Research Protocol

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Dentistry Section

Assessment of Nasopalatine Canal Proximity to Maxillary Central Incisors and its Association with Risk of Root Resorption in First Premolar Extraction Cases in Angle's Class I Bimaxillary Protrusion Cases: A Protocol for CBCT Based Observational Research

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ABSTRACT

Introduction: Orthodontic treatment for Angle's Class I bimaxillary protrusion commonly requires extractions of first premolars to contribute to improved dental and aesthetic appearance of the face. Retraction of the upper anterior teeth plays a prime role in the success of treatment; however, careful evaluation of anatomical structures, such as the Nasopalatine Canal (NPC), is essential. This canal, located posterior to the Maxillary Central Incisors (MCI), may be a risk factor also for resorption of roots during orthodontic movement of teeth. Root resorption is a common complication that could affect treatment outcomes; thus, assessment is imperative in extraction cases.

Need of the study: Despite the clinical significance of NPC proximity in orthodontic retraction, research on its direct influence on root resorption of patients undergoing first premolar extractions isn't plentiful. These relationships should be appreciated, given that they may develop into risk-based treatment regimens to minimise complications. Pertinent imaging like Cone-Beam Computed Tomography (CBCT) will provide an in-depth view of NPC, thereby giving a better understanding of its proximity to maxillary incisors, which will be useful during treatment planning.

Aim: To assess the proximity of NPC to MCIs and the risk of root resorption in first premolar extraction cases in Angle's class I bimaxillary protrusion cases using CBCT.

Materials and Methods: This prospective observational study will include records of 30 adult patient's pre and post-treatment CBCT undergoing orthodontic treatment with the extraction of first premolar in every quadrant. This study will be conducted in the Department of Orthodontics and Dentofacial Orthopaedics at Sharad Pawar Dental College, Sawangi (Meghe), Wardha, Maharashtra, India and for a duration of 21 months, June 2025-February 2027. The patients will be classified into contact and non-contact groups based on NPC proximity to the MCIs. The length of the root will be measured and other changes in morphology would be assessed prior to the retraction of teeth and after retraction, the extent of root resorption will be checked. The data will be statistically analysed using the Chi-square test, student's paired and unpaired t-tests, One-way ANOVA, and Tukey's test using IBM Statistical Package for Social Sciences (SPSS) Statistics, Version 27.0 and GraphPad Prism version 7.0 software.

Keywords: Cone-beam computed tomography, Malocclusion, Root resorption

INTRODUCTION

Orthodontic treatment frequently involves the extraction of first premolars in every quadrant in patients with Angle's Class I bimaxillary protrusion to achieve optimal dental and facial aesthetics. The most critical step in the treatment of such cases is the retraction of maxillary anterior teeth as anatomical structures proximal to the roots of the MCIs needs to be considered carefully. NPC is one such vital structure in close proximity to it [1].

NPC also referred to as the incisive canal, is located in the midline of the hard palate behind the MCI. It is a tube that joins the oral and nasal cavities. The NPC is a vital component of the anterior maxilla anatomically. It consists of the nasopalatine nerve, fat, fibrous connective tissue, seromucous glands, and the terminal branch of the descending nasopalatine artery [2]. Its spatial relationship to the MCI becomes particularly relevant during orthodontic tooth movement, as the retraction of these teeth may lead to interactions with the canal, potentially increasing the risk of root resorption [3].

The most common complication of orthodontic treatment is the 'root resorption' in which the apical portion of the root is lost. This could be linked to several factors, including the duration of treatment, the intensity of the applied force, the direction of tooth movement, the extent of apical displacement, and the technique used to apply the force [4]. This phenomenon can occur at any stage of orthodontic treatment, which may affect the tooth's prognosis and the stability of the treatment outcomes. Proximity to NPC may increase the risk of such resorption during retraction movements in extraction cases, particularly when significant tooth movement is required [5].

Advancements in imaging modalities enables the clinician to accurately visualise and assess the spatial relationship between the NPC and MCIs, which is crucial for orthodontic treatment. CBCT provides Three-dimensional (3D) imaging, which enables clinicians to evaluate the NPC's position, dimensions, and its proximity to adjacent tooth roots, as well as detecting the signs of root resorption with highest accuracy [6].

Despite the clinical relevance, limited studies [1,3] have investigated the impact of NPC proximity on root resorption in premolar extraction cases among Angle's Class I bimaxillary protrusion

patients. Understanding this relationship will help in formulating risk-based treatment plans to minimise complications and improve patient outcomes.

This study aims to assess the proximity of the NPC to the MCIs and evaluate its association with root resorption following retraction in premolar extraction cases. The findings will provide valuable insights for orthodontic treatment planning and risk management, ensuring safe and effective outcomes.

Primary objective:

- To evaluate the correlation between NPC proximity and the degree of root resorption in MCIs following anterior retraction in Angle's Class I bimaxillary protrusion cases.

Secondary objectives:

- To access the proximity of the NPC to the MCIs in Angle's Class I bimaxillary protrusion cases.
- To determine the extent of root resorption in MCIs following anterior retraction in first premolar extraction cases.

Null hypothesis: There isn't a notable relationship between the proximity or distance of the NPC to the central incisors of maxilla and root resorption risk in first premolar extraction cases.

Alternative hypothesis: There is notable relationship between the proximity or distance of the NPC to the central incisors of maxilla and root resorption risk in first premolar extraction cases.

REVIEW OF LITERATURE

Pan Y and Chen S conducted a retrospective study investigating risk factors for contact between the incisive canal and MCIs and the potential association with root resorption using CBCT. Anterior teeth were retracted using mini-implants, and CBCT scans were performed before and after retraction. The study found that a lower position of the incisive canal increases the risk of contact with maxillary incisor roots during anterior retraction, which could lead to external apical root resorption [1].

Yu JH et al., categorised subjects into a control group with minimal incisor movement and a maximum retraction group. The study evaluated changes in the shape, direction, morphology of the incisive canal, proximity of the central incisor roots to the canal, and the extent of apical root resorption after orthodontic treatment. The results indicated a high incidence of contact or invasion of the MCI roots into the incisive canal following maximum anterior retraction [2].

Chung CJ et al., assessed root contact between MCIs and the incisive canal after retraction using temporary anchorage devices in two patients. The case study concluded that significant root resorption was largely associated with extensive anterior retraction and root movement. However, the anatomical position of the incisive canal and the potential for its invasion following tooth movement require close monitoring [3].

Kuc AE et al., analysed strategies to minimise incisor root resorption during retraction through tailored treatment planning and monitoring incisor inclination relative to the incisive canal's anatomy. This systematic review included four studies involving 164 participants. All studies reported significant differences in root length after contact with the incisive canal, indicating the risk of root resorption [4].

Selvaraj A and Kumar Subramanian A retrospectively evaluated the relationship between maxillary incisors and the incisive canal in patients with Angle's Class I bialveolar protrusion and Angle's Class II division 1 malocclusion using CBCT. The study found significant differences in sagittal root canal cortical plate distance between the malocclusions and concluded that the inter-root distance was greater than the incisive canal width indicating a lower chance of canal invasion during maximum retraction [5].

Al-Rokhami RK et al., compared CBCT based changes in root morphology and incisive canal dimensions after maxillary incisor retraction in Class I and Class II extraction cases with clear aligners and fixed appliances. Both groups showed significant root resorption and reduction in canal width and root canal distance, but these changes were greater in fixed appliances. The authors concluded that retraction can alter incisive canal morphology and cause root resorption [7].

Ongprakobkul N et al., retrospectively analysed CBCT data taken before and after maxillary anterior retraction in 36 patients to evaluate changes in proximity between incisive canal and MCIs. The study concluded that significant changes occur during retraction, emphasising importance of assessing the incisive canal position in treatment planning to prevent canal damage [8].

Al-Rokhami RK et al., retrospectively investigated the position of upper central incisor roots to incisive canal using 240 CBCT images of patients with maxillary dentoalveolar protrusion. The study concluded that the low angle facial group and male patients tended to have greater sagittal distance [9].

Khurana S et al., conducted a retrospective study on 61 CBCT scans from Newark population that measured anterior-posterior distances between MCI roots and the incisive canal at three vertical levels, reporting an average distance of 5-6 mm and concluding the clinical relevance of this distance to anterior retraction and implant placement [10].

MATERIALS AND METHODS

The present prospective observational study will be conducted on 30 pre-treatment and post-treatment CBCT records of subjects. in the Department of Orthodontics and Dentofacial Orthopaedics at Sharad Pawar Dental College, Sawangi (Meghe), Wardha, Maharashtra, India for a duration of 21 months, June 2025-February 2027. The Institutional Ethics Committee (IEC) of Datta Meghe Institute of Higher Education and Research, has approved the current study (DMIHER(DU)/IEC/2025/535).

This prospective longitudinal comparative observational study will include following groups:

Group-1: Contact group (cases where MCIs are in contact with the NPC);

Group-2: Non-contact group (cases where MCIs are not in contact with the NPC).

Study population: The study will include healthy adult patients (18-35 years) who are scheduled for orthodontic treatment involving all first premolar extractions. Key criteria for selection will include:

Inclusion criteria:

- Patients diagnosed with Angle's Class I bimaxillary protrusion;
- Indicated for all first premolar extractions as part of orthodontic treatment;
- Ages between 18-35 years;
- No systemic conditions or previous orthodontic treatment.

Exclusion criteria:

- Patients with craniofacial anomalies or skeletal discrepancies;
- History of trauma or endodontic treatment involving MCIs;
- Patients with Angle's Class II, Angle's Class III and open bite.

Sample size calculation: The sample size formula used is as follows:

$$n_1=\{(\sigma_1^2+\sigma_2^2/\kappa)\times(Z_1-\alpha/2+Z_1-\beta)^2\}/\Delta^2$$

The notation for the formulae is:

n_1=sample size of Group-1

n_2=sample size of Group-2

σ_1=standard deviation of Group-1

σ_2=standard deviation of Group-2

Δ=difference in group means

κ=ratio (n_2 /n_1)

Z_1–α/2=two-sided Z value (e.g., Z=1.96 for 95% confidence interval)

Z_1–β=power

Mean lingual movement to ICs in contact group=2.30

Mean lingual movement to ICS in non-contact group=1.07

σ1=SD of lingual movement to ICs in contact group=1.20

σ2=SD of lingual movement to ICS in non-contact group=1.16

For detecting mean difference of 1.23 i.e., Δ =2.30-1.07=1.23

K=1

$$N = \frac{(1.20\times1.20+1.16\times1.16)\ (1.96+0.84)^2}{1.23\times1.23}$$

=14.43=15 patients needed in each group

Total sample size=15+15=30

The sample size was calculated by the reference of article by Clifton L et al., (2018) [11].

Power of the Test: 80%

Level of significance: 5% (95% confidence interval)

Study Procedure

Patients having Angle's Class I bimaxillary protrusion will be selected from the Department of Orthodontics and Dentofacial Orthopaedics for a CBCT scan of the nasomaxillary complex. An informed consent will be taken from the patients to take a CBCT scan after clarifying the aims and objectives of the research.

Initial assessment:

1. Pre-treatment CBCT scans will be taken to measure:
   i. NPC dimensions (length, diameter).
   ii. Distance between the NPC and the root apices of the MCIs.
   iii. Based on the analysis, patients would be divided in two groups- contact and non-contact groups.
2. Clinical data such as type of malocclusion, treatment plan, duration of treatment and mechanics of anterior retraction will be documented whereas, demographic data like age and sex of the patients will be recorded.

Treatment protocol:

1. All patients will undergo fixed orthodontic treatment (MBT 0.022" slot prescription) involving first premolar extractions and anterior retraction for a duration of 18 to 24 months.
2. Retraction will be performed using sliding mechanics with standardised force application for a duration of 6 to 8 months on average which will be monitored periodically.

Post-retraction assessment:

1. CBCT scans will be repeated after completing anterior retraction approximately 6 to 8 months apart, within a total treatment duration of 18 to 24 months.
2. Root resorption in MCIs will be evaluated based on changes in root length and morphology.

Measurements and analysis:

1. **NPC proximity:** Measured as the shortest distance from the NPC wall to the root apex of each MCI.
2. **Root resorption:** Assessed as the reduction in root length (in millimetres) or morphological changes from pre- to post-retraction scans.
3. Statistical analysis will be performed to evaluate the correlation between NPC proximity and root resorption severity.

Primary outcomes:

- Correlation between the proximity of the NPC to the MCIs and the severity of root resorption following retraction in first premolar extraction cases in Angle's bimaxillary protrusion cases will be evaluated by comparing the mean amount of root resorption between these two groups, that is contact and non-contact groups using unpaired student's t-test.

Secondary outcomes:

- To identify threshold distance between the NPC and MCIs that may serve as predictive marker for increased risk of root resorption.
- To reinforce the clinical relevance of NPC assessment in orthodontic treatment planning.

STATISTICAL ANALYSIS

Data will be analysed using both descriptive and inferential statistics. Normality of the data will be assessed using the Shapiro-Wilk test. For normally distributed variables, categorical comparison such as presence of root resorption will be evaluated using Chi-square test. Pre and post-treatment comparison within groups will be performed using paired t-test, while intergroup differences between contact and non-contact groups will be assessed by unpaired t-test. The data will be analysed using SPSS version 27.0 and GraphPad Prism version 7.0 software, with a significance level set at $p<0.05$.

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