Immediate Implant in Maxillary Central Incisors and Prosthetic Screw Channel: A CBCT Feasibility Study

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This study aimed to assess how frequently the maxilla anatomy allows for lingualized immediate implants in the central incisor region with a screw channel that has an ideal distance of 1.5 mm from the incisal margin. The effect of abutments with angle correction on case selection will also be verified. A retrospective cross-sectional study of 181 CBCT scans was carried out. Using an implant-planning software, implant placement was simulated in the lingual aspect of the socket. The location of the prospective screw channel was registered as incisal, lingual, or facial. The angle between the actual screw channel and the position of the ideal one was calculated. The effect of angle correction on allowing an ideal screw channel configuration was computed. Out of 161 eligible cases, 144 presented favorable anatomy for an immediate implant. The screw channel had an incisal position in 40 cases (28%), a lingual position in 60 cases (42%), and a facial position in 44 cases (30%). The screw channel could be placed at the planned distance from the incisal edge in 35 cases (24%). The position was unfavorable in the remaining 109 cases. In 103 of these cases, an abutment with an angled screw channel could make the conditions feasible. Within the simulated conditions, a majority of maxillary central incisors present favorable ridge anatomy for lingualized immediate implant placement. Achieving a proper location of the screw channel requires abutments with angle correction in a majority of cases.
Int J Periodontics Restorative Dent 2021;41:245–251. doi: 10.11607/prd.4564

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Submitted July 17, 2019; accepted September 27, 2019.

The anatomy of the anterior maxilla and its remodeling after extractions have been assessed in several studies,[1–7] contributing to immediate implant placement becoming a viable and documented treatment option.[8] The thickness of the buccal bone plate is thin in most cases[1–3] and undergoes postextraction resorption[2,3]; the position of the root within the bony envelope varies,[4,7] and the angle formed between the root and the buccal bone has been investigated.[6] The suggested indication for immediate implant replacement of a maxillary incisor ranges from < 5% of cases (if a buccal bone with > 1-mm thickness is a treatment prerequisite[9]) to > 80% (if a favorable sagittal root position is the treatment prerequisite[4]). In the latter case, a lingualized position is recommended in order to stabilize the implant in the palatal aspect of the alveolar socket, followed by grafting with bone replacement and with connective tissue in case of a thin fenotype.[10] This allows for enough primary stability as well as a safe distance from the buccal bone plate to avoid undue pressure on the buccal tissues, optimizing the chances to keep the soft tissue outline unaltered.

Available information on the morphology of the anterior maxilla is mostly based on linear measurements of the bone thickness and

of the angle formed between the roots and the ridge. To the present authors' knowledge, little has been presented regarding the simulated possibility of immediate implant placement in a 3D position that respects not only the optimal relation with the bony contours but, at the same time, allows for screw retention with a channel that does not interfere with the lingual aspect of the incisal edge. Only by pursuing a restorative-driven implant position, with due consideration to the root, socket anatomy, and tooth shape, is it possible to reach the objective of a natural-looking restoration that mimics the original tooth and full buccal contour and preserves the incisal-edge characteristics.

A screw-retained implant restoration seems desirable to avoid risks encountered with residual cement and a subsequent peri-implant inflammatory response.[11] Furthermore, excessive proximity of the screw channel to the incisal margin would reduce the porcelain thickness, which in turn would weaken and/or limit the esthetic characteristics of the incisal margin itself. To address this problem, a new angled abutment developed for screw retention might overcome the unfavorable angulation of the screw channel and its interference with the incisal margin.

The purpose of this CBCT study was to assess how frequently the bony anatomy allows for immediate implant placement in the maxillary central incisor region when aiming at a correctly configured lingual screw channel. Additionally, the present study aimed to assess the impact of angled abutments for screw retention on allowing for increased case selection.

Materials and Methods

This observational cross-sectional study was compliant with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) methods.

Patient Selection

CBCT images (ProMax 3D Classic, Planmeca) from the database of a private practice were searched for patients who received scans between November 2015 and February 2019 and had healthy maxillary incisor regions. One of the two centrals incisors was arbitrarily selected in each case. Images were discarded if one of the following exclusion criteria applied: presence of image artifacts affecting the visibility of the buccal plate; presence of any prosthetic restorations, as they may have altered the axis of the anatomical crown; loss of bone support due to periodontal disease; and presence of apical periodontitis or severe root resorption.

Image Analysis

For each study subject, the DICOM (Digital Imaging and Communications in Medicine) files were processed using an implant-planning software (DTX Studio Implant version 3.3.2.1, Nobel Biocare). The arch form selector tool was *(1)* centered in the middle of the bony ridge axial plane, then *(2)* centered to the midline of one central incisor, parallel to its long axis. A cross-sectional image of the ridge was then obtained, displaying the midpoint of the tooth and its associated bony socket. The cross-sectional images were screen-captured and independently evaluated by two examiners (including O.G.M.) to classify root position and feasibility of immediate implant placement. The examiners were previously calibrated by simultaneous evaluation of 60 randomly selected images. If any disagreements occurred regarding the classification of an image, the image was reevaluated jointly by both examiners until agreement was reached. For each central incisor, the Sagittal Root Position Classification (SRP) to its osseous housing was defined[4] (Fig 1):

- Class I: The root is positioned against the labial cortical plate.
- 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.
- Class III: The root is positioned against the palatal cortical plate.
- Class IV: At least two-thirds of the root is engaging both the labial and palatal cortical plates.

Implant placement in an ideal 3D position was then simulated on the planning software. Conical implants with a 4.3-mm diameter and

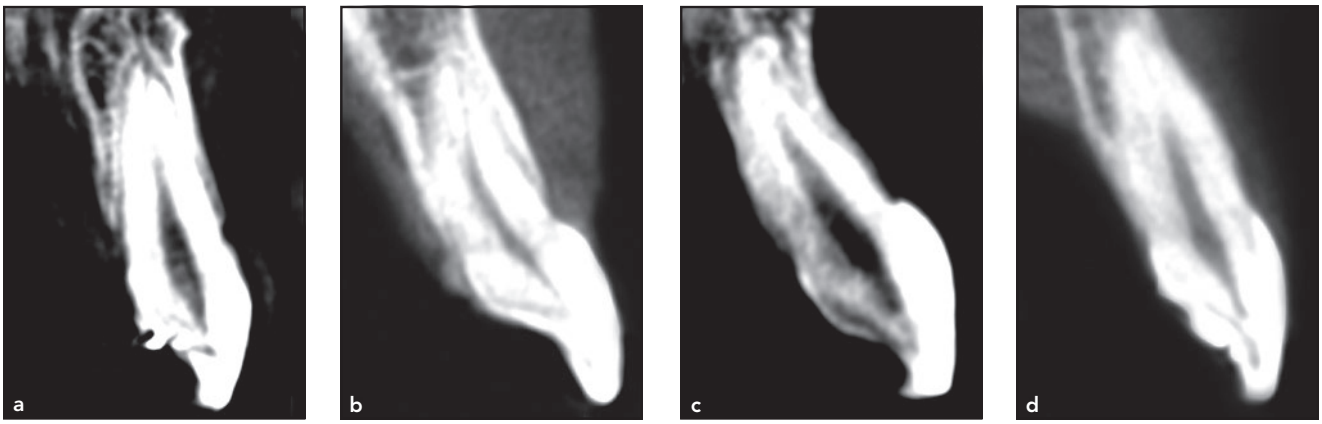

Fig 1 *Classification of the sagittal root position of the central incisors:* (a) *Class I,* (b) *Class II,* (c) *Class III, and* (d) *Class IV.*

a length adapted to the root length were used (NobelActive, Nobel Biocare). Ideal placement complied with the following criteria (Fig 2):

- At least 2 mm of engaging apical bone.
- Lingualized position allowing, over the entire implant length, a distance no less than 2 mm between an intact buccal plate and the implant .
- A minimum distance of 1 mm between the implant and the lingual bone plate over the entire implant length.
- Placement of the implant shoulder 1 mm below the buccal bony crest.
- In every case, a screw channel that was as palatal as possible was pursued, provided compliance with the above guidelines.

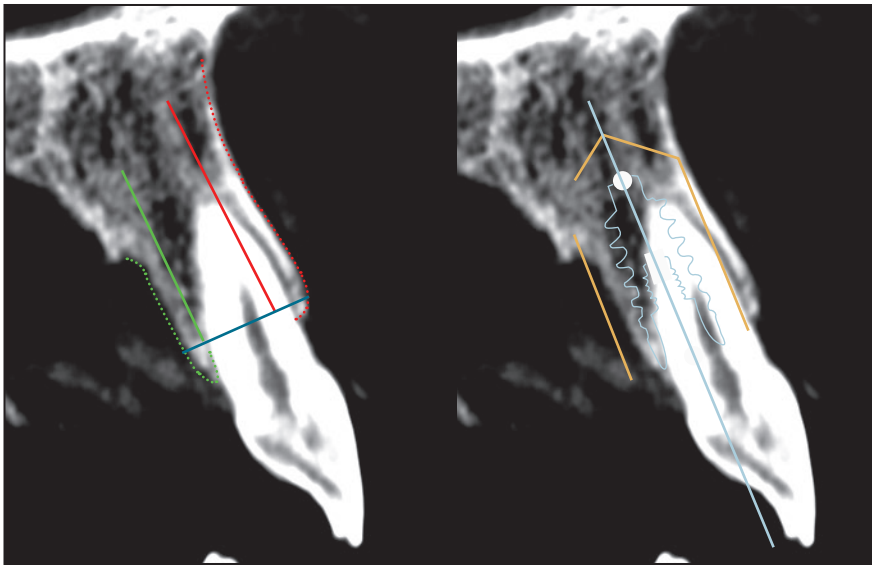

Fig 2 *Landmarks adopted for implant planning. The red line is 2 mm from the external surface of the buccal bone* (dotted red line). *The green line is 1 mm from the external surface of the lingual bone* (dotted green line). *The blue line indicates a 1-mm subcrestal placement.*

After simulated ideal implant placement, the screw channel position of a prospective screw-retained crown was assessed and classified depending on whether it was in a lingual, incisal, or buccal position (Fig 3). In addition, all cases were further assessed to discern whether they allowed a 1.5-mm distance from the most lingual part of the tooth incisal edge (ideal position) to the screw channel (Fig 4). In cases where this distance was not achieved, the screw channel angle necessary to obtain this safe distance was measured in the planning software. Implants were then grouped according to the degrees of discrepancy from the ideal screw-channel position.

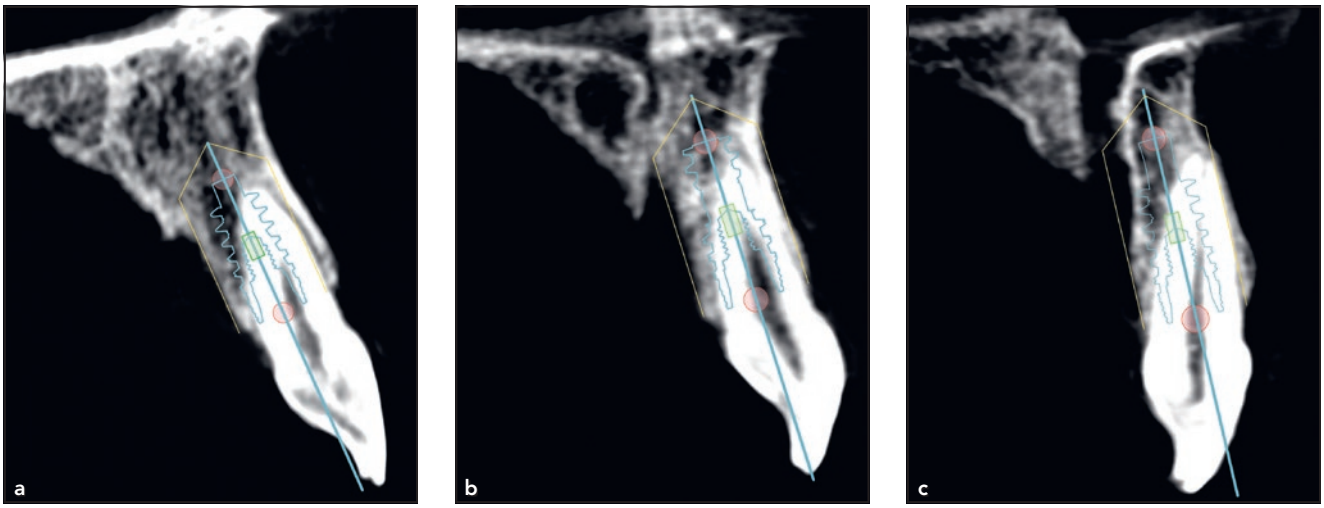

Fig 3 *Possible location of the screw channel depending on the bony ridge anatomy:* (a) *lingual,* (b) *incisal, and* (c) *buccal.*

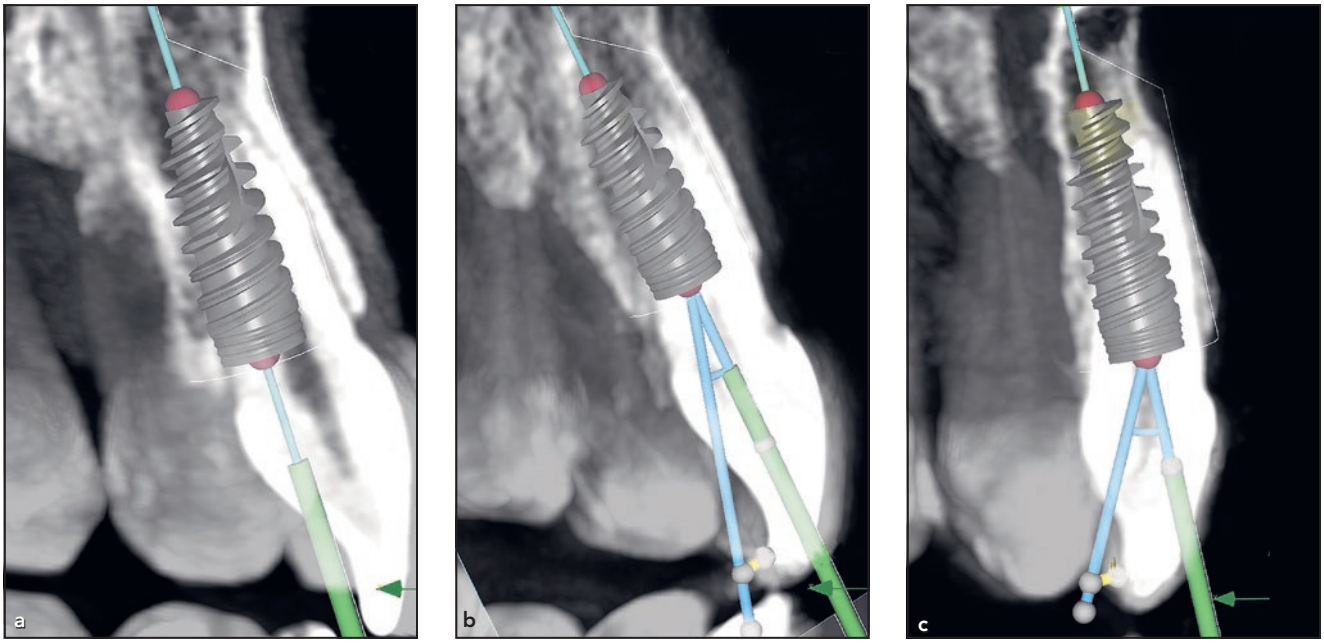

Fig 4 (a) *Ideal screw-channel location allowing a minimum distance of 1.5 mm from the incised margin (0 degrees).* (b) *Discrepancies 15 to 25 degrees and* (c) *greater than 25 degrees of the screw channel* (blue line) *compared to the ideal position* (green line).

Data Analysis

Descriptive statistics were used to describe the recorded data. Frequencies and percentages were used to summarize the observed screw channel position. The mean deviation of the screw channel from the ideal position was assessed.

Results

A total of 181 CBCT datasets that presented maxillary incisors were retrieved from the records.

Table 1 Screw Channel Location for the 144 Feasible Immediate Cases

Deviation from ideal axis, degrees	Screw channel location, n (%)			
	Lingual	Incisal	Buccal	Total
0	35 (24%)	0	0	35
< 15	24 (17%)	33 (23%)	13 (9%)	70
15–25	1 (0.73%)	6 (4%)	26 (18%)	33
> 25	0	1 (0.73%)	5 (3%)	6
Total	60	40	44	

The ideal screw channel position was present in a minority of cases feasible for immediate implant placement (35/144). However, in the vast majority of feasible cases, the discrepancy of the screw channel position is ≤ 25 degrees.

Images belonged to 57 men and 125 women (age range: 19 to 75 years). The examiners agreed on the viability of immediate placement in all but three cases, which were then agreed upon via discussion. From those datasets, 20 (11%) cases presented image-quality exclusion criteria. The remaining 161 cases were assessed for feasibility of a simulated ideal immediate implant placement in the maxillary central incisor position. Of these 161 cases, 133 (83%) were classified as SRP Class I; 18 (11%) as Class II; 3 (2%) as Class III; and 7 (4%) as Class IV. In 17 of the 161 cases (11%), immediate implant placement was not considered possible because the ridge anatomy did not fulfill the ideal placement criteria. These cases were: 4/133 of the SRP Class I ridges (3%); 3/18 of the Class II (17%); 3/3 of the Class III (100%); and 7/7 of the Class IV (100%). A feasible anatomy for immediate implant placement was instead observed in 144 cases (89%).

The screw channel had an incisal position in 40 cases (28%), a lingual position in 60 cases (42%), and a facial position in 44 cases (30%; Table 1). In 35 cases (24%), the ridge anatomy allowed for simulated placement of an immediate implant with a screw–channel axis favorable for placement at a safe distance of 1.5 mm from the incisal edge (Table 1). In the remaining 109 cases, immediate implant placement would result in an unfavorable screw channel position (interfering with the incisal margin or facial surface). In 103 of these 109 cases, an abutment with an angled screw channel could allow a correctly designed crown. In 6 cases, the angle correction required to reach a safe channel position was greater than 25 degrees, and therefore they were not considered suitable for screw retention. The 103 cases requiring angle correction had a mean channel-angle deviation of 12.7 degrees from the ideal position (range: 2.1 to 24.5 degrees). Of these 103 cases, 39 had an uncorrected screw channel position located facially, 39 incisally, and 25 lingually. In the 6 cases not allowing screw retention, the average screw channel angle deviation from the ideal was 27.8 degrees (range: 25.4 to 31.6 degrees).

Discussion

This study assessed the viability of immediate placement using a dedicated planning software for guided implant planning as well as the resulting position of the screw channel and its relation with the incisal margin. In most cases (89%), immediate implant placement was considered feasible.

Other authors have assessed the anatomy of the anterior maxilla, focusing on immediate implant placement. Chung et al[6] evaluated simulated implant placement in 250 maxillary central incisors. For a simulated implant with a 5-mm diameter, immediate placement was thought feasible in 82% of cases. This percentage is similar to the results of the present study.

Placement of 183 central incisor implants was also simulated by Gluckman et al,[7] who found a Class II sagittal root position in 77% of cases, Class III in 11%, and other classes were less common. They noticed how 61% of central incisors had enough apical bone to allow stability for immediate implant

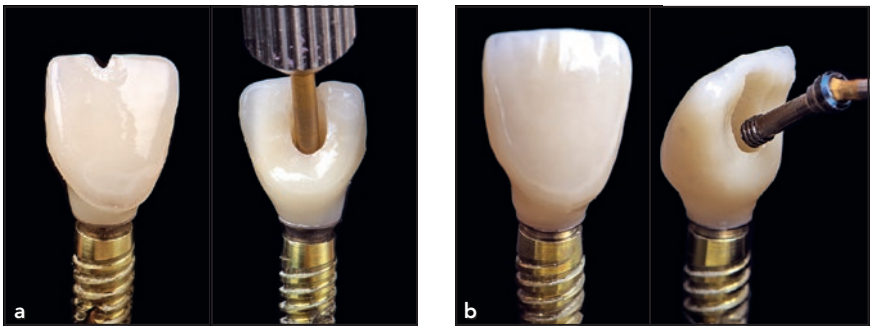

Fig 5 (a) *Thin incisal margin fractured due to interference of the screw channel when using the screwdriver.* (b) *Use of an abutment with angle correction allows relocation of the screw channel to a safer position for the incised margin.*

placement. The difference with the present data could be due to the different populations examined; additionally, in the present study, an actual simulation of the implant placement was conducted, rather than linear measurements of the bony ridge. The sagittal root position assessed herein is more similar to the original data presented by Kan and coworkers,[4] where, out of 200 central incisors, 86.5%, 5%, 0.5%, and 8% were classified as Class I, II, III, and IV, respectively. The same authors considered immediate implant placement feasible in Class I cases, thus resulting in a similar percentage to what is seen in the present study's CBCT material.

It is clear that the present and previous studies assessing case feasibility for immediate placement presented a simulation of ideal conditions. In reality, it may be difficult to replicate these high case-selection percentages. First, buccal bone thickness is very thin in most cases,[1–3] and therefore a risk exists that it could be damaged during the extraction despite the clinician's best care. This could jeopardize the feasibility of immediate placement and require guided bone regeneration instead. Second, an ideal simulated placement may be difficult to reproduce with a real-life bone site preparation. Preparation precision can potentially be improved if guided placement is adopted instead of a freehand technique, but even the former is not devoid of possible spatial errors that could influence the outcome.[12]

The immediate placement protocol simulated here was based on the use of grafting with bone replacement in the gap between the implant and the buccal bone.[8–10] This approach was successful in reducing the amount of ridge resorption that inevitably follows tooth extraction and could impact the esthetic outcome.[13] Confirmatory data were later presented, showing how lingual placement and the socket grafting protocol (simulated herein) minimize the ridge anatomy reduction at sites with immediate tooth replacement.[14] The data presented in the present study provide further insight on the frequency of case selection in a different population and expand the knowledge on the prosthetic aspects to be considered in the planning process when using the protocol for immediate placement.

A successful implant replacement is dependent on a carefully designed prosthetic restoration. In immediate cases, the implant platform is located approximately 3 mm below the level of the prospective gingival margin.[8] For this reason, screw retention may be advantageous, as cement remnants can be difficult to remove and could cause inflammation in the long term.[11] Additionally, the screw channel has to be positioned with enough clearance for adequate ceramic layering of the cervical margin to obtain structural strength and pleasing esthetics. In the present study, this safety distance has been established as 1.5 mm from the incisal margin. In fact, 3 mm is the minimum screw channel diameter, and therefore 1.5 mm seems to be the minimum distance that should be respected to avoid fracturing the porcelain when using the screwdriver, which would be a frustrating occurrence (Fig 5). This distance can be fulfilled when ridge anatomy is favorable, which was seen in 35 of 144 cases (24%) in the present study. The screw channel position was assessed in previous placement simulation studies and was found to be located lingually in only 3.6% of cases, facially in 42% of cases, and incisally in 54.4% of cases.[6] The difference between those results and the present study, where the desirable lingual position was more frequent, could be due to the different diameter of the implant, which allowed a more favorable implant placement angle within the bony ridge.

The present study also shows how screw retention feasibility increased to 138 of the 144 cases (96%) if an abutment with an angle correction was to be used. Angle-correction abutments compensate for a ridge anatomy that allows immediate placement but has a 25-degree discrepancy from the ideal axis, and they may represent an effective solution for widening the indication for immediate placement. These abutments are provided by a vast majority of implant manufacturers and are based on a modified abutment screw and screwdriver, allowing tightening over a nonlinear path of insertion of the screwdriver into the screw slot. Cases requiring a correction greater than 25 degrees were more rarely encountered, and conventionally they need to be addressed with abutment-level cemented or screw-retained restorations. Third-party abutments have been engineered to allow corrections up to 45 degrees, which could further expand case feasibility. Another option to consider is the use of implants specifically designed for prosthetic anchorage with a 12-degree deviation from the implant axis. These implants represent an alternative to using angle-correction abutments, and their initial outcomes seem promising.[15]

Conclusions

Within the simulated ideal conditions of this study, a majority of maxillary central incisors present a ridge with a favorable anatomy for lingualized immediate implant placement. Achieving a proper location of the screw channel requires abutments with angle correction in a majority of cases.

Acknowledgments

The authors would like to thank Mr Rubén García for his help with image editing. The authors declare no conflicts of interest.

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