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Effect of Dentoalveolar Trauma on Nasopalatine canal: retrospective radiographic assessment using cone beam computed tomography

Wael Aboelmaaty[1, 2, 3]*

[1]College of Dentistry, King Saud bin Abdul-Aziz University for Health Sciences, Riyadh, **Saudi Arabia**
[2] King Abdullah International Medical Research Center, Riyadh, **Saudi Arabia**
[3]Oral Radiology and Diagnostic Sciences, Faculty of Dentistry, Mansoura University, Mansoura, **Egypt**

***Correspondence:** aboelmaatyw@ksau-hs.edu.sa **Received 15-09-2022, Revised: 21-10-2022, Accepted: 30-10-2022 e-Published: 07-11-2022**

The dental traumatic injuries are the most common type of injury in the maxillofacial region. The aim of this study is to determine the effect of dent alveolar trauma of the maxillary incisor region on the size of the nasopalatine canal (NPC) using cone beam CT (CBCT).Two hundred patients were selected retrospectively from the CBCT database, they were divided into 2 groups: one study group composed of 100 cases with well-known history of previous dent alveolar trauma in maxillary incisor area, while the other 100 case with no history of trauma or endodontic treatment were selected as a control group. In both groups, CBCT was evaluated to measure the NPC carefully in different plans to understand the effect of dentoalveolar trauma on the dimensions of the NPC. The dentoalveolar trauma group shows wider measurements of the NPC rather than the non-trauma group. Also, the canal measurements increased with missing central incisors or endodontic treatment.

Keywords: Nasopalatine canal, CBCT, Dentoalveolar, canal bulge

INTRODUCTION

Dentomaxillo facial region is greatly susceptible to different injuries with the highest rate to the dentoalveolar trauma. These types of injuries considered highly serious and can cause a lot of complications to the affected patients. Any direct accident of violence can cause severe injuries such as: fracture alveolar process and teeth, intrusion or extraction of teeth, and serious soft tissue damage (Dale 2000). Dentoalveolar trauma can occur alone or as a part of maxillofacial injuries nearly account for (7.5%) of it (Cavalcanti et al. 2010).

Children from zero to 5 years old (42.1%) are among the high-risk age group for such traumatic injuries. Adults are not excluded from the risk but less likely to be affected (19.1%) than children, but the complications are more serious and significant in adults. Male had a significant predilection than females with a ratio of 9:1. Most injuries occurs at summer and mainly from falling down. These traumatic injuries varied from sever tooth movement to concussion root fracture, intrusion, and extrusion. Anterior teeth were the most affected teeth by injury while the maxillary central incisors in primary and permanent dentitions showed the highest injury incidence (Luz 1994).

Another study made in the United States also founded that one quarter of adult population showed a maxillary incisor injury (Kaste et al. 1996) Such injuries cause tooth devitalization and root resorption (Andreasen et al. 1995; Hermann et al. 2012) also may affect vital structures neighboring to teeth such as nasopalatine canal in case maxillary anterior teeth.

Bone channels between the nasal cavity and the palate are called nasopalatine nerve canals (NPCs) because of their function in transmitting sensations and blood supply between the two locations. NPC is situated palatally to maxillary central incisors. When the fetus is between 9 and 13 weeks old, NPCs develop in the back of the primary palate, not at the line connection between the primary and secondary palate (Radlanski et al. 2004). NPCs usually forms bilaterally through a tube-shaped opening (nasal tube located in front of the nasal cavity floor outside the nasal septum). The NPC moves downward in an oblique direction in the sagittal cuts of CT. The tubules on the left and right sides of the coronal CT cut join in the middle of the tube's length and continue as one. The NPC splays out into the cut hole of the palate. The former is hidden by the sharp papilla (Thomas et al. 2017).

The base of the nasopalatine nerve canal contains four small openings. Along the anteroposterior axis, the orifices of the scalp carry the nasopalatine nerve and its numerous branches. Stensen's foramen are arranged medially to laterally and convey the nasopalatine

neurovascular system and, if present, the remnants of Jacobson's organs (Jacob et al. 2000).

During radiographic analysis the NPC and foreman are commonly inferred between the central incisors' roots in traditional 2D intraoral radiographic techniques. The dimension, morphology, and sharpness of "radiographic" foremen vary because of differences in projection geometry and physical shape. Radiopaque lines can sometimes be seen going from the major foreman to the nasal floor surface. These lines show where the side walls of the NPC are (Jacob et al. 2000).

Cavalcinti et al. (1999) evaluated the diagnostic value of X-rays for NPC. CT scans and manual measurements of the NPC and labial alveolar bone width were compared to the incisor shape of the eight skulls. Despite the fact that the two methods of measurement yielded identical results, the authors concluded that the reconstructed 2D spiral CT images allowed accurate measurement of NPC and thus was satisfactory for dental implants as an important step in pre-implant analysis.

Using another imaging modality such as high-resolution MRI images, the nasopalatine canal with all its neural and vascular components are clearly visible. The images identified NPC branches germinate on both sides of the canal which can cause a great danger during implant placement and lead to serious complications (9).

The roots of central incisors show close proximity to the NPC. After dentoalveolar injury, or infection of these teeth, its displacement can occur. So, biological reactions with the structures within the NPC may happen easily. Inflammatory mediators and cytokines induce epithelium to proliferate and may lead to formation of nasopalatine duct cysts (NPDC) (Meghji et al. 1996) which still don't have a confirmed pathogenesis.

Another theory for the NPDC formation was by suggesting idiopathic proliferation of epithelial remnants located inside the NPC (Main 1970; Allard et al. 1981). Furthermore, local trauma or infection can stimulate the epithelial remnants, and this can be considered one of the etiological factors (Abrams et al. 1963; Mealey et al. 1993). Upon using immunohistochemical analysis for the epithelium lining, authors found that nasopalatine duct cyst originate from the epithelial rest of Malassez and that is the reason for direct association with chronic apical periodontitis (Tsuneki et al. 2013).

In the past years, the cone beam computed tomography (CBCT) had been used widely in various clinical fields in dentistry. That was shown in different research protocols discussing anatomical structures in the oral and maxillofacial region on larger populations (de Oliveira-Santos et al. 2012; de Oliveira-Santos et al. 2013; Von Arx et al. 2014).

The aim of the present study was to determine the effect of dentoalveolar trauma on the size of the NPC and the possibility of formation of nasopalatine duct cysts.

MATERIALS AND METHODS

Study Population:

Patients referred for CBCT scanning performed at specialized radiology unit at faculty of Dentistry, Mansoura University, Egypt between January 2018 and March 2021 were eligible for this study. Ethical approval for this study was obtained from ethical committee of faculty of Dentistry, Mansoura University, Egypt. From this database, we selected a total number of one hundred (100) cases who showed a previous history of dentoalveolar injury prior to CBCT imaging by at least 12 months acts as the study group. Another one hundred (100) cases without any history records of dentoalveolar injury acts as a control group. Exclusion criteria include any developmental anomaly or congenital disease affects the maxillary anterior teeth, also we excluded any volume showed imaging artifacts in the maxillary anterior region.

Radiographic Analysis:

CBCT images were taken with the Planmeca ProMax 3D plus CBCT machine (Planmeca, Helsinki, Finland) using different field of views according to the extension of injury. The selected imaging protocol was composed of voxel size 200 µm, kilovoltage of 90 kV, and 8 mAs. CBCT images were interpreted in a dark room with natural indirect lighting at a distance of 80 cm from a 32-inchultra-HD display monitor (Samsung 32-inch Ultra HD screen, South Korea).

The raw dicom files of the CBCT were exported from the machine database and then imported to ONDEMAND 3D APP software (Cybermed, Seoul, Republic of Korea). Reconstruction of dicom data was made at 1 mm interval. In the coronal reconstructed views, the CBCT volume was rotated so that the NPC pointed upwards, and in the sagittal reconstructed views, the palate and floor of the nose were rotated so that they pointed horizontally. The NPC was carefully examined in all orthogonal planes then distributed to one of the 3 categories of anatomical variations classified by Bornstein et al. (2011). Only type "A" canal was included in this study as it considered the most common type.

Measurements of NPC were performed in different reformatted orthogonal planes. The antero-posterior diameter of the nasal foramen was measured in the sagittal plane Fig.1, while the NPC length was measured in coronal plane Fig.2. In the axial plane, the mesio-distal diameter of the incisive foramen was measured in axial plane Fig 3. All antero-posterior and mesiodistal dimensions were measured in the middle of the nasopalatine canal.

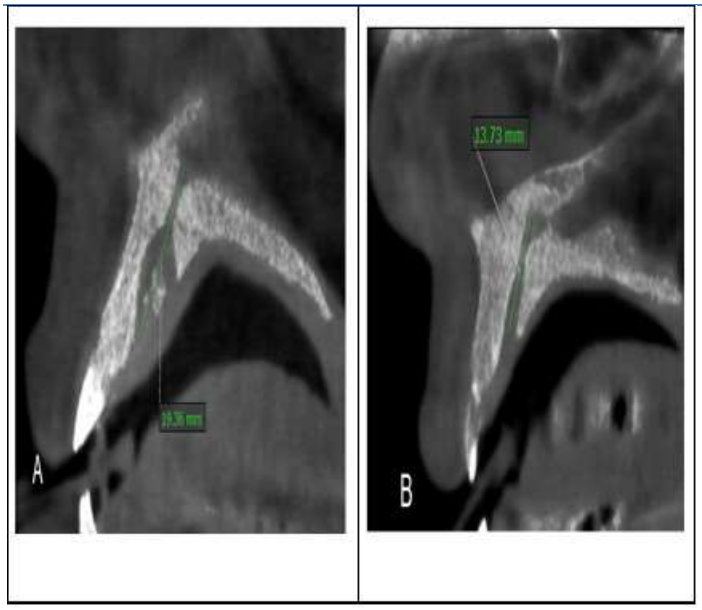

Figure 1: Showing CBCT Sagittal sections in study group (A) and control group (B)

Figure 2: Showing CBCT Coronal sections in study group (A) and control group (B)

In addition to linear measurements, any bulge inside the NPC were recorded. If any bulge found, the linear measurements of this deformity were recorded in the form of all 3 dimensions length, width, and height. The length was measured in mesiodistal direction, width measured antero-posteriorly, while height measured superior inferior direction. All measurements were done in axial, sagittal and coronal respectively. Any endodontic treatment or complete missing in the maxillary incisors were recorded. Also, any inflammatory periapical lesions especially osteolytic type was noticed especially for maxillary central incisor, if the lesion fuses with the NPC this finding is marked and highlighted. All other analysis was descriptive including presence or absence of periapical lesions, endodontic treatment, missing maxillary central incisors, and perforation to the cortical plate of bone. Scoring parameters was absence = 0, and presence = 1.

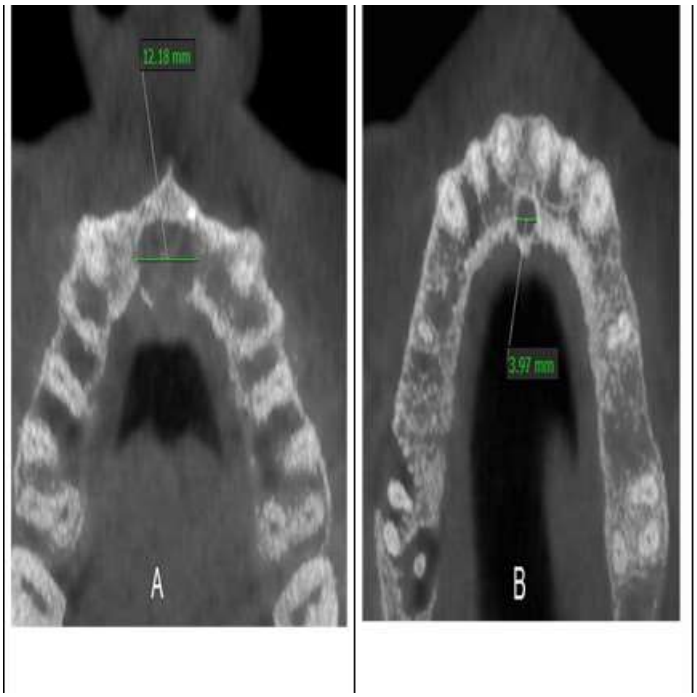

Figure 3: Showing CBCT Axial sections in study group (A) and control group (B)

All the radiographic images were evaluated by three consultants of oral and maxillofacial radiology with experience not less than 15 years. To determine intra- and inter-observer consistency, evaluations were repeated within a 2-week time frame.

Statistical Analysis:

All data were analyzed descriptively except NPC measurements. Intra- and inter-observer reliability was assessed by using Kappa statistical test (k). The following scale was used for assessment: poor 0-0.2, fair 0.21- 0.4, good 0.41-0.6, very good 0.61-0.8, and excellent 0.81-1.0 (Landis et al. 1977). NPC readings were used to determine the influence of dentoalveolar injury. Dimensional differences between the control and case groups were analyzed using an independent t test, with a significance level of $P < 0.001$.

RESULTS

An overall excellent intra- ($k \geq 0.98$, $P = 0.253$) and inter-observer reliability ($k \geq 0.95$, $P = 0.350$) was observed with no significant difference.

In the study group, Presence of periapical lesions following dentoalveolar injury showed predilection in Male patients (72%) compared with female patients (28%). Only ten patients had one or more missed maxillary incisors teeth due to previous history of trauma.

Table 1: Showing the radiographic distribution findings in study and control groups

	Study group	Control group
Number of patients	100	100
Gender	Female 35 Male 65	Female 50 Male 50
Missing maxillary incisors teeth	32	Zero
Endodontic treatments in maxillary incisors teeth	82	zero
Fixed Prosthesis in maxillary incisors teeth	75	Zero
Cortical bone perforation buccal or lingual	36	Zero

Additionally, 68% of patients had no restorations in the anterior maxillary teeth and 32% had fixed prosthesis placement following endodontic treatment.

Cortical bone perforation either buccal or palatal was seen in 45% of cases. Distribution of all these parameters presented in Table "1".

In the study group, the length of the NPC ranged from 14.3 mm to 16.7 mm with an average of 15.5 mm. While in the control group, the length of the NPC ranged from 12.95 mm to 15.53 mm with an average of 14.24 mm. Concerning the width of NPC differs greatly according to the location of measurement, the mean of width at nasal floor was 4.82 mm, mean at palate 4.14 mm, and mean at midline 9.57 mm in study group while the mean width at nasal floor was 3.94 mm, mean at palate 4.10 mm, and mean at midline 3.95 mm in control group. Lastly, the mesio-distal diameter of NPC showed great difference between both groups as the mean was 10.16 mm in study group in comparison to 4.07 mm in control group. Table "2" and Fig. 4.

Table 2: Showing the measurements of the incisive canal in study group no. 1 and control group no. 2

	Mean of group 1	Mean of group 2	Sq. diff. of group 1	Sq. diff. of group 2	P value
Length	15.5	14.24	1.2	1.29	0.000119*
Width at Nasal floor	4.82	3.94	1.09	0.53	0.000376*
Width at Palate	4.14	4.10	1.02	0.54	0.422432
Width at midline	9.57	3.95	9.18	0.27	<0.00001*
Mesiodistal diameter	10.16	4.07	13.28	0.18	<0.00001*

**** P value is significant at p < .05***

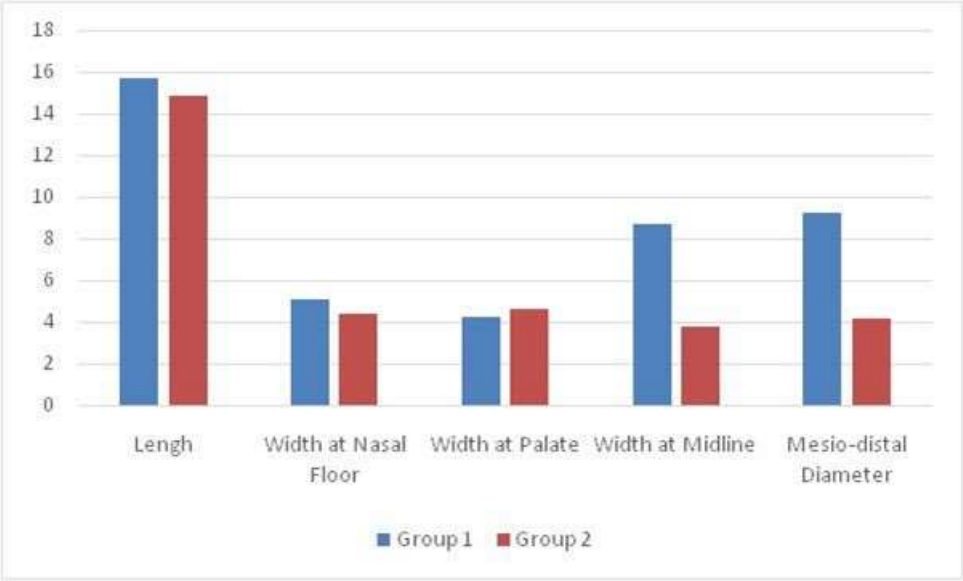

Figure 4: showing the difference between study group no. 1 and control group no. 2 in measuring the incisive canal

NPC dimensions were compared between the control and study groups, and the study group had vastly greater dimensions with high statistical significance (P = 0.00012).

DISCUSSION

The present radiographic study was performed to evaluate the influence of dent alveolar trauma on the morphology and dimensions of nasopalatine canal. The influence was remarkably noticed, and the measurements of NPC were highly increased by the presence of previous dent alveolar injury. To our knowledge, few studies correlate the history of dent alveolar study to changes occurred in NPC. Most of these studies concerned with NPC opening (incisive foramen) measurement (Mraiwa et al. 2004; Bornstein et al. 2011; Etoz et al. 2014), but none of these studies were similar in the assessment strategy as some of them used axial cuts only while others used 3d reformatted volumes (Fernández-Alonso et al. 2014). Also, some authors used oblique lines while others used horizontal lines. This results in huge variation of the measurement values. Some other recent studies concerned with the fusion of periapical lesions with the NPC resulting in bulging and increased dimensions (Jacobs et al. 2020).

NPC showed high morphogenic changes among different cases in the meaning of dimensions and number of nasal foramina (Mraiwa et al. 2004), these changes considered very important especially in the placement of dental implants in maxillary incisor region. Another article showed that missing one or two central incisors had a great influence on the diameter of incisive canal (Acar et al. 2015).

CBCT (small field of view FOV, and low dose imaging protocols) enhances the accurate evaluation of bony structures and help in accurate linear measurements of the NPC. Also, diagnosis of apical radiolucencies and their relationship with nasopalatine canals became easier. All cases of fusion between apical lesion and NPC had a previous infection component (Estrela et al. 2008; Hakbilen et al. 2018). This can occur if the inflammatory process reaches the structures within the NPC. Inflammatory cells and fibroblast release inflammatory mediators responsible for epithelial cell rests proliferation (Lin et al. 2007).

In case of presence of severe enlargement of the NPC measurement in the middle level of the canal (presence of bulge), a careful history and clinical examination should be done as high incidence of previous dentoalveolar injury is predicted. The prognosis of such enlargement is totally unknown.

CONCLUSION

The measurements of the NPC were wider in case of dentoalveolar injury. Untreated cases with subsequent formation of periapical lesions can fuse or affect the NPC internal structures resulting is bulging of the canal.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

W.A.: provided the overall study strategy, including coming up with the idea, designing the study, collecting data, and analyzing and interpreting the results.

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