INVESTIGATING THE LONGEVITY OF IMPLANT PROTECTED-OCCLUSION UTILIZING THE TEKSCAN III: A PROSPECTIVE STUDY

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MASTER'S THESIS

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ABSTRACT

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Introduction: Implant-Protected Occlusion is an occlusal philosophy thought to reduce the forces on implant-retained restorations. Implant occlusal overload is reported to cause crestal bone loss, implant fracture, screw fracture, screw loosening, and prosthesis failure. It has been supported implant protected occlusion aids in dental implant and restoration success.

Methods: Patient inclusion criteria consisted of a single, endosteal implant bound and opposed by natural dentition. Upon delivery of the restoration, the restoring dentist verified implant protected occlusion clinically. The Tekscan III quantitatively measured the occlusal force percentage exerted at maximum intercuspation on the cement-retained implant restoration. Each subject was enrolled with the intent to be followed-up at three, six, nine, and twelve months from the baseline at time of delivery.

Results: The non-parametric Wilcoxon Signed Rank Test was used for pair wise comparison between initial and three, six, nine, and twelve months of data in zones 0 (anterior), 1 (premolar), and 2 (molar). There is not a significant change in the anterior and premolar region ($p>0.05$). Initial evaluation to three, six, nine, and twelve months in the molar region results in a statistically significant difference ($p<0.05$).

Conclusions: Statistical analysis between initial and three, six, nine, and twelve month testing exhibited a significant difference in the molar restoration group. Although a statistically significant difference was shown it is questionable whether the difference is clinically significant.

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REVIEW OF THE LITERATURE

Dental implants have significantly transformed dental treatment. Merited by their high level of predictability and versatility, dental implants enhance treatment options with sufficient data to promote and guarantee single-tooth implants as a functionally and biologically sound restoration [1]. Treatment planning should reflect the best possible long-term solution for each individual. The goal is to prescribe a treatment plan restoring the patient to optimum function, esthetics, and health [2]. Multiple reports demonstrate a cumulative survival rate of single-tooth implants to be 97.2% at five years and with a ten-year rate higher than conventional, fixed partial dentures. According to Misch, this indicates a single-tooth implant has the highest treatment success rate in comparison with all other fixed or removable modalities. [1]. Other benefits also include lower adjacent tooth risk and bone preservation. Fixed partial denture abutments are at 18% risk to develop caries and at an 11% risk to require endodontic treatment following preparation [3]. A single-tooth implant requires no preparation of adjacent teeth. Single units allow for better access to cleanse providing more evidence to support a single-tooth implant over a fixed partial denture [4]. Not only are single-implant restorations beneficial to replace missing teeth but alleviate potential endodontic therapy. Systematic reviews conclude the success rate for root canal therapy ranging between 92-97% over four to eight years and dental implants ranging between 95-99% over two to sixteen years [5]. Although lacking direct comparison, literature supports for six years survival rates single-tooth implants outperforming other treatment options [5-7].

The longevity of successful dental implants depends on understanding the possible occlusal stresses and core prosthodontic occlusal concepts [8]. The biomechanics of implant restorative complications require complete understanding for ensured long-term success. An implant is not a natural tooth and varies in biologic attachment and biomechanical force distribution. Some implant versus natural tooth differences are shown in Table 1.

Table 1. Tooth and Implant Comparison

Characteristic	Tooth	Implant
Attachment	Periodontal ligament	Osseointegration, functional ankylosis, no fibrous attachment[1]
Fiber orientation	Perpendicular	Parallel[2] (except laser microetched surface)[3]
Proprioception	Mechanoreceptors in the PDL	Osseoperception for tactile sensibility
Axial mobility	25–100 μm axially[4]	3–5 μm vertically[4,5]
Horizontal Mobility	56–150 μm vertically in buccolingual direction[4]	10–50 μm in the buccolingual direction[4,5]
Response to lateral load	Rotates at apical third of the root, force diminished immediately from crest of bone along root	Concentration of greater forces at the crest of the surrounding bone of implants, no rotation of the implant, higher load concentrated at the crest
Movement phases	Nonlinear, 2 phases	Linear, lacks initial phase, secondary/elastic phase only[6,7]
	Initial: vertical within PDL boundaries	
	Secondary: elastic deformation of alveolar bone[6,7]	
Fulcrum to lateral force	Apical third of root[8,9]	Crestal bone level
Load-bearing characteristics	Shock-absorbing function, stress distribution[5]	No shock absorption, stress concentration at crestal bone[4]
Modulus of elasticity	Similar to the cortical bone[10]	5–10 times of the cortical bone[11]

Table 1 Sheridan, et al. compares natural dentition versus implants [15].

The fundamental difference between a natural tooth and dental implant is the biologic attachment. A natural tooth is contained within the bone by the periodontal ligament. The periodontal ligament provides proprioception and allows 25-100um apicogingival and 56-150 um buccolingual displacement in response to functional loading [4,9,15]. Compression of the periodontal ligament in natural teeth permits orientation to direct load axially. An endosseous implant is osseointegrated (Branemark), functionally ankylosed

(Schroeder), directly contacting bone, and lacking a periodontal ligament [4,10]. Implant movement demonstrates 3-5um vertically and 10-50 um laterally due to loading of the bone [9]. Without a periodontal ligament to cushion force distribution and relay pain, dental implants concentrate forces at the bone crest and are insufficient at discerning occlusal trauma [8]. Due to lack of the periodontal ligament to aid in redirection of forces, nonaxial loading of dental implants and implant occlusal overload promotes crestal bone loss, implant fracture, screw fracture, screw loosening, and prosthesis failure [10, 12-14]. Several studies summarized by Kim give numerical value to the potential difference in tactile perception:

> *Interference perceptions of natural teeth and implants with opposing teeth were approximately 20 and 48 mm, respectively. In another study (Mericske- Stern et al. 1995)…The detection threshold of minimal pressure was significantly higher on implants than on natural teeth (3.2 vs. 2.6 foils). Similar findings were also reported by Hammerle et al. (1995) in which the mean threshold value of tactile perception for implants (100.6 g) was 8.75 times higher than that of natural teeth (11.5 g) [11].*

Dental implants reveal potential complications to occlusal overload recognition due to lack of occlusal force distribution and proprioception.

Osseointegrated implants, unlike natural teeth, react biomechanically different to occlusal force. Occlusal overload in dental implants lacks evidence to substantiate an association with loss of osseointegration, but mechanical failure of dental implant restorative components should be considered [10]. Overloaded dental implants exhibit screw loosening, abutment and prosthesis fracture, and/or possible implant fracture [4,13,15]. Faultless occlusion includes harmonious mastication ability and esthetics without pathology. Implant-specific occlusion remains a highly variable concept within evidence-based dentistry. The literature is based on theory and anecdotal accounts with little scientific foundation [16]. Occlusion for dental implant restorations has been a variation of natural tooth occlusion and/or complete denture occlusion [16]. Dental implant occlusal overload can be heavily iatrogenic in nature and requires attention to minimize cantilevers, bruxism, steep cusps, interferences, and inappropriate force control [17]. Misch and Bidez first described implant-protected occlusion based on the principles of minimizing force [18]. To minimize force, decrease magnitude, decrease duration, align force direction axially and distribute the force to the least susceptible tooth/teeth [18]. Occlusal restorative concepts have evolved and continue to development and advance in implant dentistry [16]. Overloading factors negatively influencing implant longevity can include: large cantilevers, parafunctions, poor occlusal design, and premature contacts [9]. Currently, there are only empirical guidelines for implant restorations. However, controlling implant occlusion within the physiologic limits of the fixture environment influences long-term implant success. This may also provide possible solutions to managing complications related to implant occlusion [10]. Implant protected occlusion suggests narrowing the occlusal table, decreasing the cusp height, and distributing occlusal contacts along the dental implant long axis [18,19]. Taylor promotes creating an occlusal scheme for an implant-supported restoration to minimize potential excursive prematurities and maximize patient comfort [16]. Gross uses references to identify and support single implant occlusion:

> *Minimize occlusal force onto the implant and to maximize force distribution to adjacent natural teeth (Misch 1993; Lundgren & Laurell 1994; Engelman 1996). To accomplish these objectives, any anterior and lateral guidance should be obtained in natural dentition. In addition, working and non-working contacts*

> *should be avoided in a single restoration (Engelman 1996). Light contacts at heavy bite and no contact at light bite in MIP are considered a reasonable approach to distribute the occlusal force on teeth and implants (Lundgren & Laurell 1994). Like posterior fixed prostheses, reduced inclination of cusps, centrally oriented contacts with a 1–1.5 mm flat area, and a narrowed occlusal table can be utilized for the posterior single tooth implant restoration (Weinberg 1998; Curtis et al. 2000). Wennerberg & Jemt (1999) claimed that centrally oriented occlusal contacts in single molar implants were critical to reduce bending moments attributable to mechanical problems and implant fractures. [9]*

The occlusal philosophy for dental implants must be founded in biomechanical principles; but currently there is no evidence-based, implant-specific occlusal scheme. Future studies in this area are needed to elucidate the relationship between occlusion and implant success.

Dental practitioners must adapt conventional and modern techniques to keep current with the changes in technology and research. One area of expansion and conflict of views relates to the maintenance of dental implants. Implant success depends not only on the priority of planning but also emphasizing the significance of maintenance. Maintenance includes radiographic evaluation, inspection of the implant restoration components, and occlusal monitoring. Limited evidence suggests necessary modifications on implant restorations over the course of time, the idea of implant protected occlusion permanence remains unanswered: “occlusion of a fixed implant prosthesis developed at insertion may change significantly in the first 18 months after placement” [20].

MATERIALS AND METHODS

All required materials for the human subject research were submitted to the IRB at the Veterans Affairs Medical Center Washington DC and approved under protocol #01386. The following inclusion criteria were followed: the patient had to have a single implant restoration, located anywhere in the dentition, bound mesially, distally, and opposing by natural teeth. Restorations included in the study are cement-retained restorations, where the custom abutment was placed and torqued to the manufacturer's guidelines with the final restoration cemented. The restorative material of choice for the purpose of this study was not specified and includes porcelain fused to metal crowns as well as all ceramic restorations. The implant restorations were all restored according to implant protected occlusion protocol which included no contact on the implant restoration under light occlusal force, light contact on the implant restoration under heavy occlusal force, and no contact on the restoration in excursive movements or premature contacts. Dental providers clinically evaluated the implant contact utilizing a metal foil for occlusion testing (ShimStick, 8u, Almore International, Inc, Portland, OR).

Once the implant protected occlusion was confirmed clinically, the patient was sent to the research coordinator where occlusal analysis system utilizing the T-Scan was used (T-Scan III, Tekscan, Inc., Boston, MA). The T-Scan III was calibrated according to manufacturer's instructions. The sensor was placed in the patient's mouth. The patient was instructed to "bite down normally" three times. The position, timing, and percentage of force of the occlusal contacts were recorded with the T-Scan III. The percentage of force data recorded on the implant of interest was determined when the T-Scan algorithm automatically averaged the patient's bite force at maximum intercuspation. The data and video file were saved under a randomly assigned code, which was assigned to each patient.

The patients involved in the study were asked to return to the dental clinic at three, six, nine, and twelve months to re-evaluate the permanence of implant protected occlusion. The same protocol for the T-Scan III was followed at each follow-up appointment.

RESULTS

Over the accumulation of data in this continuing prospective study, the 50 implants investigated were distributed into positional categories: anterior (Zone 0), N=19 (38%); premolar (Zone 1), N=16 (32%); and molar (Zone 2), N=15 (30%); see Figure 1.

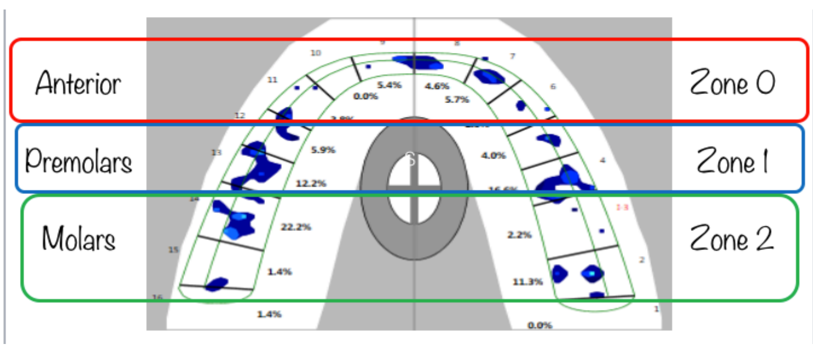

Figure 1 shows division into similar position categories and related zones.

Thirty-four implants (68%) were lost to recall. A non-parametric Wilcoxon Signed Rank Test was performed for pair-wise comparison between initial and three, six, nine, and twelve months of data in Zones 0, 1, and 2 (Table 2, 3, 4, and 5).

Table 2, 0-3 months	P-Value	Significant P-Value (<0.05)
Anterior (Zone 0)	0.28774	No
Premolar (Zone 1)	0.5	No
Molar (Zone 2)	0.00621	Yes

Table 2 P-values of Zones 0, 1, and 2 at initial to three months.

Table 3, 0-6 months	P-Value	Significant P-Value (<0.05)
Anterior (Zone 0)	0.22965	No
Premolar (Zone 1)	0.25463	No
Molar (Zone 2)	0.0017	Yes

Table 3 P-values of Zones 0, 1, and 2 at initial to six months.

Table 4, 0-9 months	P-Value	Significant P-Value (<0.05)
Anterior (Zone 0)	0.40517	No
Premolar (Zone 1)	0.38645	No
Molar (Zone 2)	0.00169	Yes

Table 4 P-values of Zones 0, 1, and 2 at initial to nine months

Table 5, 0-12 months	P-Value	Significant P-Value (<0.05)
Anterior (Zone 0)	0.34652	No
Premolar (Zone 1)	0.22789	No
Molar (Zone 2)	0.00169	Yes

Table 5 P-values of Zones 0, 1, and 2 at initial to twelve months

Measuring from initial time to three, six, nine, and twelve months, there is not a significant occlusal change in the anterior region ($p>0.05$). Using the same measuring parameters there is not a significant change in the premolar region ($p>0.05$). The same protocol in the molar region results in a statistically significant difference ($p<0.05$) in occlusal change. Although statistically significant, these occlusal changes merited no clinically detectable change in the implant protected occlusal scheme. Implant protected occlusion was not adjusted since time of delivery and no biologic or mechanical complications were discovered.

DISCUSSION

This report is the conclusion of a four-year study. It was only performed on cemented vice screw retained implant restorations. The inclusion criterion of a cement-retained implant crown is limiting, as screw-retained implant restorations are currently the favored treatment of choice in Prosthodontics. There are a limited number of subjects enrolled and retained in the study. Factors affecting this were reliability of patients and the transient nature of patients themselves. At the advent of this study, it was generally agreed that some form of "implant protected" occlusion was the accepted occlusal scheme to promote the overall lifespan and long-term survivability of endosseous root form implant fixtures. While still a controversy since that time, studies have found mechanical implant overloading does not result in osseointegration loss or marginal bone loss [21] but off-axis loading and premature contacts are of detrimental mechanical concern [11]. Speculation that molar implant restorations are most often over contoured and misaligned within the dental arches due to available bone could be the result of the noted significant change. Greater forces in zone 2 due to class 3 fulcrum explain potential for generating more of a dynamic change. In order to prevent implant complications positional changes, re-evaluation and periodic occlusal adjustments may be necessary. A better understanding of implant occlusion would allow clinicians to take a more preventive approach when performing implant treatment planning to ensure the long-term stability of implant restorations [22]. Evaluation of implant protected occlusion itself may have more clinical significance than it permanence overtime simply due to occlusal evaluation is a component of patient recall examinations. The development of evidence-based treatment and protocols is necessary to develop a practical guide to aid practitioners in reducing complexity is needed [22].

CONCLUSIONS

A study was designed to evaluation the stability of implant-protected occlusion over time. Statistical analysis between initial and three, six, nine, and twelve month testing demonstrated a significant difference in occlusal force in the molar restoration group ($p<0.05$) overtime but not in the anterior or premolar groups. Although a statistically significant difference was shown it is questionable whether the difference is clinically significant. Further investigation is required to discern the variable of implant occlusion.

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