Nasopalatine canal and periapical radiolucency fusion following dento-alveolar trauma: a CBCT-based case-control study

Running title: nasopalatine canal and periapical **radiolucency** fusion

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Nasopalatine canal and periapical radiolucency fusion following dento-alveolar trauma: a CBCT-based case-control study

Abstract

Background/Aim

There is lack of evidence regarding the radiological characteristics of a periapical radiolucency fusion with the nasopalatine canal following dento-alveolar trauma. The aim of this study was to assess the nasopalatine canal (NPC) enlargement resulting from fusion with a periapical radiolucency and its relationship with the surrounding anatomical structures.

Material and methods

A total of 100 patients were retrospectively recruited and divided into two groups: case group and control group. The case group consisted of 50 cone-beam computed tomography scans of the maxilla of patients (32 males, 18 females; age range: 11 - 83 years) with a known history of dento-alveolar trauma in the maxillary anterior region and presence of an undiagnosed and/or asymptomatic nasopalatine canal- periapical radiolucency fusion. An age- and gender-matched control group of 50 patients (32 males, 18 females; age range: 11 – 82 years) without trauma history to the upper anterior teeth, demonstrating normal maxillary scans was recruited. A subjective scoring criterion was established for assessing the characteristics of the fused lesion and its relationship with the buccal/palatal alveolar cortex, nasal cavity cortex, nasopalatine canal cortical border and maxillary sinus floor.

Results

The fused nasopalatine canal- periapical radiolucency was mainly lobular in appearance (88%) with non-corticated well-defined margins (80%). Male patients showed larger (68%) dimensions compared to female patients (32%). The nasopalatine canal cortical bone was the most commonly perforated structure in relation to fusion (72%), whereas, maxillary sinus cortical bone was the least effected (2%). A statistically significant difference was observed between the nasopalatine canal dimensions in the control and test groups, with fused lesions having larger mesio-lateral, cranio-caudal and bucco-palatal dimensions ($p<0.001$).

Conclusions

Periapical radiolucencies should be treated as soon as possible before they fuse with NPC. In case of fusion, surgical enucleation should be considered as the treatment of choice.

Keywords: maxilla, nasopalatine canal, periapical lesion, tooth trauma

Introduction

The nasopalatine canal (NPC), also referred to as the incisive or anterior palatine canal, is a neurovascular passage connecting the hard palate to the nasal cavity. Inferiorly, it emerges as the incisive foramina at the middle of the premaxilla, posterior to the anterior maxillary incisors. Superiorly, it continues usually on each side of the nasal septum ending in a nasal foramen.^{1,2} It mainly contains the nasopalatine nerve and terminal branches of the nasopalatine artery surrounded by connective tissue and seromucous glands.^{3,4}

The application of conventional two-dimensional (2D) imaging techniques, such as intra-oral radiography, to assess the maxillary anterior periapical region provides limited information and can lead to inaccurate interpretation of a periapical radiolucency (PRL) related to the central incisors.⁵⁻⁸ Factors influencing periapical assessment include morphologic variations, surrounding bone density, x-ray angulation and radiographic contrast.^{7,9,10} Hence, knowledge about the periapical anatomy and its relationship with surrounding anatomical structures is essential for proper diagnosis and treatment planning. To overcome these limitations, cone-

beam computed tomography (CBCT) as a three-dimensional (3D) imaging modality has been proposed for diagnosis, evaluation and follow-up of PRL specifically in the proximity of the NPC.^{8,9,11}

PRLs developing secondary to dento-alveolar trauma involving the anterior maxillary region have the tendency to merge with the NPC. If not detected or treated early, this can lead to a fusion with the canal, and may even compromise adjacent anatomical structures, such as perforation of the buccal/palatal alveolar cortex, nasal cavity cortex and maxillary sinus floor.^{3,12,13} Enlargement of NPC has been mostly reported to be idiopathic. However, recent evidence suggests an association between anterior maxillary dento-alveolar trauma and increased dimensions of the NPC.^{3,14} Clinically, this pathological enlargement of NPC can lead to teeth displacement and destruction of surrounding bone as well as compromising dental implant placement in the esthetic zone.¹⁴ The aim of this CBCT-based study was to assess NPC enlargement resulting from NPC-PRL fusion and its relationship with surrounding anatomical structures in patients with a known history of maxillary anterior dento-alveolar trauma compared to an age- and gender-matched control group.

Materials and methods

This study was conducted in compliance with the World Medical Association Declaration of Helsinki on medical research. Ethical approval was obtained from the Ethical Review Board of the University Hospitals Leuven, Leuven, Belgium (reference number: S57587). Informed consent was not required for this retrospective study as patient-specific information was kept anonymous.

A total of 100 patients were recruited retrospectively and divided into two groups, a case group and control group. The case group consisted of 50 CBCT scans of patients (32 males, 18 females; age range: 11 - 83 years) with a known history of dento-alveolar trauma in the maxillary anterior region and presence of an undiagnosed and/or asymptomatic NPC-PRL fusion (Figure 1). The patients in the case group were initially referred to the hospital from private dental practitioners having only a 2D radiograph and requiring a CBCT scan for further evaluation. All patients underwent surgical enucleation following diagnosis of NPC-PRL fusion. A control group of 50 normal CBCT scans was recruited matching the age and gender of the case group (32 males, 18 females; age range: 11 – 82 years). The exclusion criteria involved craniofacial syndromes, systemic diseases and presence of artefacts in the anterior maxillary region.

The CBCT images were obtained utilizing two devices, Scanora 3D[®] (Soredex, Tuusula, Finland) and Accuitomo 170[®] (J. Morita, Kyoto, Japan) with scanning parameters of 80-90 kV, a voxel size between 0.125 to 0.250 and a field of view (FOV) between 6x6 cm to 13x14.5 cm. Assessment of all images was performed by two experienced oral and maxillofacial radiologists via IMPAX software (Agfa, Mortsels, Belgium). Assessment was performed twice by both radiologists with a 2-weeks interval to calculate intra- and inter-observer reliability.

Based on a morphological classification proposed by Bornstein et al.¹⁵ NPC was classified either as single canal, two separate parallel canals or Y-type canal by viewing the canal in coronal CBCT sections. A semi-quantitative scoring criterion was established for assessing the characteristics of NPC-PRL and its relationship with adjacent anatomical structures (Figure 2, 3) as mentioned in Table 1. Following scoring, the length (vertical distance between nasal and oral opening), width at midway and diameter of the NPC at the level of incisive foramen in the control group was measured. Additionally, the longest mesio-lateral, cranio-caudal and bucco-palatal dimension of fused NPC-PRLs was measured on axial, coronal and sagittal cross-sectional views in the case group (Figure 4).

Data were analyzed using MedCalc statistical software (version 12.0, Ostend, Belgium). Kappa statistics (k) was used for assessing intra- and inter-observer reliability and interpreted as, 0-0.20: poor, 0.21-0.40: slight, 0.41-0.60: moderate, 0.61-0.80: substantial, 0.81-1.0: near perfect.¹⁶ The frequency of the relationship between NPC-PRL and adjacent anatomical structures was calculated. An independent t-test was performed to assess if any significant difference in dimensions existed between control and case group, where $p < 0.001$ was considered as statistically significant.

Results

An overall excellent intra- ($k = 0.96$, $p = 0.253$) and inter-observer reliability ($k = 0.94$, $p = 0.350$) was observed with no significant difference. According to the morphological NPC classification, the control group demonstrated most commonly a Y-shaped canal (57%), followed by a single canal type (38%), and two parallel canals (5%). The fused NPC-PRL was mainly lobular in appearance (88%) with non-corticated well-defined margins (80%). In only 7% of the cases, a mixed internal structure was seen. A mean of 1.8 apices were involved per fusion, 2 apices in 35%, followed by 32% cases involving just 1 apex. The biggest fusion involved 10 apices (Figure 5A-F). Male patients showed larger (68%) fused

NPC-PRL dimensions compared to female patients (32%). Eight patients had missing teeth in the maxillary anterior region due to early tooth loss. In the case group 56% of the patients were free from any dental restoration and 46% had crown/bridge placement following root canal treatment to prevent tooth fracture or to restore fractured teeth. None of the patients had large restorations and/or crown placement without root canal treatment. Apical root resorption was observed in 38% cases and 52% of cases showed an extension to the contralateral side, involving the intermaxillary suture.

Buccal and palatine cortical bone perforation was observed in 50% and 68% of the cases, respectively (Table 2). There were 68% of cases with involvement of both buccal and palatal cortical walls, where 53% had bucco-palatal perforation and 12% showed bucco-palatal bulging. Buccal bulging with palatal perforation was seen in 21% of the cases, whereas 9% of the cases had buccal perforation with palatal bulging. Only 5 % showed buccal perforation with thinning of the palatal wall. The nasal floor cortex was perforated in only 22% of the cases. The NPC cortical marginal bone was the mostly commonly compromised structure in relation to NPC-PRL fusion (72%), whereas maxillary sinus cortical bone was the least effected (2%).

The length of the NPC in the control group ranged between 4.3mm and 15.8mm (mean: 8.8mm) with a mean diameter of 3.8mm in both axial and sagittal planes. The NPC-PRL had a mean distance of 14mm, 12mm and 11mm in mesio-lateral (axial), cranio-caudal (coronal) and bucco-palatal (sagittal) directions, respectively. The longest distance for NPC-PRL was observed mesiolaterally (range: 4.1mm-44.3mm), followed by cranio-caudal (range: 1.9mm-23.9mm) and bucco-palatal direction (range: 3.8mm-23.1mm). A statistically significant difference was observed between the corresponding NPC dimensions in the control and test groups, with NPC-PRL having significantly larger dimensions ($p=0.00031$).

Discussion

The present radiological study was carried out to describe the fusion of NPC with PRL and its relationship with neighboring anatomical structures using a case-control study design. The presumed developmental progress of fused NPC-PRL was described by categorizing them into different stages based on the degree of involvement of the anatomical structures. No previous study has described the relationship of these lesions with surrounding anatomical structures.

Various authors have reported anatomical and morphological variations of the normal NPC.¹ Suter et al.³ and Fernández-Alonso et al.¹⁷ found the Y-type canal to be the most frequently observed variation, followed by a single canal and two parallel canals. Similar findings were also observed in the present study. In contrast, some studies have reported a single canal to be the most commonly observed variation.^{15,18} A male predilection was observed related to trauma in this study, which was in accordance with other studies.^{6,19} In some patients, evaluation of the root apices was not possible, as tooth extraction had been carried out resulting from the failure of previous treatment and/or progressive enlargement of the fused NPC-PRL.

According to CBCT evaluation, all cases of fusion had an infectious component related to the PRL development. In order to make a definitive diagnosis, histological evaluation has been recommended as a gold standard, where periapical cyst and apical granuloma are the most commonly seen periapical lesions.^{19-21,22-24} Yet, when reading the histopathological report, one should realize that this so-called gold standard diagnosis may be troubled by secondary infection, thereby, obscuring the primary cause and leading to inaccurate diagnosis. The potential risk for a false negative outcome of the biopsy report, should be contrasted to the differential diagnosis of other radiolucent lesions such as an enlarged NPC, nasopalatine duct cyst (NPDC), odontogenic keratocyst and non-odontogenic tumors which could develop in the anterior region.^{20,21,25-27} Thus, even though histology is a gold standard for diagnosis of the nature of maxillary radiolucencies, in the case of fused lesions (NPC with an apical radiolucency), CBCT may significantly aid diagnosis and treatment planning of fused NPC-PRL lesions based on its relationship with the surrounding anatomical structures. In this study, histopathological findings of the enucleated NPC-PRL demonstrated a cystic membrane with elements of granulation tissue. However, this biopsy information was insufficient for differentiating it from other periapical lesions. The retrospective nature of the study, duration of trauma and time of referral could have influenced both histological and radiological behavior of the lesions. Further comparative studies should be carried out to assess the difference in behavior related to fused lesion compared with other odontogenic and non-odontogenic lesions/cysts.

A 2D or 3D radiographic diagnosis of a radiolucency can be established if the following conditions are met in relation to a pulpless, infected tooth: loss of the lamina dura at the root apex, existence of periapical inflammatory radiolucency epicenter at the root apex, non-corticated well-defined periphery showing a transition with the normal surrounding bone,

radiolucent internal structure indicating a loss of bone density at an initial stage with no surrounding bone reaction and in chronic cases external resorption of the root apex.²⁸⁻³⁰ In this study the abovementioned criteria were met although some cases showed mixed internal structure which was due to the inclusion of endodontic filling material within the boundaries of the radiolucency. From the history of all the cases in this study, one may assume that origin of the fused lesions can be from an early childhood dento-alveolar trauma of the frontal maxillary region. An absence of proper treatment and standardized follow-up protocols can lead to lesions being overlooked both radiographically and clinically over time, thereby reaching large dimensions and compromising the surrounding anatomical structures. In a previous study assessing the association between periapical osteolytic lesions and NPC, the authors observed significantly larger bucco-palatal and mesio-distal dimensions in cases with fusion, which was in accordance to the current findings. They also found that osteolytic lesions with bucco-palatal dimensions of more than 5mm were more prone to fusion.³

In relation to surgical procedures, such as implant placement or bone grafting in anterior maxilla, an early diagnosis and surgical enucleation of the lesion is required to prevent surgical site infection. The penetration of NPC during implant placement is not an unusual phenomena^{31,32} and optimal treatment of such lesions beforehand is essential for a good prognosis. As the NPC gets secondarily infected resulting from the PRL fusion, if not enucleated it can induce bone infection and even lead to possible development of osteomyelitis.^{33,34} In such cases of fusion, 3D CBCT imaging can provide more information rather than 2D imaging, thereby increasing the chances of early detection, diagnosis and adequate treatment.

In conclusion, this case-control series demonstrated the presence of fused lesions in the anterior maxilla based on PRL development and NPC enlargement to be linked with dento-alveolar trauma rather than being idiopathic.

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TABLE 1 Scoring criteria for CBCT-based evaluation of the nasopalatine canal area, with a specific focus on nasopalatine fusion lesions and their relationship with neighboring anatomical structures

Fusion characteristics		Scoring criteria
a. Periphery		0: defined but not corticated, 1: defined and corticated, 2: ill-defined
b. Shape		1: circular/lobular, 2: scalloped/multilocular, 3: irregular
c. Internal structure		0: radiolucent, 1: radiopaque, 2: mixed
d. Root apex involvement		total number of root apices involved in the lesion
e. Root resorption		0: absent, 1: present
f. Crossing midline and intermaxillary suture involvement		0: absent, 1: present
Neighbouring anatomical structures		Scoring criteria
a. Nasopalatine canal cortical border		0: no involvement, 1: bordering, 2: thinning, 3: bulging, 4: perforation
b. Buccal/ palatine cortical plate		0: no involvement, 1: thinning, 2: bulging, 3: perforation
c. Nasal floor cortex		0: no involvement, 1: bordering, 2: thinning, 3: bulging, 4: perforation
d. Maxillary sinus cortical bone		0: no involvement, 1: bordering, 2: thinning, 3: bulging, 4: perforation

TABLE 2 Characteristics of diagnosed nasopalatine fusion lesions in relation to neighboring anatomical structures

Anatomical structures	Scoring criteria	Percentage of observations (%)
Buccal cortical bone	Not affected	15%
	Lesion thins buccal cortical bone	8%
	Lesion bulges buccal cortical bone	27%
	Lesion perforates buccal cortical bone	50%
Palatine cortical bone	Not affected	13%
	Lesion thins palatine cortical bone	4%
	Lesion bulges palatine cortical bone	15%
	Lesion perforates palatine cortical bone	68%
Nasal floor cortex	Not affected	47%
	Bordering the nasal floor	6%
	Thinning the nasal floor	12%
	Bulging the nasal floor	13%
	Perforation of the nasal floor	22%
Maxillary sinus cortex	Not affected	73%
	Bordering the sinus floor	10%
	Thinning the sinus floor	5%
	Bulging the sinus floor	10%
	Perforation of the sinus floor	2%
Nasopalatine canal cortex	Not affected	9%
	Bordering NPC cortical margin	7%
	Thinning NPC cortical margin	7%
	Bulging into NPC cortical margin	5%

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