Classification of Sagittal Root Position in Relation to the Anterior Maxillary Osseous Housing for Immediate Implant Placement: A Cone Beam Computed Tomography Study

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Purpose: *The purpose of this study was to classify the relationship of the sagittal root positions of the maxillary anterior teeth to their respective osseous housings using cone beam computed tomography (CBCT). The frequency of each classification was also reported.* ***Materials and Methods:*** *A retrospective review of CBCT images was conducted on 100 patients (40 men, 60 women; mean age, 53.1 years) who fulfilled the inclusion criteria. The CBCT images were evaluated and the relationship of the sagittal root position of the maxillary anterior teeth to its associated osseous housing was recorded as Class I, II, III, or IV.* ***Results:*** *The frequency distribution of sagittal root position of maxillary anterior teeth indicated that, of the 600 samples, 81.1%, 6.5%, 0.7%, and 11.7% were classified as Class I, II, III, and IV, respectively.* ***Conclusions:*** *An understanding of the clinical relevance of sagittal root position will provide adjunct data for the treatment planning of immediate implant placement and provisionalization in the anterior maxilla. A classification system may lead to improved interdisciplinary communication in treatment planning for implant-based therapy in the anterior maxilla.* Int J Oral Maxillofac Implants 2011;26:873–876

Key words: *anterior maxilla, cone beam computed tomography, esthetics, immediate implant placement, immediate provisionalization, osseous housing, sagittal root position, single-tooth replacement, treatment planning*

Immediate implant placement and provisionalization (IIPP) of a single tooth in the esthetic zone was first advocated in the mid-1990s and has since been considered a predictable treatment option for replacing failing teeth.[1–9] In addition to preserving tissue architecture, reducing treatment time, and providing the patient with the convenience of an immediate tooth replacement,[1,3,7,8] IIPP procedures have also been documented with high success rates when established clinical guidelines are followed.[3,6,9] To ensure successful IIPP, in addition to the presence of an intact bony socket following extraction and the absence of active infection, primary implant stability must be achieved by engaging the implant with the palatal wall and the bone approximately 4 to 5 mm beyond the root apex.[6–8] Unfortunately, because the available bone around the failing tooth may not always be sufficient to achieve primary implant stability, alternative treatment options should be considered. Factors such as root length, sagittal root position (SRP), and the morphology of the osseous housing are important in determining the feasibility of IIPP and must be evaluated via the use of cone beam computed tomography (CBCT). While the effect of root length on the IIPP is easily

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Fig 1 Class I sagittal root position.

Fig 2 Class II sagittal root position.

Fig 3 Class III sagittal root position.

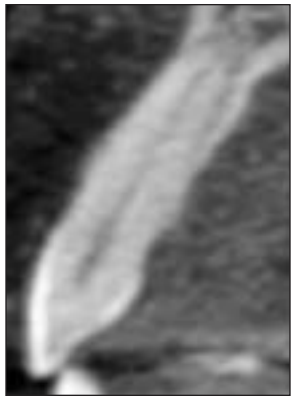

Fig 4 Class IV sagittal root position.

understood (the longer the root, the less available bone beyond the root apex and the more limited the selection of implants of appropriate length), the influence of the relationship between the SRP and its osseous housing on IIPP has not been documented.

The purpose of this CBCT study was to classify the SRP with respect to the anterior maxillary osseous housing to aid in treatment planning for immediate implant placement. The frequency of each classification is reported and the clinical implications are discussed.

MATERIALS AND METHODS

Patient Selection

This retrospective study was approved by the Institutional Review Board of Loma Linda University and was conducted in the Center for Implant Dentistry, Loma Linda University School of Dentistry, California. Pretreatment records and CBCT images (Classic i-CAT, Imaging Sciences International) were reviewed for patients who received treatment between May 2006 and February 2010. Forty male and 60 female patients between the ages of 19 and 84 years (mean, 53.1 years) were selected according to the following criteria: at least 18 years of age at the time of the CBCT scan; all maxillary anterior teeth (canine to canine) were present, with at least two occluding posterior teeth (premolar and/or molar) in each quadrant; no radiographic evidence of infection, severe root resorption, and/or trauma to the anterior maxillary dentition; and no radiographic evidence of surgical (guided bone/tissue regeneration) treatment in the anterior maxillary dentition.

Data Collection

For each study subject, the SRP of each maxillary anterior tooth in relation to the osseous housing was evaluated using images from CBCT scans (i-CAT Vision, Imaging Sciences International). The arch form selector tool was centered through the middle of the arch in the axial plane. The SRP in relationship to the osseous housing was evaluated by viewing the cross-sectional image made at the midpoint of the tooth parallel to its long axis. A proposed classification system was used during image assessment. The cross-sectional images were screen-captured and independently evaluated and classified by two examiners. The examiners had been previously calibrated by simultaneous evaluation of 60 randomly selected images. If any disagreements occurred regarding the classification of an image, the image was reevaluated concurrently by both examiners until agreement was reached about the most appropriate classification.

SRP Classification

Each SRP in relationship to its osseous housing was classified as follows:

- Class I: The root is positioned against the labial cortical plate (Fig 1).
- Class II: The root is centered in the middle of the alveolar housing without engaging either the labial or the palatal cortical plates at the apical third of the root (Fig 2).
- Class III: The root is positioned against the palatal cortical plate (Fig 3).
- Class IV: At least two thirds of the root is engaging both the labial and palatal cortical plates (Fig 4).

Statistical Analysis

Descriptive statistics were used to report the frequency (number and percentage) of each classification. The distribution of each SRP classification according to tooth position was also recorded.

Table 1 Frequency Distribution of Sagittal Root Position Classification

	Percentage (no.)			
SRP	Central incisor	Lateral incisor	Canine	Overall
Class I	86.5 (173)	76 (152)	81 (162)	81.1 (487)
Class II	5 (10)	8.5 (17)	6 (12)	6.5 (39)
Class III	0.5 (1)	1.5 (3)	0 (0)	0.7 (4)
Class IV	8 (16)	14 (28)	13 (26)	11.7 (70)
Total	100 (200)	100 (200)	100 (200)	100 (600)

RESULTS

From among the 600 SRP images evaluated in this study, there were eight disagreements (1.3%) between the examiners. The disagreements were between Class I and Class IV (n = 7) and Class I and Class II (n = 1). The frequency distribution of SRP classes indicated that, of the 600 samples, 487 (81.1%) were Class I, 39 (6.5%) were Class II, 4 (0.7%) were Class III, and 70 (11.7%) were Class IV (Table 1).

The frequency distribution was categorized according to tooth position and SRP (Class I, II, III, and IV) (Table 1). The central incisors presented with 86.5%, 5%, 0.5%, and 8%, respectively, of Class I, II, III, and IV. The lateral incisors presented with 76.5%, 8.5%, 1.5%, and 14%, respectively. The canines presented with 81%, 6%, 0%, and 13%, respectively.

DISCUSSION

Anatomically, the palatal aspect of an extraction socket in the anterior maxilla is thicker and more cortical in nature than its labial counterpart, making the former a more suitable foundation for implant placement and the latter more prone to bone resorption and/or collapse. In the Class I SRP, in which the entire length of the root is in contact with the labial cortical plate, a considerable amount of bone is present on the palatal aspect for implant engagement to attain primary stability during IIPP. In general, this palatal implant engagement leaves the labial bone intact and results in a small gap between the implant and the labial plate.[8] This implant-socket gap is usually filled with bone grafting material so that an esthetic hard tissue contour can be maintained both vertically and horizontally.[8] In this study, 81.1% (range, 76% to 86.5%; Table 1) of the 600 samples had a Class I SRP. This suggests that, regardless of tooth position, the SRP of the majority of the teeth in the present study was favorable for IIPP according to guidelines that have been established in the literature.[6–8,10]

The frequency of Class III SRP in this study was only 0.7% (range, 0% to 1.5%; Table 1), illustrating the rarity of this root position. In the Class III SRP, the entire length of the root engages the palatal cortical plate; therefore, the stability of the implant relies on its engagement in the available bone on the labial aspect. Because of the increased trabecular nature of the labial bone, there is a higher tendency for labial bone resorption as a result of peri-implant bone remodeling. Furthermore, labial concavities, occasionally observed near the base of the anterior maxilla, can potentially lead to fenestration/perforation when labial implant engagement is attempted.

Only 6.5% (range, 5% to 8.5%; Table 1) of the study samples were Class II SRP, in which the root was centered in the middle of the alveolar housing without engaging either the labial or palatal cortical plates at the apical third of the root. Generally, the volume of bone available surrounding the extraction socket on both the palatal and labial aspects is less than what is encountered in Class I or Class III SRPs, respectively. This amount of bone, while it may be sufficient to prevent labial/palatal bone fenestration, may not be adequate to ensure implant stability. Therefore, when a clinician is considering IIPP procedures in a site with Class II SRP, the amount of available bone beyond the apex of the extraction socket must be critically evaluated, as the stability of the implant relies primarily on it.

In the Class IV SRP, which comprised 11.7% of this study's population, the existing tooth root occupies the majority of the alveolar volume, and the base of the anterior maxilla is often pedunculated. Following extraction, there is a limited amount of bone with which appropriate implant stability can be obtained. To increase the predictability of the treatment, adjunctive bone grafting procedures are often necessary prior to

implant placement.[11] Therefore, a Class IV SRP is considered by the authors to be a contraindication for IIPP. It is interesting to note that the frequency of Class IV SRP at the lateral incisors (14%) and canines (13%) is almost twice as high as that observed at the central incisors (8%) (Table 1). These results emphasize the importance of CBCT during diagnosis and treatment planning for IIPP, especially in lateral incisor and canine areas.

This study demonstrates the importance of CBCT as an adjunct to implant treatment planning.[12–14] Precise assessment and preoperative planning will allow clinicians to appropriately recognize sites that are favorable for IIPP (Class I SRP), sites that are more technique sensitive and entail additional attentions (Class II and Class III SRP), and sites that are contraindicated for IIPP, ie, that require hard and/or soft tissue augmentation prior to implant placement (Class IV SRP).

CONCLUSIONS

As the concept of immediate implant placement has become more widely accepted, understanding the importance of sagittal root position through the use of cone beam computed tomography will be a vital adjunct to treatment planning of immediate implant placement and provisionalization in the anterior maxilla. Furthermore, the proposed classification system for sagittal root position may lead to improved interdisciplinary communication in treatment planning for implant-based therapy in the anterior maxilla.

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