A RISK ASSESSMENT TREATMENT PLANNING PROTOCOL FOR THE FOUR IMPLANT IMMEDIATELY LOADED MAXILLA: PRELIMINARY FINDINGS

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Statement of problem. There is debate as to the efficacy of maxillary complete arch reconstructions when only 4 implants are used.

Purpose. The purpose of this study was to determine what risk factors, if any, may increase the likelihood for implant failure in immediate function by using a tilted distal, 4-implant approach in the maxilla.

Material and methods. A retrospective analysis of implant performance was conducted for patients treated with 4 implants placed in 285 maxillae (1140 implants) and 273 mandibles (992 implants) providing immediate function for complete arch implant-supported prostheses. The consecutively treated patient cohort consisted of those who provided consent between April 2008 and December 2010. A retrospective chart review was conducted to assess potential maxillary implant failure factors, including a history of smoking, gender, opposing occlusion, bone density, bone volume, insertion torque, parafunction, failed implant site, addiction, and systemic factors. Data were analyzed with descriptive statistics. A series of risk factors were postulated in an effort to establish guidelines for modification of treatment planning protocols in response to combined risks.

Results. Several common primary factors in maxillary implant failure scenarios were identified through this process of patient profiling. Opposing natural dentition, male gender, lack of bone density, the distal implant site, and parafunction were sufficiently frequent occurrences in failure situations to suggest that either the use of additional implants or delayed loading and the provision of a complete denture as an interim prosthesis may be more appropriate in the management of patients identified as being high risk. Secondary factors such as bone availability (volume) and smoking were less common in failure situations.

Conclusions. A preliminary protocol is suggested for both treatment planning and profiling patients with respect to presenting characteristics that may contribute to implant failure. A decrease in failure occurrence has been noted anecdotaly during the short term implementation of this protocol. (J Prosthet Dent 2011;106:359-366)

Clinical Implications

As a result of a performance analysis from a population of immediately loaded complete arch maxillary implant patients, a treatment planning protocol is suggested to help identify those parameters that may contribute to increased risk for implant failure.

A popular emerging concept since the introduction of osseointegration in 1982 is the use of implants for immediately loaded restoration of edentulous or failing dentition patients.1-13 Among modifications to the immediate load surgical technique has been a suggested redirection of the distal implants from vertical to distally inclined axial positions in both jaws to enhance the anterior-posterior spread and increase the distally inclined implant length. Published results of up to 10 years duration using tilted distal implants in multiples of 5 or more have shown favorable success rates.14-21 Further refinements have sug-

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b Private practice, Dallas, Texas.
suggested that the number of implants generally required for either arch can be reduced to 4, resulting in the popularization of the “All-on-4” technique.22,23 This concept uses 2 vertical anterior implants in conjunction with 2 distally tilted inclined implants with their apices positioned anterior to the sinus wall or mental foramen.14,22 The resultant increase in anterior-posterior spread when compared to their placement in noninclined positions eliminates the need for grafting, facilitates cross-arch stabilization, and minimizes the cantilever extension.

Based on the literature specific to this 4 implant concept, there appears to be a tendency for maxillary implant failure at a rate of 5 to 6 times that found in the mandible. This trend has been replicated in a recently completed review of implant patients from a private practice (Table I). Given this disparity in arch specific implant survival, the present study was initiated to identify presenting risk factors at the time of initial examination that may be predictive in treatment planning for immediate loading in the maxilla.

**MATERIAL AND METHODS**

Records were reviewed for all patients who experienced an immediately placed/loaded primary maxillary implant failure in a private practice focused on implant placement and restoration from April 2008 through December 2010 (Table I). Only patients who were restored with 4 maxillary immediately loaded implants according to the tilted distal implant protocol were included.22 Patients who were edentulous on initial presentation, or who required complete arch extractions due to excessively compromised or failing dentition were included. Individuals who required maxillary grafting as a prerequisite for implant placement were excluded from participation in this retrospective review. All patients underwent a cone beam Computerized Axial Tomography (CAT) scan film study (i-CAT, Imaging Sciences Intl, Hatfield, Pa) and evaluation of presenting osseous parameters as part of the initial examination. A complete periodontal evaluation and a complete mouth, periapical radiographic series was also completed for patients with residual dentition. All patients were deemed healthy enough to undergo the surgical procedure with intravenous sedation techniques with the exception of 4 individuals who required hospitalization for various medical conditions. Those with lesser medical contingencies were required to obtain a medical release before any surgical procedures were performed.

Data were collected from the records of those patients who experienced a primary failure of an immediately implant placed by using the tilted distal implant protocol. The ages of the 285 patients included in this study ranged from 18 to 102

Table I. Overall survival rates for both jaws treated with only 4 implants per jaw by using tilted distal, 4 implant approach

<table>
<thead>
<tr>
<th>Number of Jaws</th>
<th>Number of Implants Placed</th>
<th>Number of Failed Implants</th>
<th>Implant Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxilla</td>
<td>285</td>
<td>1140</td>
<td>41</td>
</tr>
<tr>
<td>Mandible</td>
<td>273</td>
<td>992</td>
<td>7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>558</td>
<td>2132</td>
<td>48</td>
</tr>
</tbody>
</table>

*Six implants lost directly to trauma. Survival excluding these implants: 96.93%

Table II. Rate of occurrence of either primary or secondary contributors to implant failure (n=41) in 20 patients

<table>
<thead>
<tr>
<th>Factor</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opposing natural dentition</td>
<td>16 of 20</td>
</tr>
<tr>
<td>Opposing implant-supported complete arch restoration</td>
<td>4 of 20</td>
</tr>
<tr>
<td>Poor Bone Density</td>
<td>17 of 20</td>
</tr>
<tr>
<td>Male gender</td>
<td>15 of 20</td>
</tr>
<tr>
<td>Posterior implant</td>
<td>32 of 41</td>
</tr>
<tr>
<td>Bruxism</td>
<td>9 of 20</td>
</tr>
<tr>
<td>Smoker</td>
<td>4 of 20</td>
</tr>
</tbody>
</table>
years, with a mean of 67.2 years.

There was no attempt in this retrospective review to evaluate the performance of implants used in rescue procedures placed to manage implant failures. The record search included the following presenting characteristics for each patient failure experience: opposing natural dentition, opposing implant denture, presence and location of soft bone, insertion torque of all implants loaded as determined by the manufacturer recommended insertion device, parafunctional habit, smoking history, implant location, drug use (addiction), systemic factors, gender, and pathology (Table II).

RESULTS

The study period was 33 months, with a minimum observation period of 4 months. The relative incidence of the various factors is presented in Table III. The primary factors contributing to implant failure that the patients had in common were opposing natural dentition, poor bone density, male gender, bruxism, and the location of the failure at a posterior distally inclined site.

Smoking, bone availability (volume), systemic factors, and local infections did not have meaningful repeatability as a finding. Of the other remaining factors evaluated, addictive drug use and pathology, including the existence of periapical infections did not appear to be related to implant failure in this patient population.

Six of the primary maxillary implant failures documented were attributed directly to trauma, including 4 in one patient as a result of a motor vehicle accident at an early stage in the healing process. The remaining 2 failures were from a sports injury and an assault. All of these failures were included in the documentation, but they do not represent a common mode of failure in the general implant population.

Both existing opposing natural mandibular dentition (80%) and poor bone density (85%) presented the highest percentages of all failure scenarios. The inherent strength of the remaining teeth, the often irregular opposing occlusal plane, or the skeletal occlusal classification may have significant relevance to these findings (Figs. 1-3). Maxillary fixed restorations with a failure opposed by a mandibular corresponding fixed implant prosthesis were less common (9 of 41), possibly due to a better control capability of the distal forces and occlusal plane.

The diagnosis, retrospectively, of soft bone based on CBCT scan Hounsfield unit (HU) values was a significant finding (Figs. 4-7). The same scan unit was used for presurgical evaluation of all patients in the present retrospective review. A spiral CT unit is beneficial to obtain an actual CT reading of Hounsfield units, but since all measurements attained here were from the same cone beam unit, a relative theoretical value could be used for evaluation. All failure sites recorded had measurements of 100 HU or less based on the results of the present retrospective review. Correlation of the insertion torque values at each failure site was also identified as a concern, with insertion torques of all failed implants being less than found in adjacent integrated maxillary sites in most situations.

The distal location of the vast ma-

<table>
<thead>
<tr>
<th>Table III. Decision tree for risk analysis of immediate loading in maxilla based on occurrence of these risk factors as findings at time of initial examination. Any single finding is elevated as potential risk for failure when combination of factors occurs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highest Risk</strong></td>
</tr>
<tr>
<td>Male Patient</td>
</tr>
<tr>
<td>Opposing Natural Dentition</td>
</tr>
<tr>
<td>Poor Bone Density</td>
</tr>
<tr>
<td><strong>Lesser Risk</strong></td>
</tr>
<tr>
<td>Systemic Factors</td>
</tr>
<tr>
<td>Local Infections/Pathology</td>
</tr>
<tr>
<td>Opposing Complete Arch Implant Restoration</td>
</tr>
<tr>
<td>Bone Volume</td>
</tr>
<tr>
<td>Smoking</td>
</tr>
<tr>
<td>Bruxism</td>
</tr>
<tr>
<td>Distal Posterior Implant Site</td>
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</tbody>
</table>
The majority of the failed implants (32 of 41) is an especially important finding. Given the increasing load potential in the posterior sextants when compared to that of the anterior sextant, it is reasonable to conclude that implants in the premolar-molar cantilever region are subjected to higher occlusal loads, even when the distal extension cantilever length was reduced in the provisional prosthesis. The initial failure of any distally inclined implant may also contribute to a cascade effect on the adjacent anterior implant(s) due to the occlusal load transfer anteriorly when bone support on the distally inclined sites is compromised. If the length of the implant used in this region was compromised, or the insertion torque was challenged in achieving initial stability, a modification in implant numbers, type, or arrangement may be indicated either on a preplanned basis...
Evidence of occlusal wear pattern emanating from horizontal bruxing pattern on residual mandibular dentition. Patients with similar wear patterns on natural opposing dentition require careful management of occlusal forces for opposing complete arch maxillary implant prostheses.

Even though bone volume (availability) is favorable, low HU density measurements (consistent values below 100 HU) in maxillary medullary bone may result in commensurate low insertion torque values at surgery.

Panoramic view shows completed screw-retained complete arch CAD/CAM titanium framework implant prosthesis supported by 6 implants (most posterior implants distally inclined).

or as needed at time of surgery.

The disparity in gender failures may also be important, with men almost 3 times more likely to experience a primary implant failure. Although again speculative, it is possible that the generally stronger occlusal forces that can be generated by men may play a role in this finding. Only 4 patients with a failed primary implant were smokers.

An evaluation of bruxing patterns revealed that these were a contributing factor, but not at the same level as those noted as a primary predictor for failure potential. Horizontal bruxers in particular have the ability to create extreme wear patterns on the natural dentition and have equal ability to wear occlusal surfaces of implant-supported prostheses. About one-half of the failures recorded had a bruxing component. However, in none of these individuals was bruxing a sole contributing factor (Figs. 8-11).

DISCUSSION

Since the initiation of the profiling approach to treatment planning, a significant reduction in primary implant failures has been noted. No patients in a primary risk category or combination of categories experienced a failure of a maxillary implant. These patients were either immediately loaded with more than 4 implants or placed in provisional dentures because of poor bone density, identified by the CAT scan (Hounsfield unit assessment) preoperatively and subsequent low insertion torque confirmed surgically.

Based on information gathered over a 33 month period in this dedicated implant practice environment, it is suggested that the effect of opposing natural dentition on the distribution and control of occlusal forces against a maxillary complete arch implant-supported prostheses may be critical. Additional implants may be necessary to stabilize the prosthesis in this immediate load protocol or be planned for delayed loading with a conventional provisional tissue-borne complete maxillary denture.

The evaluation of bone volume and especially bone density with a CAT scan was noted as significant as regards its importance in planning

5 Insertion torques for all implants placed in maxilla were approximately one-half (25 N/cm to 30 N/cm) of desired values for implant being used.

6 All implants were capped at abutment level following surgery. Intaglio surface of provisional denture was relieved to prevent any inadvertent overloading during healing.

7 All implants integrated successfully and now support complete arch maxillary and mandibular, screw-retained, implant-supported prostheses.
appropriate for this patient.

8 CAT scan for patient showed some areas of bone with low (below 100 HU) density values but acceptable bone availability.

9 In addition to areas of soft bone noted in Figure 8, combination of opposing natural dentition, irregular occlusal plane, bruxing pattern, and male gender suggested placement of greater number of implants might be appropriate for this patient.

10 Six maxillary implants were ultimately loaded following implicated healing. Two pterygoid implants were left unloaded (sleepers) but are integrated should they be needed.

11 Final maxillary, complete-arch, fixed 6-implant supported prostheses recorded at 16.5 months after treatment.
maxillary implant therapy.

The anticipation of low insertion torque based on less than ideal bone density measurements may help prepare both surgeon and patient for the clinical reality. Planning for additional implants for immediate load situations or not loading at all if insertion torques are below the threshold level for the system in use are both viable alternatives to help avoid an unintended postsurgical consequence. Creating an informed consent based on the possibility that an interim denture may be necessary instead of an immediate load provisional fixed implant prosthesis is an essential aspect of assuring a satisfactory patient experience.

Factoring other clinical findings such as gender, bruxism, systemic disease, anatomic limitations (bone availability), and smoking into the planning process may also help determine if more than 4 implants or an implant variation such as zygoma or pterygoid implants might be needed to help avoid failure.

Only 4 patients with a failed primary implant were smokers. Recent literature has shown that surface treated implants offer less failure probability than the original machined surface fixtures for those patients known to be smokers. The same effect may have occurred with this patient group as all implants used had an enhanced oxide surface treatment (TiUnite, NobelBiocare, Yorba Linda, Calif) and smoking played only a small effect in the failure analysis.

Patient compliance with preoperative and postoperative instructions such as smoking cessation, soft diet, and use of an occlusal guard can have a potentially significant role in the occurrence of primary failures. Unfortunately, this is a difficult parameter to assess during the preoperative planning stage as all patients received the same instructions and agreed to comply. It is also an unreliable data point to address in the interview following an implant loss since some patients deny being noncompliant or having a parafunctional habit of which they are unaware. For these reasons, the issue of noncompliance was not included in the present evaluation.

The ability to create an intake patient profile based on the experience of failure derived from this retrospective review can be useful when diagnosing and planning the treatment of implant patients with regard to possible implant failure (Table IV). Even though the percentage of maxillary implant failures in this patient group was low, the overall number of failures was high enough to identify trends, possibly draw significant conclusions, and offer the opportunity to counsel patients regarding the risk/reward of the procedure.

It is possible that any one of the previously mentioned profile findings may be a strong enough single consideration to directly influence the number of implants potentially needed for a successful outcome. It is probably more realistic, however, that these factors in combination will make a stronger statement when considering variations on the 4 implant scheme for maxillary implant reconstruction. It is important to realize that the planning principles suggested here are based on a relatively small patient population in a single practice with a relatively small implant failure rate. How uniformly these guidelines can be applied to other clinical settings may depend on variables not yet determined and on clinical practice protocols already in place.

Preliminary results from a second patient population treatment, planned by using the failure criteria presented here, demonstrates an early trend towards significantly improved implant rates of survival. Further experience and the failure evaluation of larger patient populations over longer periods will be necessary before more definitive conclusions can be drawn.

**CONCLUSION**

The findings of a retrospective chart analysis of primary implant failures in 285 consecutively treated patient maxillae using the tilted distal, 4 implant concept, suggest that a number of presenting factors may have potential influence on implant survival. These factors, when considered and evaluated presurgically, can be helpful in planning the treatment of patients with regard to the possible number of appropriate implants necessary and the possible loading sequence for optimal integration and prosthesis success. When encountered in combination, these factors could be considered even more powerful predictors of potential implant complications.

**REFERENCES**


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