Accuracy of Bone Sounding in Assessing Facial Osseous-Gingival Tissue Relationship in Maxillary Anterior Teeth

The aim of this study was to evaluate the accuracy of bone sounding (BS) in assessing the facial osseous-gingival tissue relationship (FOGTR) of failing maxillary anterior teeth. Dental records of patients who received immediate implant placement (IIP) at the maxillary anterior area were screened. Mid-FOGTR prior to extraction (BS), and immediately after flapless extraction (direct bone level [DBL] measurement) were analyzed. A total of 160 patients with 190 maxillary anterior teeth were included. The mean FOGTR obtained from BS and DBL were 3.19 ± 0.71 mm and 3.47 ± 1.29 mm, respectively (P = .004). The two measurements were identical 83.2% of the time, within 1-mm discrepancy 4.7% of the time, and > ± 1 mm discrepancy 12.1% of the time. When discrepancy was observed, BS underestimated DBL 14.2% of the time and overestimated 2.6% of the time. Though statistically significant, the correlation was weak (Pearson correlation coefficient r = .238, P = .0018). BS is an acceptably accurate and minimally invasive diagnostic tool for measuring FOGTR. However, while the mean difference between BS and DBL measurement is small (0.28 mm), the large range of difference can be alarming. Therefore, clinicians should always prepare alternative treatment options for IIP prior to extraction. Int J Periodontics Restorative Dent 2017;37:371–375. doi: 10.11607/prd.2664

The facial osseous-gingival tissue relationship (FOGTR) of anterior teeth is one of the key prognosticators for eventual gingival position following periodontal, restorative, and implant procedures. While immediate implant placement (IIP) and immediate implant placement and provisionalization (IIPP) procedures have been viable treatment options for replacing maxillary anterior failing teeth, they require the presence of an intact facial bone with a normal FOGTR (3 mm) of the failing tooth to achieve optimal facial gingival esthetics. Therefore, an accurate assessment of FOGTR is essential to proper planning for IIP and IIPP.

Several methods have been used for FOGTR assessment with varying degrees of accuracy and invasiveness. Direct bone level (DBL) measurement, performed under direct vision after flap reflection, is the most accurate method and is considered the gold standard. Nonetheless, because of its invasive nature that can potentially cause bone resorption and gingival recession, it is not recommended as a presurgical diagnostic procedure. Cone beam computed tomography (CBCT) has become a standard tool for diagnosis and planning of implant treatments, especially due to the significantly lower effective radiation dose produced when compared to conventional computed tomography.
In addition, CBCT is particularly useful in identifying the sagittal root position, which is crucial in IIP situations. Although CBCT is noninvasive, identifying the thin facial bony crest is often challenging due to the low contrast resolution of CBCT.

Bone sounding (BS), also known as transgingival probing, was advocated in 1976 by Greenberg et al as an estimator of alveolar bone level. Studies have evaluated the accuracy of BS by comparing BS measurements to DBL measurements and unequivocally indicate that BS measurements accurately reflect the alveolar bone level. Due to its simplicity and minimal invasiveness, BS recently has become an indispensable method to evaluate FOGTR of teeth for various periodontal and restorative procedures.

Nevertheless, most BS accuracy studies primarily evaluated interproximal sites and posterior teeth, where gingival esthetics may not be of primary concern. The aim of this study was to evaluate the accuracy of BS as a diagnostic aid in assessing the FOGTR at the midfacial aspect of failing maxillary anterior teeth prior to extraction for IIP.

Materials and Methods

Subject Selection and Data Collection

This study was approved by the Institutional Review Board of Loma Linda University. Dental records of patients who received IIP in the esthetic zone (maxillary canines and incisors) from January 1998 to December 2013 at the Loma Linda University School of Dentistry, Center for Implant Dentistry, were reviewed. Figure 1 presents a periapical radiograph of a failing maxillary right central incisor included in this study. Patients were included if the information on probing depth at the midfacial aspect of studied teeth was available. Probing depth, BS, and DBL measurements were recorded to the nearest millimeter using the same type of periodontal probe (PCP126, Hu-Friedy) for all study participants. Age and sex of the patients were also recorded. Patients who experienced loss of facial bony plate, trauma, or tear of the facial free gingival margin during extraction were excluded from the study.

Statistical Analysis

Descriptive statistics were presented and the frequency distribution of BS and DBL measurement discrepancy was also assessed. BS and DBL measurements were compared using paired t test and their correlation was expressed as Pearson correlation coefficient (r). The α level was set to .05 for statistical significance.

Results

A total of 160 patients (103 women and 57 men) with a mean age of 48.4 (range = 19 to 80) years were included in the study. A total of 190 maxillary anterior teeth (120 central incisors, 56 lateral incisors, and 14 canines) were included. The mean probing depth recorded at the midfacial aspect of studied teeth was 1.77 ± 0.55 mm (range = 1–4 mm). The mean FOGTR obtained from BS and DBL were 3.19 ± 0.71 mm and 3.47 ± 1.29 mm, respectively (Table 1). The measurement discrepancy (BS–DBL) ranged from −9 to 3 mm. The mean difference of 0.28 ± 1.31 mm between BS and DBL measurements was statistically significant (paired t test; P = .004).

BS and DBL measurements were identical 83.2% of the time (158/190) and had 1-mm discrepancy 4.7% of the time (9/190), 2-mm discrepancy 4.7% of the time (9/190), and > ± 2-mm discrepancy 7.4% of the time (14/190) (Fig 4). When the discrepancy (16.8%; 32/190) was observed, BS underestimated DBL value 14.2% of the time.

Fig 1 Periapical radiograph of failing maxillary right central incisor due to external root resorption.
time (27/190) and overestimated it 2.6% of the time (5/190). Though statistically significant, the correlation between the two measurement methods was weak ($r = .238; P = .002$).

**Discussion**

The percentage frequency distribution of ≤ 1 mm measurement discrepancy (87.9%) and the mean difference (0.28 mm) between BS and DBL measurements in this study are similar to those reported by other studies (91%–97% and 0.1–0.3 mm). Although these measurements validate BS as an acceptably accurate diagnostic tool, it should be acknowledged that it is far from 100% accurate. Factors such as root surface anatomy, cervical crown contour, thickness of the facial bony plate, presence of bony dehiscence, presence of calculus, presence of facial infrabony defects, tip diameter of the periodontal probe, health of the gingival tissue, and clinician experience can result

<table>
<thead>
<tr>
<th>Table 1 Comparison of FOGTR as Assessed by BS and DBL (n = 190)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement method</strong></td>
</tr>
<tr>
<td>BS</td>
</tr>
<tr>
<td>DBL</td>
</tr>
<tr>
<td>BS–DBL</td>
</tr>
</tbody>
</table>

*Statistically significant using paired t test ($\alpha = .05$).

![Fig 2](image1) Clinical example of bone sounding measurement prior to extraction of the maxillary right central incisor shown in Fig 1.

![Fig 3](image2) Clinical example of direct bone level measurement immediately after extraction of the maxillary right central incisor.

![Fig 4](image3) The frequency distribution of measurement discrepancy between bone sounding (BS) and direct bone level measurement (DBL).
in an under- or overestimation of the FOGTR measured by BS. Inaccurate diagnosis due to errors in BS measurements can affect clinicians’ decision making on treatment planning for various surgical and restorative procedures, including IIP and IIPP. The clinicians should always be prepared in the event that BS does not reflect the actual FOGTR after tooth removal or flap reflection in planned IIP situations.

In this study, the BS-DBL measurement discrepancy ranged from 1 to 4 mm. The majority of the discrepancy (14.2%) was an underestimation, where the actual crest of facial bone was more apical than expected (BS < DBL). Underestimation is common when the facial bone dehiscence is deep and narrow, preventing the probe from reaching the most apical part of the facial bone. This kind of defect, more often than not, does not affect the surrounding soft tissue condition, which, when healthy, may be resistant to the BS force, making it hard for clinicians to discern the tactile sensation between tight tissue fibers and thin bony crests. Therefore, deep and narrow bone dehiscence with intact connective attachment can sometimes affect the accuracy of BS measurement. The average probing depth of 1.77 ± 0.55 mm (range = 1–4 mm) recorded in this study indicates shallow pockets at the majority of the data collection sites. Fortunately, a recent study has shown that the shape (morphology) rather than the depth of the facial bone defect may have a greater influence on facial gingival esthetics and thus treatment planning in IIPP situations.29 Although underestimation in V-shape defect situations usually does not alter the treatment plan for IIPP, an accurate assessment of FOGTR before surgery is still important to minimize unexpected complications.

An overestimation (actual crest of facial bone is more coronal than expected; BS > DBL) occurs when the probe stops beyond the facial bone crest during BS and/or there is a change in facial gingival levels during/after extraction. Thin facial bony plate is more likely to cause probe slippage beyond the bone crest during BS, especially when a probe with a thicker tip is used. The diameter of the periodontal probe tip used in this study was 0.56 mm. This is comparable to the recommended size of 0.6 mm with 0.20 gram force to obtain a pressure that demonstrates approximate probing depth.30 However, for BS, a smaller tip might be advantageous, as less force is needed to reach the bone level and thus there is less chance of slippage. The presence of infrabony defect has also been associated with overestimation.20 During even minimally traumatic extraction, free gingival margin is usually displaced apically, causing FOGTR reduction and thus overestimation is introduced in this study; the frequency distribution of overestimation was only 2.6%. Compared to underestimation, overestimation is less problematic clinically as the crest of bone is more coronal than expected and the treatment is less extensive.

This study has limitations compared to underestimation. While only one experienced examiner (J.Y.K.) was involved in data collection, clinical measurements were not as well-standardized as in a prospective study. The measurement location of BS and DBL might not be as consistent as when a template is used. Furthermore, an inevitable slight facial free gingival margin distortion and/or minimal bony crest change after extraction was not factored into the study. Collectively, these likely contribute to the weak correlation between BS and DBL measurements in this study (r = .238; P = .002). In prospective studies,18–23 templates were used as references to minimize the possible measurement errors mentioned above. However, the results of the present study may be useful as they represent realistic clinical situations rather than a well-controlled study environment.

Conclusions

Within the limitations of this study, BS was shown to be an acceptably accurate and minimally invasive diagnostic tool for measuring FOGTR. However, while the mean difference between BS and DBL measurements was small, the large range in difference can be alarming. For a successful IIP/IIPP, the periodontal condition of the failing tooth should be as ideal as possible. Regardless, BS is still the less invasive method to estimate the gingiva-to-bone relationship in spite of the slight possibility of measurement discrepancy. Therefore, clinicians should always prepare for treatment alternatives in IIP/IIPP situations.
References


Acknowledgments

The authors reported no conflicts of interest related to this study.