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Morphometric Analysis of the Relationship between the Maxillary Sinus Floor and Maxillary First Molar – A CBCT Study

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ABSTRACT:

Aim: The study aimed to investigate the proximity of maxillary First Molar teeth roots to maxillary sinus floor.

Materials and Methods: The methods used to analyse and measure are as follows: Evaluation of the vertical relationship between the maxillary first molar teeth and the MSF was done in sagittal and coronal CBCT planes simultaneously and categorized into the three types.

Type IS: The root tips extendingabove/inside the MSF

Type CO: The root contacting with the MSF

Type OS: The root extending below/outside the sinus floor

Results: Reviewing and Evaluating the roots of maxillary first molar in relation to the proximity to various CBCT scans, the data received showed that out of 2500 scans, only 1500 samples were such where the root of maxillary first molar was either approaching the sinus lining or perforating the sinus lining. The evaluation states that 60% of the maxillary first molar roots are at the proximity with the maxillary sinus lining.

Conclusion: Thorough knowledge of the case is must, with precautionary measures to be taken for any endodontic therapy such as CBCT scans, or even a panoramic Xray is must to identify the maxillary sinus lining and refrain

KEYWORDS:maxillary sinus floor, maxillary first molar, CBCT, sodium hypochlorite accident.

I. INTRODUCTION

The pyramid-shaped maxillary sinus (or antrum of Highmore) is the largest of the paranasal sinuses and drains into the middle meatus of the nose. It is one of the first paranasal sinuses to develop and it stops growing on the eruption of the third molar around 20 years of age.

This sinus has three recesses: An alveolar recess pointed inferiorly, bounded by the alveolar process of the maxilla; a zygomatic recess pointed laterally, bounded by the zygomatic bone; and an infraorbital recess pointed superiorly, bounded by the inferior orbital surface of the maxilla. The medial wall is composed primarily of cartilage. The maxillary sinus varies in its extension. If the sinus is of an average size, it is on a level with the floor of the nose; if the sinus is large, it reaches below this level. Projecting into the floor of the antrum is several conical processes, corresponding to the roots of the first and second molar teeth; in some cases, the fangs of the teeth perforate the floor[(1)]

In about half of the population, the sinus floor extends between adjacent teeth or individual roots, creating elevations in the antral surface, commonly referred to as 'hillocks. The roots of the maxillary premolar, molar and occasionally canine teeth may project into the maxillary sinus. Because of the implications this can have complications on surgical procedures, it is essential for clinicians to be aware of the exact relationship between the apical roots of the maxillary teeth and the maxillary sinus floor. ([2])

The pathological disruption of both periapical and adjacent sinus tissue resulting from endodontic infection has since been well documented (Selden & August 1970, Selden 1974, Selden 1977, Selden 1989). The reported frequency of sinusitis of dental origin varied considerably, between 4.6 and 47% (Mélen et al. 1986) of all sinusitis cases. The spread of pulpal disease beyond

the confines of the dental supporting tissues into the maxillary sinus was termed Endo–antral syndrome (EAS) by Selden (1974), Selden (1989) and Selden (1999). [3]

II. MATERIALS AND METHODS

The study material was composed of dental CBCT images collected from the archives of SCANMAX CBCT centre (Ahmedabad). Written informed consent was obtained from the individuals for using the data for research purpose. The study was exempt from approval by an institutional review board because of the retrospective nature**.**

Inclusion criteria: Cases presenting with the following findings were included for analysis:

(i) Patients of age >21
(ii) Presence of maxillary molar teeth on cbct scans,
(iii) Fully erupted teeth with fully formed apexes,
(iv) Maxillary posterior teeth with neither definitive root resorption nor bony destruction around the teeth.
(v) Complete msf with no damage by disease.

Exclusion criteria: Cases presenting with the following findings were excluded:

(i) Presence of periapical or periradicular lesions,
(ii) Teeth which had previously undergone orthodontic treatment
(iii) Images with artifacts.

Procedure methodology

Cone-beam computed tomography image evaluation: The vertical relationship between posterior roots and the MSF was classified into three categories according to Tian et al. [4]

• Type IS: The root tips extending above/inside the MSF
• Type CO: The root contacting with the MSF
• Type OS: The root extending below/outside the sinus floor.

The CBCT images were assessed using Carestream 3D Imaging Software V.3.10.11 (Carestream Dental LLC, Atlanta, GA) with the following parameters: exposure – 90 KV, 4 mA, 15s; dose – 733 mGy.cm2; and voxel size – 150 µm × 150 µm × 150 µm.

The methods used to analyse and measure were as follows: Evaluation of the vertical relationship between the maxillary first molar teeth and the MSF was done in sagittal and coronal CBCT planes simultaneously and categorized into the three types. The priority order of the three types was Type IS, Type CO, and Type OS. So, if the relationship was Type IS in the sagittal plane and Type CO in coronal plane; then, it was categorized under Type IS.

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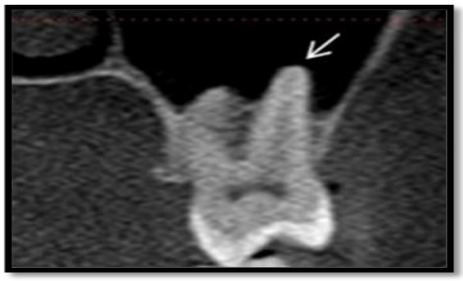
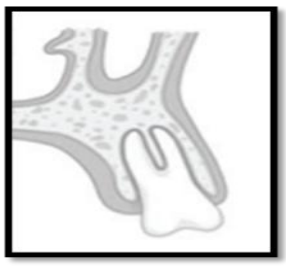
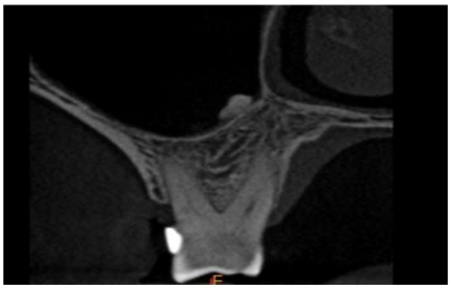
➢ **TYPE-IS**



➢ **TYPE-CO**

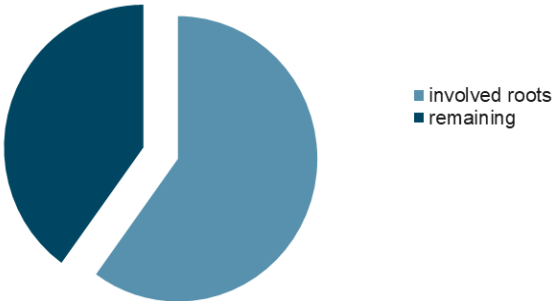
➢ **TYPE-OS**





III. RESULTS

Reviewing and evaluating the roots of maxillary first molar in relation to the proximity to various CBCT scans, the data received showed that out of 2500 scans, only 1500 samples were such where the root of maxillary first molar was either approaching the sinus lining or perforating the sinus lining. The evaluation states that 60% of the maxillary first molar roots are at the proximity with the maxillary sinus lining.



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IV. DISCUSSION

It is very crucial to assess the relationship between maxillary posterior teeth roots and floor of the maxillary sinus before planning any treatment procedure to avoid any procedural complication. Many potential risks are associated with maxillary posterior root tips in proximity to the sinus floor. For example, during endodontic procedure, there is increased risk of perforation of sinus floor with the root canal instruments in Type 1 and 3 relationships. A case of orbital abscess has been reported in the literature as a complication resulted from a rapid exacerbation of periapical inflammation after endodontic treatment of a maxillary first molar. [5]

The buccal root of the maxillary molars was more commonly protruded into the maxillary sinus. Among the roots of maxillary posterior teeth, mesiobuccal root of first molar and palatal root of second premolar were found in close proximity to the floor of maxillary sinus. The bone thickness on the buccal aspect to the root was significantly thinner in the maxillary first premolar and maxillary first molar as compared to other maxillary posterior teeth roots. [6]

When a panoramic radiograph shows that a root projects into the sinus, a CBCT scan should be requested, considering that it involves actual root protrusion. Therefore, we evaluated panoramic radiographic signs indicating actual root protrusion. Previous studies have proposed panoramic radiographic signs that could alert the dental clinician to possible root protrusions into the maxillary sinus. Lopes et al. reported 5 panoramic signs of root protrusion into the maxillary sinus, as follows: projection of the root apices, interruption of the maxillary sinus floor, absence of the lamina dura, darkening of the root apices, and a superiorly curving sinus floor enveloping the associated tooth root. They found that the projection of the root into the sinus and the interruption of the cortex of the maxillary sinus floor were statistically relevant indicators[7] Themkumkwun et al. modified one of the panoramic radiographic signs from the study of Lopes et al. by investigating the periodontal ligament space instead of evaluating the lamina dura due to the difficulty of identifying the radiopaque line of the lamina dura on panoramic images. They demonstrated that projection of the root into the sinus and darkening of the involved root apices on panoramic images were significant high-risk signs of root protrusion into the maxillary sinus[8]

The situation becomes more complex when the root tip is laterally or medially positioned to the sinus. It is easy to view the OPG and assess the vertical relationship between the two structures; however, one must also take into consideration the horizontal relationship. The studies recognized that the root tip could be positioned laterally or medially to the sinus floor, which in part can be due to an inferiorly curving sinus. Shahbazian et al found that in second premolars, when OPG showed an intimate relationship with the sinus, the CBCT revealed that 63% of them were positioned laterally, and not actually in/contacting as suggested by the OPG.18 Kalkur et al found that when CBCT determined the tooth to be laterally projecting and not in the sinus, 87% of the OPG readings of the same teeth determined that the teeth projected into the sinus, which is incorrect.14 These results show a high level of disagreement between the two modalities when the root is laterally projecting over the sinus. Such positioning is difficult to assess on a 2-D image of a 3-D structure. The OPG appears to give a worse outcome than the reality, and could lead the practitioner to unnecessarily order a CBCT. This is a difficult situation to assess clinically and must be approached with caution. Ultimately, if there is a high degree of uncertainty, then a CBCT should be ordered for clarification. (9) CBCT analysis has shown that a correlation exists between thickening of sinus mucosa and carious maxillary posterior teeth and/or periodontal disease. Microorganisms and their toxins present in the periapical lesions of involved teeth may infiltrate maxillary sinus through either the blood/lymph vessels or porous maxillary bone. Hence, there is positive correlation exist between the periodontal lesions and maxillary sinus mucosal thickening. (10)

Perforation to the maxillary sinus following molar and premolar apical surgery occurs in approximately 18% of cases[11] Freedman and Horowitz estimated that perforation to the antrum during apical surgery is 23% for molars, 13% for second bicuspids, and 2% for first bicuspids.[12] In a study of 200 posterior upper roots, Rud and Rud estimated that, in 50% of cases, perforation to the sinus occurred [13] Such endo-antral communication occurs in 26.1% of premolars and in 40% of upper molars during apical surgery. In the present study, we found a high percentage of roots inside the maxillary antrum; therefore, this must be considered when performing endodontic treatment in the maxillary molars and premolars, in order to avoid or minimize complications. [14]

In case of maxillary posterior teeth with root protrusion into the maxillary sinus, bacteria from the root canal system may cause not only periapical disease, but also sinus inflammation

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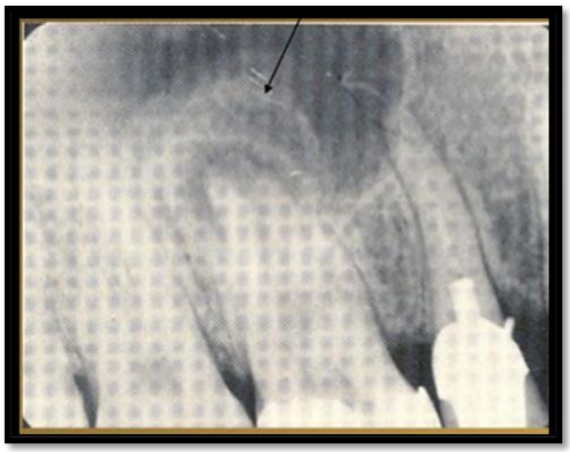
and/or infection, which may localize or generally spread into the sinus region. [15] Microbial contamination and/or extrusion of infected debris because of erroneous dental procedures and accidental endodontic over-instrumentation might cause maxillary sinusitis or mucositis [16] This condition, where the periapical disease invades the maxillary sinus through the adjacent supporting tissues, is termed "endo-antral syndrome" .[17] Therefore, clinicians need to exercise caution against the risk of overextension of root canal instruments and extrusion of irrigants or filling materials into the maxillary sinus during surgical or nonsurgical endodontic procedures [18] It has been reported that 10–12 % of cases of sinusitis result from odontogenic infections such as periapical periodontitis and chronic abscess associated with the roots of maxillary posterior teeth located near the maxillary sinus [19] In cases where the periapical bone is thin, bony perforation or sinus tract to the maxillary sinus occur readily.

The direct extension of dental sepsis into the sinus was shown for the first time in a study by Bauer (1943). His study was performed on cadavers and showed examples of pulpally involved teeth with histologically evident extension of disease into the maxillary sinus. These examples ruled out generalized sinus disease and clearly implicated the infected teeth. Microscopically, the 'diseased areas' showed the destruction of the bone separating the sinus from the teeth, with particular loss of the cortical bone normally found on the sinus floor. In addition, the sinus mucosa was seriously altered in many ways such as swelling with inflammation, granulation tissue, hypertrophy, fibrous changes, hyalinization or complete necrosis. The spread of pulpal disease beyond the confines of the dental supporting tissues into the maxillary sinus was termed Endo–antral syndrome (EAS) by Selden (1974), Selden (1989) and Selden (1999)

The findings that characterize EAS are: (i) pulpal disease in a tooth whose apex approximates the floor of the maxillary sinus; (ii) periapical radiolucencies on pulpally involved teeth; (iii) radiographic loss of the lamina dura defining the inferior border of the maxillary sinus over the pulpally involved tooth; (iv) a faintly radiopaque mass bulging into the sinus space above the apex of the involved tooth, connected neither to the tooth nor the lamina dura of the tooth socket (representing a localized swelling and thickening of the sinus mucosa); and (v) varying degrees of radiopacity of the surrounding sinus space (comparison of the contralateral sinus is often helpful).



This radiograph shows all signs of EAS associated the symptomatic maxillary right first molar

According to Bauer (1943), periapical infection spreads through the bone marrow, following the path of blood vessels and lymphatics. If pulpal disease develops slowly, as in chronic inflammation with no significant infection, then the spread to the sinus can be slow with minimal impact. Acute infectious pulpal disease is much more destructive and rapidly spreading, capable of significantly involving the adjacent sinus within a short time. Reports in the literature of the rapid spread of dental infections through the maxillary sinus and subsequent periorbital cellulitis, blindness and even life-threatening cavernous sinus thrombosis [21] Irrigant in contact with the patient's or operator's eyes results in immediate pain, profuse watering, intense burning, and erythema. Immediate ocular irrigation with large amounts of tap water or sterile saline should be performed by the dentist and the patient referred to an ophthalmologist for further examination and

treatment (Ingram 1990). [22] Sodium hypochlorite (NaOCl) is a common chemical disinfectant and irrigant used as an adjunct to mechanical debridement. It was used as a wound irrigant in 1915 and became the most popular irrigation solution in endodontics. It was also used during World War I to cleanse contaminated. [23]

NaOCl is the most effective, inexpensive, readily available chemical. It is considered to be the most optimal irrigant for use throughout instrumentation because it possesses potent antimicrobial and proteolytic activity [24] It is used to remove the debris and smear layer that forms on instrumented dentin surfaces. In addition, it acts as a lubricant[25]With a pH of 11–13, it causes injury primarily by the oxidation of proteins and it can dissolve necrotic and vital pulp tissue, killing a broad range of pathogens.At high concentrations, NaOCl causes hemolysis, ulceration, inhibition of neutrophil migration, damage to endothelial and fibroblast cells, facial nerve weakness, and necrosis after extrusion during endodontic treatment.(26)

The sequence of signs and symptoms that occurs after extrusion of NaOCl into the periapical tissues, seems to follow a typical pattern. According to Hulsmann's criteria, the diagnosis of NaOCl accident includes the following: (1) acute pain, swelling, and redness; (2) bruising; (3) progressive swelling involving the infraorbital area or mouth angle depending on the site of NaOCl injection; (4) profuse hemorrhage often manifesting intraorally from the orifice of the tooth; (5) numbness or weakness of the facial nerve; and (6) secondary infection, sinusitis, and cellulitis [27]In the case presented, the patient developed typical presentation of NaOCl accident, with acute pain, swelling, echymosis, and paresthesia. The majority of cases have shown complete resolution within couple of weeks[28] whereas a few were marked by long-term paresthesia or scarring[30]

Inadvertent injection of sodium hypochlorite beyond the apical foramen may occur in teeth with wide apical foramina or when the apical constriction has been destroyed during root canal preparation or by resorption. Additionally, extreme pressure during irrigation or binding of the irrigation needle tip in the root canal with no release for the irrigant to leave the root canal coronally may result in contact of large volumes of the irrigant to the apical tissues. If this occurs, the excellent tissue-dissolving capability of sodium hypochlorite will lead to tissue necrosis. [31] Kaufman & Keila (1989) reported a case of hypersensitivity to sodium hypochlorite. As this reaction was detected before initiation of endodontic therapy, the patient was referred to an allergist. Following a skin patch test, the allergist diagnosed a hypersensitivity to household materials containing NaOCl and recommended not to use NaOCl during root canal treatment. [32] As a result of insufficient access and a lateral root perforation of a right maxillary central incisor, Bhat (1974) reported that hydrogen peroxide of unknown concentration was injected into the soft tissues. As treatment was performed under local anaesthesia, the patient experienced no pain but complained about a rapidly developing swelling on the upper lip and some difficulty in breathing. The canal was left open, the patient was prescribed antibiotics and instructed to apply cold packs. The emphysema, caused by oxygen liberated from the hydrogen peroxide, subsided in 1 week and root canal treatment was completed. [33

V. CONCLUSION

There by I conclude this by stating the obvious fact, that thorough knowledge of the case is must, with precautionary measures to be taken for any endodontic therapy such as CBCT scans, or even a panoramic Xray is must to identify the maxillary sinus lining and refrain the common yet complicated mishaps in endodontics.

Knowledge of the anatomical relationship between the maxillary sinus floor and the maxillary posterior teeth root tips is important for the preoperative treatment planning of maxillary posterior teeth. In view of the proximity of the maxillary sinus floor and maxillary root tips, clinicians must be cautious when performing dental procedures involving the maxillary posterior teeth particularly the first and second molars. The measurements found in the present study highlight the need for preoperative treatment planning.

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