Preoperative Diagnostic for Palatal Implants: Is CT or CBCT Necessary?

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ABSTRACT

Objective: To evaluate (a) the diagnostic value of lateral radiographs and (b) whether computed tomography (CT) or cone beam computed tomography (CBCT) is necessary in preoperative diagnostics for orthodontic anchorage implants.

Patients and Methods: We reviewed all patients who had presented for insertion of a palatal implant between January 2003 and December 2007 at the University Hospital Mainz. On the basis of lateral radiographs, the palatal bone was assessed as follows: (a) sufficient (bone height > 4 mm in the implant axis), (b) ambiguous, or (c) insufficient (bone height < 4 mm in the implant axis). In group A the surgical insertion procedure was performed without further radiological investigation. Group C required other types of anchorage. In cases of an ambiguous bone situation (group B), further diagnostic procedures (CT/CBCT) were performed.

Results: During the observation period, 105 patients were screened. Fourteen patients opted for alternative treatment leaving 91 patients for final evaluation. In 89 patients (97.8%), the lateral radiographs showed sufficient bone in the vertical dimension. In all of these cases, the availability of sufficient bone was confirmed intraoperatively. Further investigations were performed in two patients (2.2%) of group B (one CT, one CBCT). Finally, one patient had insufficient bone whereas the second had sufficient bone.

Conclusions: Nearly 98% of the patients included in this study had sufficient bone for palatal implant insertion. Lateral radiographs permit correct and reliable evaluation of the quantity of bone in preoperative diagnosis of palatal implants. Additional imaging (CT or CBCT) is only required in rare cases of borderline dimensions.

KEY WORDS: CT and CBCT, palatal implants, preoperative diagnostic, skeletal anchorage

INTRODUCTION

In the last decade, palatal implants have emerged as a powerful tool used for achieving stationary orthodontic anchorage. Palatal implants are used in adults as well as in adolescents. Substantial clinical and experimental evidence supports the reliability and suitability of endosseous implants for the purpose of orthodontic and orthopedic anchorage.[1–8]

Because of the specific location of these implants in the anterior region of the hard palate, several authors[9–14] recommend routine use of computed tomography (CT) scans or cone beam tomography (CBCT) for preoperative evaluation of the insertion area. Even for preoperative planning for implant removal 3-D imaging techniques have been advocated.[15]

However, these recommendations have been derived, by and large, from theoretical considerations, taking into consideration the proximity of the incisory nerve canal and the incisor roots. So far, the distinct need for preoperative 3-D imaging has not been substantiated by thorough research.

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3-D imaging procedures (CT/CBCT) have obviously extended the scope of diagnostic options particularly in conventional implantology because they provide precise information of the bony structures free of superimposition and distortion.[16–18] Especially in the last few years, the CBCT technique has became more and more popular in clinical orthodontics.[19–23] However, although the radiation exposure of CBCT is lower compared with standard CT protocols, any additional radiation dose has to be questioned unless a true benefit can be proven for the patient. This is especially true for orthodontic diagnostics, because the large majority of patients in clinical orthodontics are children and adolescents.

To this end, we set out to investigate whether CT or CBCT data are required for preoperative assessment of patients scheduled for the insertion of palatal implants. Thus, we reviewed a large series of patients who received palatal implants. Specifically, we wanted to find out how often lateral radiographs provided sufficient information for implant placement and how often additional diagnostic procedures were needed.

MATERIAL AND METHODS

Study Design and Patients

All patients who presented at the University Hospital Mainz for insertion of a palatal implant between January 2003 and December 2007 were included in this retrospective study. In all patients, the orthodontic treatment required a stationary anchorage. Patients who needed transversal expansion of the palate via two lateral palatal implants were excluded from the study.

Preoperative Planning

Preoperative planning included a clinical and radiological examination. The bone base was assessed by means of digital lateral radiographs (Figure 1). Measurements were taken with the computer software SIDEXIS XG, version 5.5 (Sirona, Bensheim, Germany). The image analysis program SIDEXIS is operated within the standard Microsoft environment. Apart from several image processing functions, it permits measurements of lengths and angles. Prior to measurement, calibration was performed for manual adjustment of grey tones. The parameter for radiological assessment was vertical bone height along the prospective implant axis prior to insertion of a palatal implant. The bone base was assigned to one of three groups:

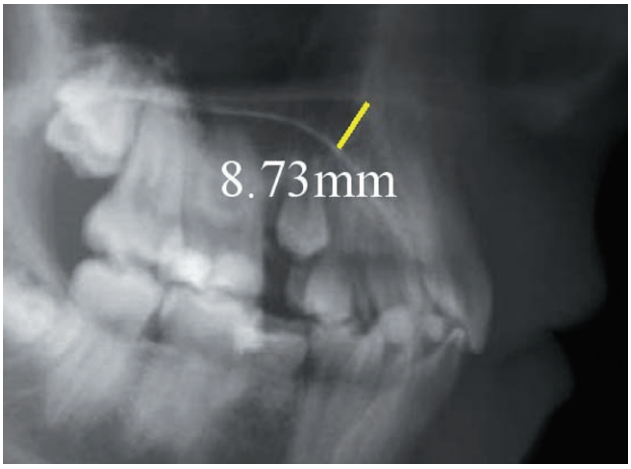

Figure 1 Preoperative assessment of bone on lateral radiographs: vertical bone height was measured along the prospective longitudinal axis of the implant. In this case, 8.73 mm of bone was available at the site of the implant.

- Group A: adequate bone base (the bone height in the implant axis was >4 mm)
- Group B: the bone base could not precisely assessed
- Group C: insufficient bone base (the bone height in the implant axis was <4 mm)

In group A, surgical insertion was performed without conducting any further radiological diagnostic procedures (Figure 2, a and b). In group B (Figure 3, a–c), further diagnostic procedures (CT/CBCT) were performed subsequently. Group C (Figure 4a) required other types of anchorage (Figure 4b).

Palatal Implant and Surgical Protocol

Ortho-implants of the first and second generation (single-piece implant, sand-blasted and acid-etched surface [SLA], Straumann, Basel, Switzerland) of 3.3×6 mm, 4 mm and 4.1×4.2 mm were used. According to the manufacturer's instructions the implant were inserted in the mid- or para-sagittal plane of the median region of the anterior palate by experienced surgeons.

Surgical insertion was performed under local anesthesia, approximately at the level of the first or second premolars, perpendicular to the bone surface. Briefly, the palatal mucosa at the insertion site was first removed with a small mucosal punch. A round bur of 3 mm in diameter was used to create a slight bony groove at the proposed site of the implant. The implant site was prepared using the specific ortho instruments of the respective generation in ascending sequence (first generation: profile drills; second generation: spiral drills). After the

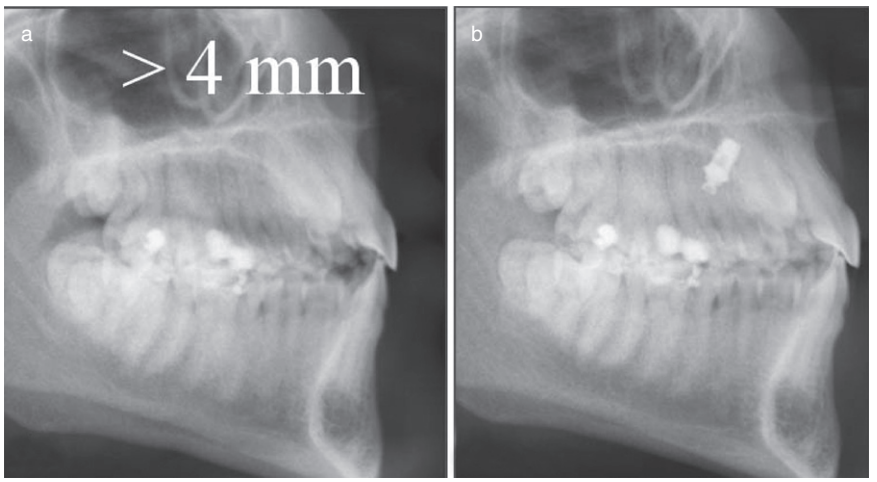

Figure 2 (a) Lateral radiograph shows a sufficient bone base (group A), defined as bone height in the prospective implant axis > 4 mm. All patients of this group underwent implant insertion (b) without any further imaging.

drilling procedures, a Bowman's probe (Aesculap Dental, Tuttlingen, Germany) was used to check for perforation of the nasal duct. The self-cutting implant was finally inserted with a ratchet and was sealed with a healing cap.

Postoperative Controls

A postoperative lateral radiograph was performed to verify the implant axis and implant position.

Statistical Analysis

Evaluation was performed on the basis of absolute and relative frequencies. All calculations were performed using SPSS for Windows, version 12 (SPSS Inc., Chicago, IL, USA).

RESULTS

Demographic Data

A total of 105 patients (age 12–63 years) were initially screened during the observation period. Fourteen patients decided not to undergo the treatment, mainly for economic reasons. Thus, 91 patients were available for final evaluation.

Assignment of Groups, Intraoperative Findings and Complications

In 89 of 91 patients (97.8%), the preoperative lateral radiographs showed adequate vertical bone (group A). Paramedian insertion was performed in 23 patients, whereas median insertion was performed in 66 patients. In all cases the presence of adequate bone was confirmed

Figure 3 (a) The lateral radiograph could not define the bone base (group B). (b) The patient had a clinically apparent facial deformity. Thus, an additional DVT was performed (c).

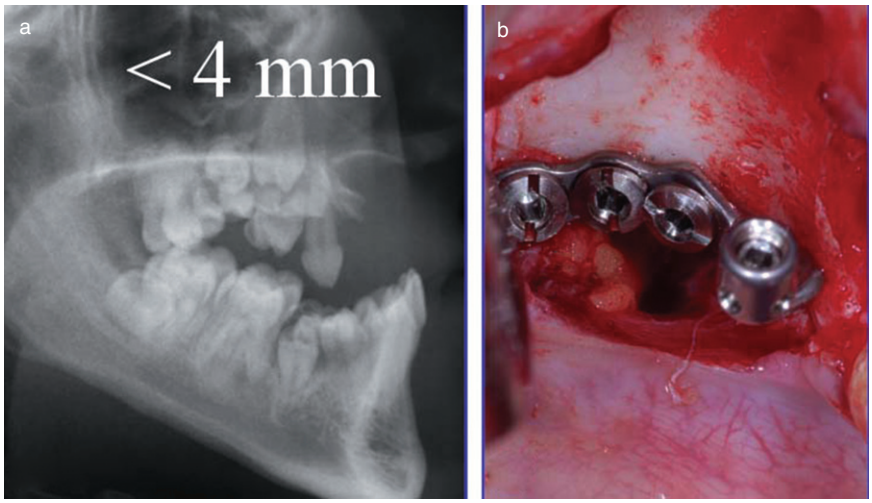

Figure 4 (a) Lateral radiograph shows an insufficient bone base (group C), defined as bone height in the implant axis < 4 mm. In this specific case a bone anchor was used as an alternative (b).

intraoperatively so that primary stability of the implants could be achieved. No complications were encountered during surgical insertion, especially there was no perforation of the nasal duct.

Two patients (2.2%) were assigned to group B and underwent further investigation (CT in one and CBCT in the other). These finally revealed insufficient bone in one patient while the second patient had an adequate bone base. Figure 5 summarizes the results of our investigation.

DISCUSSION

"Surgical" complications of palatal implants, like perforation of the nasal floor, damage to the incisory nerve or of the front teeth, are rare and largely theoretical in nature.[24,25] The elective character of palatal implant surgery requires thorough exclusion of patients who may be prone to any of these unfortunate events. To date, lateral radiographs represent the gold standard of imaging in the diagnostic workup of the orthodontic patient.

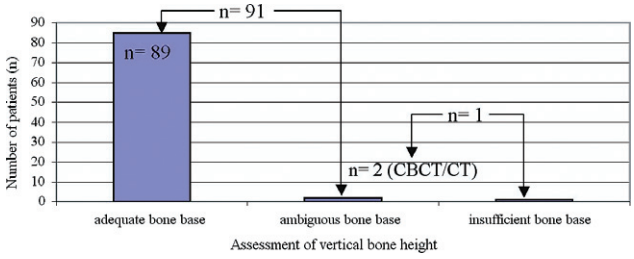

Figure 5 The figure shows the results of the current investigation: in 89 patients (97.8%) the lateral radiographs showed sufficient bone in the vertical aspect. In all of these cases a sufficient amount of bone was confirmed intraoperatively. Further radiological investigations were performed in two patients (2.2%) of group B (one CT, one CBCT).

Thus, it was the purpose of this investigation to verify whether this diagnostic modality alone will allow a final decision on the feasibility of palatal implants or whether additional imaging technologies are required.

We therefore reviewed all patients who applied for insertion of a palatal implant between January 2003 and December 2007. Within this period, the initial preoperative planning was performed on the basis of lateral radiographs. CTs or CBCTs were only added when the lateral radiograph was ambiguous or suggested critical bone configuration.

First of all, it was remarkable that almost 98% of the patients of this study group, who were neither selected for demographic data nor for specific dentofacial anomalies, proved to have sufficient bone for palatal implant placement. Furthermore, these data clearly demonstrate that lateral radiographs alone will allow the final decision on the feasibility of a palatal implant in the vast majority of the patients (89 out of 91). For all patients assigned to group A, intraoperative exploration confirmed sufficient bone for stable implant placement. Moreover, lateral radiograph could depict all patients with either critical or insufficient bone (two out of 91). These data strongly suggest that CBCT or CT is not required as a first-line diagnostic technology for palatal implants.

Figure 6 The lateral radiograph shows a complex dentofacial deformity. Even in this specific case the lateral radiograph provided sufficient diagnostic information for the placement of a palatal implant as part of the combined surgical-orthodontic treatment.

This holds true even in more complex dentofacial deformities requiring combined surgical-orthodontic treatment (Figure 6). Eleven of 89 patients of this study received palatal implants as part of their combined surgical-orthodontic treatment and in all these cases, lateral radiographs provided sufficient diagnostic information for the placement of palatal implants.

The relevance of these findings may be expressed in the substantial difference of radiation dose associated with these diagnostic modalities. While radiation exposure of a digital lateral radiograph amounts to about 5 μSv,[26] the respective dose of CBCTs ranges from 30–650 μSv,[27,28] and conventional CT-sequences may even exceed 1000 μSv.[29,30] Thus, first-line diagnostics by lateral radiograph alone will save at least 80–85% of radiation exposure.

It should be added that apart from implant planning CBCT or even conventional CT may be of considerable general diagnostic value for the orthodontic patient when either structural deformities of the facial skeleton or specific parameters of the soft tissue have to be assessed prior to orthodontic or combined treatment. In such cases, all diagnostic information needed for palatal implant placement may be derived from CT or CBCT data, rendering additional lateral radiograph unnecessary.

Apart from the median-sagittal insertion, paramedian insertion might be required in some cases such as unilateral palatinal displaced canines. In these cases, lateral radiographs may not provide sufficient information for a valid assessment of vertical bone height.

Anatomical and radiographic investigations[9,12,13,31] have demonstrated a general decrease of mean vertical bone thickness from the midpalate to the paramedian region. However, sufficient bone (on average 5 mm[9] to 8 mm[31]) for paramedian palatal implant placement is typically found at the level of the first and second premolars[9,12,13,31] Indeed, these studies show marked individuals variations in the paramedian bone thickness. Therefore, three-dimensional imaging procedures might be a valuable option for preoperative assessment in patients scheduled for paramedian insertion of palatal implants.

CONCLUSIONS

1. Lateral radiographs permit correct and reliable assessment of the vertical bone dimension prior to the insertion of palatal implants.
2. CT or CBCT scans are rarely needed for placement of palatal implants. The benefit of 3-D imaging is limited to cases in which the lateral radiograph shows a marginal vertical dimension of bone.
3. For reasons of radiation protection, 3-D imaging cannot be recommended for routine preoperative use in palatal implants.

REFERENCES

1. Wehrbein H, Merz BR, Diedrich P, Glatzmaier J. The use of palatal implants for orthodontic anchorage. Design and clinical application of the orthosystem. Clin Oral Implants Res 1996; 7:410–416.
2. Tinsley D, O'Dwyer J, Benson P, Doyle P, Sandler J. Orthodontic palatal implants: clinical technique. J Clin Orthod 2004; 31:3–8.
3. Heymann GC, Tulloch JFC. Implantable devices as orthodontic anchorage: a review of current treatment modalities. J Esthet Restor Dent 2006; 18:68–80.
4. Tausche E, Hansen L, Hietschold V, Lagravère MO, Harzer W. Three-dimensional evaluation of surgically assisted implant bone-borne rapid maxillary expansion: a pilot study. Am J Orthod Dentofacial Orthop 2007; 131:S92–S99.
5. Jung BA, Kunkel M, Göde M, Wehrbein H. Clinical success parameters of paramedian insertion during growth. Z Zahnärztl Impl 2007; 23:28–35.

6. Jung BA, Kunkel M, Göllner P, Liechti T, Wehrbein H. Success rate of palatal implants of the second generation – preliminary results of a prospective study. Angle Orthod 2009; 79:85–90.
7. Borbély P, Miklós P, Dunay DVM, Jung BA, Wehrbein H, Wagner W, Kunkel M. Primary loading of palatal implants for orthodontic anchorage – an experimental animal study. J Craniomaxillofac Surg 2008; 36:21–27.
8. Männchen R, Schätzle M. Success rate of palatal orthodontic implants: a prospective longitudinal study. Clin Oral Implants Res 2008; 19:665–669.
9. Bernhart T, Vollgruber A, Gahleitner A, Dörtbudak O, Haas R. Alternative to the median region of the palate for placement of an orthodontic implant. Clin Oral Implants Res 2000; 11:595–601.
10. Bantleon HP, Bernhart T, Crismani AG, Zachrisson BJ. Stable orthodontic anchorage with palatal osseointegrated implants. World J Orthod 2002; 3:109–116.
11. Gahleitner A, Prodesser B, Schick S, Watzek G, Imhof H. DentalCT and orthodontic implants: imaging technique and assessment of availble bone volume in the hard palate. Eur J Radiol 2004; 51:257–262.
12. King KS, Lam EW, Faulkner G, Giseon H, Major PW. Vertical bone volume in the paramedian palate of adolescents: a computed tomography study. Am J Orthod Dentofacial Orthop 2007; 132:783–788.
13. Kang S, Lee SJ, Ahn SJ, Heo MS, Kim TW. Bone thickness of the palate of orthodontic mini-implant anchorage in adults. Am J Orthod Dentofacial Orthop 2007; 131:S74–S81.
14. Wexler A, Tzadok S, Casap N. Computerized navigation surgery for the safe placement of palatal implants. Am J Orthod Dentofacial Orthop 2007; 131:S100–S105.
15. Grognard N, Vande Vannet B. Aspects in post-orthodontic removal of orthosystem implants. Clin Oral Implants Res 2008; 19:1290–1294.
16. Besimo C, Lambrecht J, Nidecker A. Dental implant treatment planning with reformatted computed tomography. Dentomaxillofac Radiol 1995; 24:264–267.
17. Kraut R. Interactive CT diagnosis, planning and preparation for dental implants. Implant Dent 1998; 7:19–25.
18. Hatcher DC, Mayorga C. Cone beam CT for pre-surgical assessment of implant sites. J Calif Dent Assoc 2003; 31:825–833.
19. Mah J, Enciso R, Jorgensen M. Mangment of impacted cuspids using 3-D volumetric imaging. J Calif Dent Assoc 2003; 31:835–841.
20. Maki K, Inou N, Takanishi A, Miller AJ. Computer-assisted simulations in orthodontic dignaosis and the application of a newcone beam x-ray computed tomography. Orthod Craniofac Res 2003; 6:95–101.
21. Baumrind S, Carlson S, Beeres A, Curry S, Norris K, Boyed RL. Using three-dimensional imaging to assess treatment outcomes in orthodontics: a preogress from the University of the Pacific. Orthod Craniofac Res 2003; 6:132–142.
22. Hohlberg C, Steinhauser S, Geis P, Rutzki-Janson I. Cone-beam computed tomography on orthodontics: benefits and limitations. J Orofac Orthop 2005; 66:434–444.
23. Silva MAG, Wolf U, Heinecke F, Bumann A, Visser H, Hirsch E. Cone-beam computed tomography for routine orthodontic treatment planning: a radiation does evaluation. Am J Orthod Dentofacial Orthop 2008; 133:640.e1–640.e5.
24. Wehrbein H, Merz BR, Diedrich P. Palatal bone support for orthodontic implant anchorage – a clinical and radiological study. Eur J Orthod 1999; 21:65–70.
25. Wehrbein H, Jung BA, Kunkel M. Wissenschaftliche Stellungnahme zur kieferorthopädischen Verankerung mit Gaumenimplantaten und Kortikalisschrauben. J Orofac Orthop 2008; 6:487–490.
26. Broer N, Fuhrmann A, Bremert S, Schulze D, Kahl-Nieke B. Evaluation of transversal slice imaging in the diagnosis of tooth displacement with special considerations of the upper canines. J Orofac Orthop 2005; 66:94–109.
27. Kau CH, Richmond S, Palomo JM, Hans MG. Three-dimensional cone beam computerized tomography in orthodontics. J Orthod 2005; 32:282–293.
28. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercury, NewTom 3 G and I-Cat. Dentomaxillofac Radiol 2006; 35:219–216.
29. Ludlow JP, Davies-Ludlow LE, Brooks SL. Dosimetry of two extraoral direct imaging devices: NewTom cone beam CT scans and OrthoposPlus DS panoramic unit. Dentomaxillofac Radiol 2003; 32:229–234.
30. Cohnen M, Kemper J, Mobes O, Pawelzik J, Modder U. Radiation dose in dental radiology. Eur Radiol 2002; 3:634–637.
31. Baumgaertel S. Quantitative investigation of palatal bone depth and cortical bone thickness for mini-implant placement in adults. Am J Orthod Dentofacial Orthop 2009; 136:104–108.