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Analyzing the teeth next to the alveolar cleft: Examination and treatment proposal prior to bone grafting based on three-dimensional versus two-dimensional diagnosis—A diagnostic study

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ABSTRACT

Purpose: The objective was to evaluate the diagnostic and prognostic value of three-dimensional (3D) cone beam computed tomography (CBCT) on information about the cleft and alignment of cleft neighboring teeth.

Materials and methods: Panoramic X-rays, small-volume CBCTs, and study casts of 20 patients with a total of 22 alveolar clefts were analyzed prior to secondary bone grafting. Six maxillofacial surgeons and 6 orthodontists rated the following parameters: visibility of alveolar cleft expansion, position and probability of alignment of cleft neighbored teeth. Two-dimensional (2D) X-rays and casts were rated first; CBCT and casts followed at least 4 weeks later. Radiologic bone height in the region of the former alveolar cleft, as well as alignment and reasons for nonalignment of cleft neighbored teeth, were recorded 4 years later.

Results: The rate of proper proposals regarding the real treatment outcome using 2D- or 3D-material did not differ statistically. Although 5%–45% of the proposals were changed when using 3D instead of 2D records, Fleiss multirater kappas showed no essential differences. Raters' profession and experience had no influence on the rate of correct proposals.

Conclusion: In orthodontics, small-volume CBCT may be justified only as supplement to a routine panoramic X-ray, and only in selected cases or for surgical preparation.

1. Introduction

During the rehabilitation of patients with cleft lip and palate, the closure of the alveolar cleft is performed at different times according to the schedule of the cleft team (Bergland et al., 1986b; Amanat and Langdon, 1991; Al-Nawas et al., 2007). Nowadays it is common sense that the alveolar cleft has to be closed (Long et al., 2015) and that, in contrast to early gingivoperioplasty (Hsieh et al., 2010, Wojtaszek-Slominska et al., 2010), there is no significant influence on craniofacial growth after bone grafting (Gesch et al., 2006). However, there is still discussion on the perfect timing and the way to operate (Koberg, 1973; Henkel and Gundlach, 1997, 2002; Enemark et al., 2001; Bayerlein et al., 2006; Berkowitz, 2009; Dissaux et al., 2016; Paterson et al., 2016; Pessoa et al., 2016).

To define the amount, quality, and stability of the transplanted new bone in the region of the alveolar cleft after bone grafting, the postoperative use of three-dimensional (3D) diagnostics (cone-beam computed tomography [CBCT]) is quite popular today (Hamada et al., 2005; Feichtinger et al., 2007, 2008; Garib et al., 2012; Seike et al., 2012; Zhang et al., 2015; Liu et al., 2016). A CBCT before bone grafting is a standard procedure by many cleft teams to calculate the size of the cleft defect (Linderup et al., 2015) and to decide on necessary removal of hypoplastic non-alignable teeth near the cleft.

The purpose of this diagnostic retrospective cohort study was to evaluate whether 3D diagnostics (CBCT) are superior to two-dimensional (2D) diagnostics (panoramic X-ray) in patients with cleft-lip and palate for assessing cleft dimensions as well as the position and probability of the alignment of the teeth adjacent to the alveolar cleft.

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2. Materials and methods

A diagnostic study was conducted of 20 consecutive patients undergoing (late primary) secondary bone grafting of the alveolar cleft in the year 2009. All patients had nonsyndromatic uni- or bilateral complete cleft lip and palate. As 18 patients had a total unilateral and two patients a bilateral cleft, there were 22 alveolar clefts to be analyzed. The mean age of the patients was 12.5 ± 5.5 years, with a median of 10 years and a range of 8–32 years. Nearly all 16 male and 4 female patients were treated according to the former Mainz procedure (Wriedt, 2004; Al-Nawas et al., 2007): the closure of the lip was performed at the age of 3–6 months according to a modified Tennison-Randal technique, and the soft and hard palate were reconstructed one stage at the age of 9–18 months using bipedicled flaps initially described by Veau/Langenbeck/Axhausen. After orthodontic transverse expansion of the maxilla, the closure of the alveolar gap was performed using iliac crest spongiosa according to the original secondary bone graft procedure (Boyne and Sands, 1972; Abyholm et al., 1981). This usually took place at the age of 8–12 years. As a prerequisite, the roots of the tooth distal to the alveolar cleft (lateral incisor or canine) had to be developed one-half to two-thirds of its length (Bergland et al., 1986a).

Patients' records used within the framework of the study comprised study casts and 2D panoramic radiographs for orthodontic treatment planning, as well as low-volume CBCT images produced routinely prior to the bone graft operation. Patient data were anonymized, and no additional examinations were taken, so ethical approval was covered by the professional rights of Rhineland-Palatinate (Landeskrankenhausgesetz §§ 36 and 37).

A total of 12 examiners (6 maxillofacial surgeons and 6 orthodontists) evaluated the records in two steps. There were 6 specialists in orthodontics or maxillofacial surgery and 6 postgraduates; 5 examiners (3 of the maxillofacial surgeons and 2 of the orthodontists) were experienced for many years in treating patients with cleft lip and palate. First, digital 2D panoramic radiographs and study casts (representing the clinical intraoral situation) were examined. At least 4 weeks later, study casts and 3D CBCTs were evaluated. The low-volume CBCT images (40 × 40-mm Cylinder; Accuitomo, Morita, Japan) were examined using the one Data Viewer Plus (Morita, Japan); observers were able to scroll through the whole 3D image. Clinical criteria of interest were the clearly defined border of the alveolar cleft, the visibility of the roots, the position, and the probability of alignment of the teeth central and lateral incisor as well as the canine. Possible reasons for nonalignment were collected.

At least 4 years later, the actual treatment results were extracted from the patients' records: were the cleft neighbored teeth aligned? Which reasons for nonalignment could be seen? The success of the operation was determined using the scales developed by Bergland et al. (1986b) and by Witherow et al. (2002).

The evaluations were referenced in spreadsheet software (Excel 2007; Microsoft Corporation, Redmond, WA, USA) and descriptively analyzed in SPSS version 23 (SPSS, IBM Corporation, Armonk, NY, USA) or SAS version 9.2 (SAS Institute, Cary, NC, USA) statistics software. For comparing agreement between raters (diagnostic accuracy), multirater kappas with confidence intervals were obtained using R 3.1.2, package irr. For each cleft, the proportion of dentists was determined that gave a positive prognosis based on CBCT or panoramic x-rays respectively (prognostic accuracy). Percentages based on CBCT and percentages based on panoramic X-rays were compared using Wilcoxon signed-rank tests. Nominal significance level was chosen as $\alpha = 0.05$. As the analysis had exploratory intention, no adjustment for multiple testing was performed, and p-values are given merely for descriptive purposes.

3. Results

3.1. Diagnostic accuracy: change in treatment proposals using 2D or 3D documents

In 74.2% of cases (n = 196), the parameter "cleft type" was rated the same in 2D and 3D examination. Although the analyzed alveolar cleft sides were always complete clefts, 56 (21.2%) alveolar clefts were rated as incomplete using 2D and 30 (11.4%) using 3D material. All borders (100%) of the clefts were evaluated as "clearly visible" in 3D ratings, whereas in 2D ratings in 144 (54.5%) examinations of the vertical, in 152 (57.6%) of the transversal, and in 160 (60.6%) of the sagittal dimension borders were unclear.

The parameter "clearly defined root" or "not clearly defined root" did not differ between 2D and 3D examination: 130 times (49.2%) for the central incisor, 124 times (47.3%) for the lateral incisor, and 153 times (57.9%) for the canine. The roots could not be clearly defined using 2D but could be clearly defined using 3D material in 131 (49.6%) ratings of the central incisor, 122 (46.2%) ratings of the lateral incisor, and 103 (39.0%) ratings of the canine.

The rate of the same treatment proposals using 2D or 3D material is given in Table 1. As the results concerning the canine and the central incisor were within the expected eventuality, only the numbers concerning the lateral incisor were analyzed, as shown in Tables 2 and 3. As displayed, the unchanged proposals comprise the majority of all suggestions. The kappas measuring interrater agreement of all observers for "visibility of the lateral incisor" showed moderate agreement (Landis and Koch, 1977) and only minor changes comparing 2D ($\kappa = 0.413$) to 3D examination ($\kappa = 0.459$), as well as fair agreement and little changes for lateral incisor alignment (2D: $\kappa = 0.228$, 3D: $\kappa = 0.230$), and for the reasons of nonalignment of the lateral incisor (2D: $\kappa = 0.275$, 3D: $\kappa = 0.239$), meaning that agreement among raters was similar for 2D and 3D examination.

Similar kappa values show that, looking at 2D or 3D materials, the amount of changing the given answers was similar in the different groups (maxillofacial surgeons versus orthodontist, specialist versus postgraduates, or cleft specialist versus non-specialized clinicians). The only exception was the decision of lateral incisor's possible alignment, when the maxillofacial surgeons ($\kappa = 0.486$; 95% CI = 0.356–0.616) seemed to be more stable in their decision compared to the orthodontists ($\kappa = 0.324$; 95% CI = 0.173–0.474).

3.2. Long-term evaluation

One of the 22 cleft sides needed to undergo reoperation: additional bone layers were necessary to make orthodontic movement of the adjacent teeth possible.

More than 4 years after bone grafting, the vertical bone level in the region of the former alveolar cleft was rated 1 (perfect) according to the Bergland et al. (1986b) scale 16 times; 4 cleft sides were rated 2 (at least three-fourths of normal height); 1 cleft side was rated 3 (height less than three-fourths of normal height); 1 rating was not possible because of the poor resolution of the panoramic X-ray.

Table 1
Rate of same proposals using 2D- or 3D images.

Same proposals using 2D or 3D images	Tooth	%
Alignment	Central incisor	95.5
	Lateral incisor	71.2
	Canine	87.1
Reason for nonalignment	Central incisor	95.9
	Lateral incisor	56.1
	Canine	89.0