Instrument Selection and Application Used to Probe Dental Implants

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**Purpose:** The purpose of this study was to survey clinicians’ choice of peri-implant instrument selection and the application used to probe dental implants as well as to evaluate peri-implant probing force and pressure applied compared with that reported in current literature. **Materials and Methods:** Forty-eight clinicians (16 periodontists/periodontal residents, 16 restorative dentists, and 16 hygienists) participated in the study. A questionnaire to determine the frequency and method of probing dental implants was provided and subject to the chi-square test. Each participant was given a choice of three periodontal probes (Marquis, UNC-15, plastic) to use on the typodont, and the probing force was recorded blindly. The probing force and pressure data were analyzed with analysis of variance (ANOVA) among subject groups as well as probe types per site; where statistical differences (P < .05) were detected, Tukey’s post hoc test was applied. **Results:** The questionnaire resulted in a variety of answers, although the majority demonstrated an agreement on probing implants in everyday practice. There was no significant difference among provider groups in regard to instrument selection, probing forces, and pressure in both the maxilla and mandible, although the mean probing forces and pressures in all provider groups were higher than the suggested value reported in the literature. **Conclusion:** This study indicated that there are variations among clinical provider groups with regard to peri-implant probe instrument type used and forces applied, though these are not statistically significant. Probe tip diameter should be considered to avoid bleeding on probing false positives when probing dental implants, especially as the forces generally used by the clinicians may be higher than advised. INT J ORAL MAXILLOFAC IMPLANTS 2019;34:115–123. doi: 10.11607/jomi.6950

**Keywords:** bleeding on probing, implant health, implant probing, probing pressure

Endosseous dental implants have become a highly popular modern treatment to restore compromised function and esthetics in edentulous sites. Excellent personal oral hygiene and dedicated dental implant maintenance are crucial to achieve long-term success with dental implants. The importance of appropriate diagnosis of the peri-implant tissue health is magnified with the ever-increasing number of dental implants placed and restored. Diagnostic parameters used in assessing peri-implant health and disease include mobility, suppuration, peri-implant probing, bleeding on probing (BOP), radiographs, and gingival indices.1–3 Current peri-implant hard and soft tissue disease conditions are categorized as either peri-implant mucositis or peri-implantitis. Peri-implant mucositis is defined as the presence of visual inflammation of the peri-implant soft tissues and bleeding on peri-implant probing.4 Peri-implantitis is defined as the presence of peri-implant probing depth ≥ 5 mm associated with BOP and/or suppuration with radiographic evidence of bone loss.5

The use of the periodontal probe in estimating peri-implant probing depth and detecting clinical signs of inflammation has historically been a linchpin in clinical diagnostics. The degree of peri-implant inflammation is often characterized based on BOP, wherein the absence of BOP serves as a strong positive prognostic value in determining peri-implant health. Clinical
trials report that BOP represents a low positive predictive value for disease progression and/or recurrence; however, the absence of BOP has a rather high negative predictive value and, hence, indicates periodontal stability for health. BOP has been reported to have a higher diagnostic accuracy for peri-implant health than for natural teeth. Lutherbacher et al compared dental implant probe sites vs natural tooth probe sites and reported that at all threshold frequencies, implant sites yielded higher sensitivity and specificity for a positive BOP test result than did natural tooth sites. When peri-implant BOP frequencies of ≥ 50% were achieved, the positive predictive value for disease progression to occur was 100%. BOP is a valuable diagnostic marker for monitoring peri-implant tissue changes and can be a reliable predictor of loss of support around peri-implant mucosa.

The accurate clinical assessment of peri-implant BOP and probing depth depends on variables including the degree of peri-implant soft and hard tissue inflammation, peri-implant probe tip diameter, probe angulation, probing force used, and even the effect of systemic medications. Previous studies suggest an optimal probing force around natural teeth ranging from 0.25 N to 0.75 N; however, the heterogeneity of probe types studied limits valid comparisons of the recommended probing forces. The probing forces and the specific probe types used in the probing studies require appropriate calibration in order to compare potential discrepancies, as the probing pressure at the tip ultimately determines the probing depth.

Probing pressure is determined by dividing the probing force applied on the probe by the area at the tip end. Larsen et al investigated the significance of the concept of probing pressure around natural teeth and provided a correction factor that compensates for the different probing pressures used in various studies. The review critiqued that the majority of probing studies failed to incorporate the probing force and the probe tip dimension together; instead, they reported only one or the other. It is important for clinicians to acknowledge the principal of probing pressure when understanding such recommended “optimal probing forces.” Unfortunately, the idea of probing pressure has been largely unrecognized in the dental literature.

To the best of the authors’ knowledge, there has been no recommendation in the implant literature with regard to the probing pressure around dental implants. Gerber et al applied different peri-implant probing forces (0.15 N and 0.25 N using the same 0.4-mm probe diameter) to assess BOP tendency and probe penetration in well-maintained peri-implant tissues and concluded that 0.15 N of probing force when using a 0.4-mm-diameter probe would avoid false positive BOP readings around dental implants.

Although the authors inadvertently described 0.15 N as “the threshold pressure,” they failed to meet the criteria of the definition of pressure. The true “threshold pressure” could be extracted from the given information, which was calculated to a pressure of 119 N cm².

Sparse information is available for modern dental clinicians regarding the use of peri-implant diagnostic tests including recommended instruments and probing force or pressure that should be applied. Recognizing the limitations of the current clinical practice in peri-implant probe selection and diagnostic pressure is a fundamental step toward improving future implant dentistry. Therefore, the purpose of this study was to assess clinicians’ attitude to probing around dental implants and probe type chosen, and to evaluate the probing force and pressure used at different implant sites. The peri-implant pressure based on force and tip diameter was ultimately calculated and compared.

**MATERIALS AND METHODS**

A plastic tyndont representation of a human maxilla and mandible (Tyndont implant training models courtesy of Nobel Biocare) with mounted detection devices recording probing forces (N) was used. The maxillary model (Fig 1a) had a mounted force detection device (Digital Force Gauge) with a covered screen, thus blinding measurements from the study participants. An implant (Nobel Biocare Replace Select RP 4.3-mm-diameter dental implant) was placed in the maxillary right central incisor site with a healing abutment (Nobel Biocare Replace Select RP) in place. The mandibular model (Fig 1c) also had a mounted force detection device (Shimpo FGV-5XY) with a cover over the probe force display read-out and a dental implant (Nobel Biocare Replace Select RP 4.3-mm-diameter dental implant) with a healing abutment (Nobel Biocare Replace Select RP) positioned at the mandibular right second premolar site. Each implant site was masked using a soft tissue silicone-based material (Kerr Soft tissue Moulage, Gingival Simulation Material). Specific implant sites were chosen for simplicity and visibility. Forty-eight dental professionals (16 periodontists/periodontal residents, 16 prosthodontists/general dentists, and 16 practicing dental hygienists) participated in the study. The periodontist/periodontal residents (“Pe” group), prosthodontist/general dentists (“Rd” group), and two hygienists (“Hy” group) were recruited from a university setting, and the remaining 14 hygienists were recruited from a local hygiene study club meeting.

Each subject was given three survey questions to answer; all answer choices were dichotomous, yes or no:
Do you probe dental implants?
Do you probe implants and teeth in the same way?
Do you probe implants and teeth with the same instrument?

For the probing test, each subject was given written instructions, which asked the subjects to:

- Choose the type of probe one would normally use in practice.
- Probe only a single time at the marked point (Fig 2a) on the palatal surface of the maxillary right central incisor implant healing abutment on the maxilla model.
- Probe once at the marked point (Fig 2b) on the buccal surface of the mandibular right second premolar implant healing abutment on the mandible model.

Maxillary and mandibular models were joined together to simulate the supine position similar to that of a patient in a dental chair, as seen in Figs 2c and 2d. The measurements (N) were recorded, and the survey participants were blinded to the results.

All analyses were done using SAS version 9.3 (SAS Institute). A chi-square test was used to analyze survey questions and compare the type of peri-implant probe selected. Probing force and pressure data were analyzed with analysis of variance (ANOVA) among subject groups as well as probe types per site (mandible vs maxilla) with a post hoc Tukey’s test for pairwise comparisons. A P value less than .05 was considered as statistical significance. Results were compared to the suggested probing force (0.15 N) and pressure (119 Ncm²) from the literature. Probing pressure (Ncm²) was calculated by dividing measured probing force (N) by surface area of the probe tip using the
probe tip diameter. The three probes provided to each study participant included the UNC-15 (PCPUNC156, Hu-Friedy, metal, 0.5-mm tip diameter), the Marquis X2 (Marquis, metal, 0.4-mm tip diameter), and a plastic probe (Premier PerioWise, 0.6-mm tip diameter); tip diameters were measured with a digital caliper (Mitutoyo). The surface area of a circle was used; hence, pressure = \( F / \pi r^2 \) (\( F \) = force, \( r \) = radius). The calculated surface areas were 0.126 mm\(^2\), 0.196 mm\(^2\), and 0.283 mm\(^2\) for Marquis, UNC-15, and PerioWise plastic probe, respectively.

### RESULTS

#### Survey Questions

When asked, “Do you probe implants?,” 100% of the Pe group and Rd group answered “yes”; 1 out of 16 answered “no” in the Hy group. No differences were found between the three groups (\( P = .1 \)) in whether they probe dental implants or not (Table 1). Even though one hygienist denied probing implants clinically in her practice, the data provided by this subject were still included in the data analysis. To the question, “Do you probe dental implants and teeth in the same way?,” there was a statistical difference between the three groups since \( P = .045 \). Eleven out of the 16 (68.8%) dental hygienists answered that they probe dental implants as they probe teeth (\( P < .05 \)). Twelve out of 16 (75%) in the Rd group answered that they do not probe dental implants in the same way that they probe natural teeth (\( P < .05 \)). Nine out of 16 (56%) in the Pe group answered that they do not probe dental implants and teeth with the same instrument (\( P < .05 \)). When surveyed, “Do you probe dental implants and teeth with the same instrument?,” 62.5% of the Pe group answered “yes,” whereas 62.5% of the Rd group and 56.3% of the Hy group answered “no” (Table 1). The results showed no statistical difference between the three groups, \( P = .338 \).

#### Type of Probe Chosen

There was no statistical difference between groups in probe selection, \( P = .152 \) (Fig 3a). Probe selection for hygienists was relatively equally distributed compared with the other groups (37.5% Marquis vs 37.5% plastic vs 25% UNC-15). The Pe group preferred the Marquis probe (62.5%) to plastic (25%) or UNC-15 (12.5%). The Rd group, however, seemed to favor the plastic probe (56.3%) compared with Marquis (18.5%) or UNC-15 (25%). When comparing probe material types (plastic vs metal), 29 out of 48 (60.4%) chose metal probes (Marquis or UNC-15) and 19 out of 48 (39.6%) chose a plastic probe (Fig 3b). No differences were found between the types of probe used, \( P = .191 \).

#### Probing Force for Maxilla (N) and Mandible (N)

The Hy group demonstrated the widest probing force range in the maxilla, whereas the Rd group demonstrated the narrowest range. There was no statistically significant difference (\( P = .85 \)) between the three groups regarding probing forces in the maxilla as shown in Fig 4a. The Hy group demonstrated the widest probing force range as well in the mandible; the Pe group demonstrated the narrowest. Similarly, there was no difference (\( P = .96 \)) among the three groups in the mandible as shown in Fig 4b.

#### Probing Pressure Per Provider Type for Maxilla (Ncm\(^2\)) and Mandible (Ncm\(^2\))

Pressure (Ncm\(^2\)) was calculated based on measured probe tip diameters per provider type. All groups had plotted outliers as shown in Fig 5a. Excluding the outliers, the Pe group had the widest range, whereas the Hy group had the narrowest range of pressures. There was no statistical difference (\( P = .6 \)) between the three groups in regard to the probing pressure in the maxilla. Excluding the outliers, the Hy group had the widest range, whereas the Rd group had the narrowest range of pressures. ANOVA results concluded that there was

<table>
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<th>Table 1 Survey Results Comparison Among Provider Groups</th>
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<tr>
<td>Hygienist</td>
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<tr>
<td>Do you probe implants?</td>
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<tr>
<td>No</td>
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<tr>
<td>In the same way?</td>
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<tr>
<td>No</td>
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<td>With the same instrument?</td>
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*Statistical significance, \( P < .05 \).
no difference ($P = .78$) between the three groups in regard to the probing pressure in the mandible as shown in Fig 5b. All outliers were included in the data set to run ANOVA because they were true data.

**Probing Pressure Per Probe Type for Maxilla (Ncm$^2$) and Mandible (Ncm$^2$)**

Pressure (Ncm$^2$) was calculated per probe type based on the tip dimension of each probe. Nineteen participants selected the Marquis probe or plastic probe, respectively, and the remaining 10 subjects chose the UNC-15 probe. Using the ANOVA method, it was assumed that the data fit normal distribution. The widest probing pressure range resulted from the Marquis probe group, whereas the narrowest resulted from the UNC-15 probe group. There was no statistical difference ($P = .0705$) between the three groups in the maxilla. The Marquis probe group showed the widest probing pressure range in the mandible as well; the plastic probe group demonstrated the narrowest probing pressure range. ANOVA results concluded that there was a statistical difference between probe types ($P < .05$). Post hoc Tukey’s test indicated that the mean probing pressure in the Marquis group was significantly lower compared to the other two groups.

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**Fig 3** (a) Graphical representation of three types of probe selection distribution among three dental professional groups. No statistical significance ($P = .152$). (b) Graphical representation of probe material choice (metal vs plastic) among three dental professional groups. No statistical significance ($P = .191$).

**Fig 4** (a) Graph demonstrating measured probing force (N) in maxilla model. Horizontal black solid lines indicate medians of each group. No statistical significance ($P = .85$). (b) Graph demonstrating measured probing force (N) in mandible model. Horizontal black solid lines indicate medians of each group. No statistical significance ($P = .9604$).

**Fig 5** (a) Graph demonstrating calculated probing pressure (Ncm$^2$) in the maxilla model. Horizontal black solid lines indicate medians of each group. Blue line represents the suggested peri-implant probing pressure (119 Ncm$^2$) from the dental literature.$^{28}$ No statistical significance ($P = .60$) is noted. (b) Graph demonstrating calculated probing pressure (Ncm$^2$) in the mandible model. Horizontal black solid lines indicate medians of each group. Blue line representing suggested, calculated pressure (119 Ncm$^2$) from literature.$^{28}$ No statistical significance ($P = .78$) is noted.
higher than that in the plastic probe group \( (P = .0394) \) in the mandible model. The statistical significance resulted between the same groups whether the outliers were included or not. This result is expected based on the fact that the plastic probe tip diameter (0.6 mm) is significantly wider than the Marquis probe (0.4 mm).

**DISCUSSION**

The survey questions were distributed to different clinicians in regard to peri-implant probing. All clinicians except one hygienist answered that they probe dental implants in their clinical practices. The one hygienist who answered “no” commented that she does not probe dental implants, but her clinical supervisor does in their practice. Dental professionals in this study generally probe dental implants to assess health and disease; however, some clinicians question whether peri-implant probing may cause detrimental effects on the soft tissue seal. Etter et al conducted a histomorphometric study to evaluate the peri-implant mucosal healing following clinical probing around healthy implants.\(^29\) They reported a separation between the implant surface and the junctional epithelium, which healed completely by day five; Taylor and Campbell reported a similar healing around natural teeth.\(^30\) Moreover, some clinicians express a concern in contaminating noninfected peri-implant tissues from an infected pocket following probing. Christersson et al examined the transmissibility of *Actinobacillus actinomycetemcomitans* (*Aa*) predominantly found in localized aggressive periodontitis patients.\(^31\) They found that healthy sites were infected by *Aa* transfer via a probe; however, the newly infected sites were detected free of the microorganisms within 3 weeks.

The dental professional groups presented different preferences in responding to the question, “Do you probe dental implants and teeth in the same way?” This could be a considerable range due to the diverse education background, current learning experiences, and specific philosophy of their practices. Furthermore, this would explain the variations in the answers to the question, “Do you probe dental implants and teeth with the same instrument?” as well. When asked to choose an instrument, the Hy group did not demonstrate a clear preference. Most of the hygienists mentioned that they chose a probe based on availability in their offices; the majority of them work in general dental practices. The Hy and Pe groups inclined toward metal probes, whereas the Rd group favored a plastic probe. Some clinicians added that they generally do not probe around implant healing abutments. Healing abutments were used in this study instead of implant restorations since the convexity of the crown anatomy could hinder a proper insertion of the probes or unintentionally affect the probe angulation.\(^32\)

Interestingly, many subjects noted that they were taught to probe implants with plastic probes, but they have developed their own empirical philosophies throughout the years of practicing. Traditional belief was that a metal probe could scratch the titanium abutment or leave damage at the implant-abutment interface as the probe entered the peri-implant soft tissue seal; a damaged interface could attract bacterial accumulation, which may lead to implant failure.\(^33,34\) Therefore, it was commonly suggested to use a plastic probe when probing around dental implants.\(^29,35\)

Currently, Fakhravar et al investigated whether a different probe material would leave different surface alterations; in fact, they utilized the same UNC-15 metal probe and Periowise plastic probe chosen for the present study.\(^36\) The results from a contact profilometer and light microscopy concluded that the metal probe left no apparent surface alterations. Meanwhile, the plastic probe showed possible plastic residues from instrumentation, although they did not affect the abutment surface significantly.

Force variations did not provide a practical implication without incorporating the probe tip dimensions. When the probe tip diameters were taken into consideration, a proper comparison was reached. Within the sample of this study, the majority of probing pressure values were consistently higher than the recommended probing pressure found in the dental literature, 119 N/cm\(^2\), and represented by the blue bar (Fig 5), to avoid false positive BOP readings.\(^28\) The outcome signifies that dental professionals in this study may be applying too much pressure when probing around dental implants. Gerber et al showed that BOP percentages per increment of 0.1-N force applied appeared to be twice as high at implant sites as in teeth; increasing the probing force from 0.15 N to 0.25 N resulted in a 13.7% increase of BOP sites in implants and 6.6% for natural teeth.\(^28\) This is in agreement with Mombelli et al, who compared the relationship between increasing force and tissue resistance to probing; the depth-force curve showed a steeper curve for implants than teeth.\(^37\)

Peri-implant tissue is more sensitive to BOP due to its different structural composition from natural gingiva in regard to attachment. Previous studies reported that collagen fiber bundles originated from the root cementum and advanced in a perpendicular fashion to the gingival tissues around teeth; in comparison, peri-implant mucosa displayed a parallel orientation of the collagen fibers to the implant titanium surface.\(^38,39\)

Numerous studies have published recommendations for optimal probing forces to prevent false readings of probing depths and BOP.\(^12,21–26,40,41\) Probing forces measured with diverse probe types in such
Fig 6 (a) Graph demonstrating calculated probing pressure (Ncm²) per probe type in the maxilla model. Horizontal black solid lines indicate medians of each group. No statistical significance (P = .0705) is noted. (b) Graph demonstrating calculated probing pressure (Ncm²) per probe type in the mandible model. Horizontal black solid lines indicate medians of each group. P = .0394, demonstrating statistical significance; P < .05.

Table 2 Recommended Forces with Different Probe Tip Diameter Dimensions to Achieve the Same Desired Pressure, 119 Ncm²

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<th>Tip diameter</th>
<th>Surface area (πr²)</th>
<th>Recommended force</th>
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<tr>
<td>0.4 mm (Marquis)</td>
<td>0.126 mm²</td>
<td>0.15 N = 15 g</td>
</tr>
<tr>
<td>0.5 mm (UNC-15)</td>
<td>0.196 mm²</td>
<td>0.23 N = 23 g</td>
</tr>
<tr>
<td>0.6 mm (Plastic)</td>
<td>0.283 mm²</td>
<td>0.34 N = 34 g</td>
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studies require a necessary standardization. Modern dental clinicians must consider probing pressure at the probe tip, which ultimately controls probe penetration into the peri-implant sulcus and adjacent soft tissues.21

Pressure exerted on the tip is directly proportional to the probing force and inversely proportional to the surface area at the tip. Since periodontal probe tips are round, the surface area of a circle is used; hence, pressure = F/πr² (F = force, r = radius). Increases in probing force add probing pressure by a proportional amount; however, increases in probe diameter will decrease the pressure by a proportional amount, squared.15 Consequently, a change in probe tip diameter has more weight than the probing force exerted in determining probing pressure. The Marquis probe demonstrated the highest probing pressure and the most variable range in both the maxilla and mandible compared with the other probes in this study (Fig 6). The Marquis probe has the smallest tip diameter among the three probes provided; it resulted in a higher probing pressure even if the same probing force were exerted with wider tip diameter probes. This principle could be used to work backwards to calculate a recommended probing force (N) with a specific probe to achieve the recommended probing pressure from literature, 119 Ncm² as shown in Table 2.28 As the tip diameter increases, more force needs to be applied to achieve the same amount of pressure.

BOP prevalence is also known to be associated with increasing peri-implant probing depths. Merli et al recently concluded that for each 1-mm increment in probing depth increase, the odds ratio of a site to experience BOP was increased by 1.81, and a higher risk was observed for site-specific factors, especially interproximal sites.42 However, one must consider several varying factors before assuming the severity of peri-implant disease due to mere signs of deep probing depths and BOP around peri-implant tissues. Deep probing depths may represent nonpathologic pockets. For example, if an endosseous dental implant were to be placed apical to the crest of alveolar bone for a better emergence profile, it can result in a thick, long peri-implant soft tissue tunnel.43 Even though many reports from periodontal societies recommend certain guidelines to determine peri-implant diagnoses, it is imperative for dental professionals to think critically beyond what the guidelines suggest to avoid over-diagnosis and overtreatment. The present study asks a thought-provoking question to the clinicians as to how little is known about the meaning of BOP around a dental implant, which is widely used in clinical practice. A future study designed to discuss and apply clinical implications of peri-implant probe pressure would be beneficial.

One limitation of the present study includes the use of a typodont model that has a silicone-based soft tissue moulage to mimic gingival tissues around the healing abutment. There was a gap (Figs 2a and 2b) present between the healing abutment surface and the soft tissue moulage. When the participants probed to the base of the gap for the metal sensor to detect the force (N), in a few occasions, they noted the difficulty of tactile sensitivity. Lack of resistance from the lateral gingiva could have contributed to the outliers in the present study. The lateral gingival wall could be a factor that resists probe advancement in relatively healthy or nonincised gingiva.25 Moreover, with the increasing level of inflammation, the peri-implant probe...
could penetrate further because of reduced resistance from the lateral gingival wall. Another limitation of this study was that only three types of periodontal probes were provided with varying degrees of taper. Preference of probe choice could have resulted differently outside the university setting as well. This study simply reflected clinicians’ inability to probe dental implants at “an optimal probing force.” Multiple questions arise regarding the current clinical practices of using manual metal or plastic probes to assess peri-implant health. Should dental clinicians be using a force-limiting peri-implant probe (e.g., the Florida Probe) in everyday practice to avoid false positive BOP? Could clinicians ever be standardized? Whether a standardization of clinicians is even clinically applicable or not is another question for another study.

CONCLUSIONS

Within the limitations of this survey, there were variations among the groups with regard to the instrument type, probing forces, and probing pressure applied. Even though no statistical differences existed, the range of values among groups did differ. Clinicians must understand the physical dimension of the peri-implant probe as well as the probing forces being applied. Dental professionals may be applying too much probing pressure around dental implants, and this could lead to false positive BOP sites; inappropriate probing may also lead to misdiagnosis, which in turn, may result in inappropriate treatment. This study should provide a basis of current perception in regard to implant probing pressure and can be used to inform clinicians on what might be done.

ACKNOWLEDGMENTS

The authors acknowledge Mr Richard O’Brien BSEE for his expert assistance in designing and building the typondont test model. This study was part of an MSD project and previously presented at the Academy of Osseointegration Annual Meeting, Orlando, Florida, March 16, 2017, as an E-Poster presentation in the Clinical section. The authors reported no conflicts of interest related to this study.

REFERENCES