ($W$) of the metal connection doubles the strength, but doubling the occlusogingival height ($H$) increases the strength 8 times. Therefore, the thickness in height and width of connectors should be increased. Furthermore, the metal connector next to the cantilevered pontic should be unit-cast and be constructed for maximum strength.
6. **Preloading**—Abutment screws should be retightened several minutes after the initial torque application.
7. **Technological Improvements to Implant Components and Design**—Textured dental implants should be used because they provide increased retention to bone and provide greater surface area to transmit stresses to the bone.
8. **Occlusion and Occlusal Prosthesis Material**—Place the cantilever in infraocclusion (0.1 to 0.2 mm). In addition, a nightguard can be worn to buffer forces applied while sleeping.
9. **Retention of Abutment Crowns**—Abutment preparations should have maximum axial wall length with minimal taper (convergence angle) to increase the retention and resistance form.
10. **Crown-to-Root Ratio**—If the crown-to-implant ratio is extreme, thought should be given either to using wider implants to resist bending moments or employing additional implants for strength.

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**Prosthesis Survivability and Bone Loss Around Implants**

Prosthetic constructs with increased CIRs from one to 2 have a high survivability rate (Table 3). Pertinently, studies that included restorations with CIRs of 2 also demonstrated high survivability. Three additional studies which evaluated cantilevered prostheses reported mean CIRs of 1.6, 1.63, 1.65; their retention rates (≥ 5 years) respectively were 97%, 98.4%, and 95.7%. Likewise, short implants that support prostheses that have increased CIRs have high survival rates. The clinical height of a crown that cannot be surpassed to avoid deossseointegration or implant fracture is undefined and will be affected by many factors (eg, splinting of implants, implant diameter, and magnitude of occlusal forces). Investigators also noted that...
prostheses with increased CIRs did not manifest additional bone loss compared to constructs that did not have elevated CIRs.\textsuperscript{17,18,44-46,48-50}

**Technical Problems**

There is a dearth of information addressing how often technical complications occur with various prosthetic designs (single tooth, straight-line splint, or fixed restorations that have cross arch stabilization) when there are increased CIRs. Several studies assessed the occurrence of technical problems.\textsuperscript{44,46,49} For example, Tawil and Youn\textsuperscript{49} reported the incidence of screw loosening (7.8\%) and porcelain fractures (5.2\%) among teeth with increased CIRs. Similarly, Schneider et al\textsuperscript{46} found no statistically significant increase of technical problems among prostheses with increased CIRs. They reported that 13 out of 76 patients (18.6\%) demonstrated technical complications. The percentage of implants manifesting problems are listed (N = 100 implants): loss of retention (5\%), occlusal screw loosening (4\%), abutment screw loosening (4\%), and chipping of veneer material (4\%). These results are within the range of technical issues associated with implant supported single crowns\textsuperscript{56} and fixed dental prostheses.\textsuperscript{29}

**Conclusions and Recommendations**

The data (Table 3) indicate that constructs with increased CIRs up to 2 have a high survival rate and do not cause further peri-implant bone loss. It can be concluded that implants with elevated CIRs can be used to support single teeth and fixed restorations. These remarks are in accord with the European Association for Osseointegration.\textsuperscript{32} However, since increased CIRs can

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### Table 3. Crown-to-Implant Ratios (CIRs)

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SINGLE UNITS VS SPLINTING</th>
<th>NO. OF IMPLANTS</th>
<th>DURATION (MONTHS)</th>
<th>TYPE OF IMPLANTS</th>
<th>MEAN CIR</th>
<th>PERCENT SURVIVAL</th>
<th>CIR &gt; 2</th>
<th>PERCENT SURVIVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schulte et al\textsuperscript{42}</td>
<td>Single units</td>
<td>889</td>
<td>27</td>
<td>Bicon</td>
<td>1.3</td>
<td>98.2</td>
<td>32/33</td>
<td>97</td>
</tr>
<tr>
<td>Rossi et al\textsuperscript{43}</td>
<td>Single units</td>
<td>40</td>
<td>24</td>
<td>Straumann</td>
<td>1.5</td>
<td>95</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>Urdaneta et al\textsuperscript{44}</td>
<td>Single units</td>
<td>326</td>
<td>79</td>
<td>Bicon</td>
<td>1.6</td>
<td>96</td>
<td>40/40</td>
<td>95</td>
</tr>
<tr>
<td>Birdi et al\textsuperscript{45}</td>
<td>Single units</td>
<td>309</td>
<td>23</td>
<td>Bicon</td>
<td>2</td>
<td>100</td>
<td>139</td>
<td>100</td>
</tr>
<tr>
<td>Schneider et al\textsuperscript{46}</td>
<td>Single units</td>
<td>100</td>
<td>60</td>
<td>Straumann</td>
<td>1.48</td>
<td>95.8</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>Nendir et al\textsuperscript{47}</td>
<td>Mixed; 32% single unit\textsuperscript{b}</td>
<td>528</td>
<td>84</td>
<td>Straumann</td>
<td>1.55/1.97+</td>
<td>100</td>
<td>a</td>
<td>100</td>
</tr>
<tr>
<td>Rokni et al\textsuperscript{48}</td>
<td>Mixed; 38% single units\textsuperscript{b}</td>
<td>199</td>
<td>44</td>
<td>Endopore</td>
<td>1.5</td>
<td>98.2</td>
<td>20/20</td>
<td>100</td>
</tr>
<tr>
<td>Tawil et al\textsuperscript{49}</td>
<td>Mixed (could not decipher)\textsuperscript{b}</td>
<td>234</td>
<td>53</td>
<td>Brânemark</td>
<td>a</td>
<td>99</td>
<td>8/8</td>
<td>100</td>
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<tr>
<td>Blanes et al\textsuperscript{50}</td>
<td>Mixed; 18.7% single units\textsuperscript{b}</td>
<td>192</td>
<td>120</td>
<td>Straumann</td>
<td>1.77</td>
<td>99</td>
<td>48/51</td>
<td>94.1</td>
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<tr>
<td>Sohn et al\textsuperscript{51}</td>
<td>Mixed; 17% single units\textsuperscript{b}</td>
<td>122</td>
<td>55.8</td>
<td>Endopore</td>
<td>1 to 2</td>
<td>&gt; 95</td>
<td>9/9</td>
<td>100</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Not reported.
\textsuperscript{b}Mixed means single crowns and splinted crowns average together.
Table 4. Clinical Recommendations for Restoring Teeth With Increased Crown-to-Implant Ratios (CIRs)²

1. Restore posterior regions so that incisal or canine guidance discludes the posterior teeth and reduces lateral contact in mandibular excursions.⁵⁷

2. Add additional implants to increase the surface area where occlusal forces are conveyed.

3. Wider implants will provide additional bone implant contact area.

4. Centric contacts are centered over the implants⁵² and decrease the occlusal width of posterior teeth.

5. In bruxers, overengineer the case or avoid elevated CIRs.

6. To decrease nocturnal stresses on the prosthetic constructs, patients can use a nightguard.

7. To maximize prosthesis support, short implants ought to be splinted together and furnish cross arch stabilization if feasible.⁴¹,⁵⁸

8. A greater bone implant contact will be achieved with textured surfaced implants.

9. Flatten cuspal inclines.⁵²

10. Use implants with reduced thread pitch (space between the threads), which increases the number of threads per unit length and surface area.⁵⁷

cause increased occlusal forces, techniques to reduce stresses on prostheses are listed in Table 4.²,⁴¹,⁵²,⁵⁷,⁵⁸

Part 2 of this article will be published in the next issue of Dentistry Today.

REFERENCES


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1. In terms of the relationship between bone microstrain and physiological responses, which relationship is CORRECT?
   a. 50 to 1,500 ue—atrophy.
   b. 1,500 to 3,000 ue—normal bone modeling.
   c. > 3,000 ue—overload.
   d. None of the above.

2. The stress on implants supporting an implant-supported cantilevered fixed dental prosthesis (ICFDP) is __________ greater than found on single implants not supporting a cantilever.
   a. 1.5 times.
   b. 2 to 3 times.
   c. 4 times.
   d. 5 times.

3. Which statement about cantilevered prostheses off of 2 implants is FALSE?
   a. They have a reduced survival rate compared to implant-supported prostheses without cantilevers.
   b. There is no increased bone loss around the terminal abutment.
   c. There is increased torque on abutment teeth.
   d. Their utilization broadens treatment options.

4. Which recommendation for construction of cantilevers is FALSE?
   a. It is beneficial if the interimplant distance between 2 implants is 8 mm.
   b. It is beneficial if the pontic on a cantilevered prosthesis is around 8 mm.
   c. If a cantilevered bridge is constructed in a bruxer, the case should be overengineered.
   d. Cantilevered prostheses should be limited to the anterior section of the dentition.

5. Fixed dental prostheses utilizing 2 to 3 implants to support a cantilever are successful. A span of at least 12 mm between the centers of implants seems proper.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.
6. Data indicate that short-span IC FD Ps are a predictable technique for restoring partially edentate areas. However, this finding is not in accord with the European Association for Osseointegration.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.

7. The prevalence of technical complications related to IC FDPs are within the range for implant-supported prostheses. In general, these complications do not jeopardize the survivability of IC FDPs.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are false.
   d. Both statements are true.

8. When restoring teeth with increased CIRs, use implants with reduced thread pitch. Reduced thread pitch increases the number of threads per unit length and surface area.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.

9. Strategies to consider when fabricating fixed dental prostheses with increased CIRs include the following:
   a. Minimize lateral excursions on posterior prostheses and increase the number of supporting implants.
   b. Increase clinical crown height.
   c. Employ textured surfaced implants.
   d. Both a and c.
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3. ☐ a ☐ b ☐ c ☐ d
4. ☐ a ☐ b ☐ c ☐ d
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