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Radiological Assessment of the Mandibular Coronoid Process and its Proximity to the Maxillary Third Molar Using CBCT and IOPA

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Abstract
Background: The mandibular coronoid process, a prominent bony structure involved in jaw movement and masticatory function, lies in close anatomical proximity to the maxillary third molar. This spatial relationship carries significant clinical implications for surgical planning, particularly in cases involving extraction of the maxillary third molar or surgical procedures performed near the mandibular coronoid process. Understanding the morphological variations of the coronoid process and its positional relationship with adjacent structures is essential for anticipating potential surgical complications and optimizing operative approaches.
Methods: A retrospective study was conducted on 108 mandibles using archived Cone Beam Computed Tomography and Intraoral Periapical images. The morphology of the coronoid process was evaluated, and its spatial proximity to the maxillary third molar was assessed. Radiographic data were systematically analyzed to characterize the shape and positional relationships of these anatomical structures.
Results: The most commonly observed shape of the coronoid process was triangular, accounting for 68.1% of the specimens examined, followed by a round shape, which was observed in 31.9% of the cases. The triangular morphology was predominantly noted in both male and female subjects, with frequencies of 67.8% and 68.3%, respectively. This shape was most frequently observed in young individuals, with a prevalence of 70.8% in this demographic group.
Conclusion: Radiological evaluation of the mandibular coronoid process in relation to the maxillary third molar is pivotal for enhancing clinical decision-making and surgical outcomes. Pre-operative assessment of coronoid morphology aids in anticipating potential surgical impingements, identifying anatomical variations that may complicate procedures, and optimizing patient care through more precise surgical planning. The findings underscore the importance of thorough radiographic evaluation prior to interventions involving the maxillary third molar or the mandibular coronoid process region.

Introduction

The mandibular coronoid process is a critical anterior bony prominence of the mandibular ramus that serves as the primary insertion site for the temporalis muscle [17]. This structure plays an essential role in mastication and mandibular function, as the temporalis muscle exerts significant forces during jaw elevation and retraction. The coronoid process is heavily involved in jaw movement and lies in close anatomical proximity to the maxillary third molar. This tight spatial relationship can heavily impact surgical planning, particularly in cases involving the extraction of impacted maxillary third molars or reconstructive procedures performed near the coronoid process [8, 18]. The close proximity between these structures means that surgical interventions in the posterior maxilla carry inherent risks of unintended contact with the coronoid process, which may result in iatrogenic injury, postoperative pain, or functional impairment.
The size and shape of the coronoid process are not static; rather, they are influenced by a combination of factors including dietary habits, hormonal influences, genetic constitution, and, most significantly, the activity of the temporalis muscle [15, 21]. Muscle and bone exist in a dynamic relationship, where the functional demands placed by muscle contraction can directly affect the morphology of the underlying bone [5, 11, 25]. This principle, rooted in Wolff's law, suggests that bone adapts its structure in response to the mechanical loads it experiences. Continuous biomechanical loading and stress generated during mastication dictate the trabecular orientation and overall density of the coronoid process [25]. Individuals with greater masticatory function tend to develop more pronounced coronoid processes, while those with reduced muscle activity may exhibit smaller or less distinct morphology.
This structure is of immense clinical importance to the maxillofacial surgeon for several reasons. In reconstructive procedures, the coronoid process may serve as a donor site for autogenous grafts, providing a source of vascularized or non-vascularized bone for mandibular reconstruction [4, 7]. Additionally, the morphological characteristics of the coronoid process have utility in forensic dentistry, where they assist in determining age, sex, race, and species

identification based on skeletal remains. Understanding the variability in coronoid morphology across different demographic groups is therefore essential for both clinical and forensic applications.
By examining radiographic images, such as panoramic radiographs or cone beam computed tomography scans, clinicians can accurately assess the spatial relationship between the coronoid process and the maxillary third molar [19]. These imaging modalities provide detailed visualization of the anatomical relationships in three dimensions, allowing for precise measurement of distances and identification of potential areas of impingement. This evaluation is essential for identifying potential risks, such as iatrogenic injury to the coronoid process during maxillary third molar extraction, or the impact of coronoid process abnormalities, including hyperplasia, on the adjacent maxillary third molar [2]. In cases where coronoid hyperplasia is present, the enlarged process may impinge upon the posterior maxilla, potentially contributing to limited mouth opening or interfering with the eruption or surgical access to the third molar. Understanding the radiological findings in this anatomical context aids in developing precise treatment plans and minimizing complications associated with surgical interventions in the maxillofacial region [24]. Pre-operative assessment of coronoid morphology and its relationship to the maxillary third molar enables the surgeon to anticipate potential surgical challenges, modify the surgical approach as needed, and reduce the likelihood of postoperative complications. This knowledge ultimately contributes to improved patient outcomes, shorter recovery times, and more predictable surgical results. The present study aims to evaluate the morphological characteristics of the mandibular coronoid process and its spatial relationship to the maxillary third molar using archived radiographic data, with the goal of providing clinically relevant guidance for surgical planning in the maxillofacial region.

Materials and methods

Study Design and Patient Selection

This retrospective study was carried out using archived records of Cone Beam Computed Tomography and Intraoral Periapical images of patients who presented for diagnostic or treatment purposes to the Department of Oral and Maxillofacial Surgery at Saveetha Dental College. A total of 108 mandibles were evaluated to assess the different shapes of the coronoid processes and their specific relationship to the adjacent maxillary third molars. The sample included images from patients across a range of age groups and both sexes to ensure adequate representation of morphological variation within the population. The archived records were selected based on the availability of clear, diagnostically acceptable images that allowed for accurate visualization of both the coronoid process and the maxillary third molar region. Cases with significant pathological changes, previous surgical intervention in the region, or incomplete imaging data were excluded to maintain consistency and reliability of the measurements.

Radiographic EvaluationRadiographic measurements and morphological assessments were conducted using the proprietary viewing software associated with the imaging units [13, 20]. This software allowed for precise linear measurements, magnification correction, and multi-planar reconstruction of the CBCT datasets. While Intraoral Periapical radiographs provided a two-dimensional baseline for initial assessment, Cone Beam Computed Tomography scans were utilized for their superior multi-planar reconstruction capabilities, which allowed for exact spatial analysis without the superimposition of adjacent anatomical structures [14]. The use of CBCT was particularly valuable in cases where the relationship between the coronoid process and the maxillary third molar was complex or where overlapping structures on two-dimensional images could obscure accurate measurement.The coronoid processes were categorized morphologically into two primary shapes: triangular and round. The triangular shape was defined as having a distinct pointed apex with relatively straight borders converging to form an acute angle, while the round shape was characterized by a more blunt, curved apex with convex borders. To establish the spatial relationship between the two structures, linear measurements were strictly taken from the most superior-anterior tip of the coronoid process to the distal cementoenamel junction of the adjacent maxillary third molar [6, 9]. All measurements were performed by a single calibrated examiner to minimize inter-observer variability, and a subset of measurements was repeated to assess intra-observer reliability.

Statistical Analysis

Statistical analysis was performed using SPSS version 21.0, Statistical Package for Social Science Inc., Chicago, Illinois [23]. The data set was analyzed using descriptive statistics to summarize the frequency and distribution of coronoid process morphologies across the study sample. The chi-squared test was employed to evaluate the association between coronoid process morphology and demographic variables, including sex and age group, as well as the spatial proximity to the maxillary third molar. A p-value of less than 0.05 was considered statistically significant for all comparisons. The results were presented as frequencies and percentages, with cross-tabulations used to illustrate the relationships between categorical variables.

Results

In the present study, a total of 108 mandibles were evaluated to analyze the different morphological shapes of the coronoid processes. The most common shape observed for the coronoid process was triangular, accounting for 68.1% of the specimens examined. This was followed by the round shape, which was observed in 31.9% of the cases. The distribution of these morphological variants suggests that the triangular configuration represents the predominant anatomical form

within the study population.When analyzing demographic variables, the triangular shape remained the most common morphology in both male and female subjects. Among male subjects, the triangular coronoid process was observed in 67.8% of cases, while in female subjects, the prevalence was 68.3%. This similarity in distribution across sexes indicates that coronoid process morphology is not strongly influenced by sex-based anatomical differences within the study population. The round shape was correspondingly distributed, accounting for the remaining percentages in both groups.
When the prevalence of mandibular parameters was compared across age groups, the most common shape observed in young individuals was triangular, with 85 specimens, representing 70.8% of this demographic. Further stratification of this finding revealed that among young males, the triangular shape was observed in 41 specimens, accounting for 78.8% of young male subjects, while among young females, the triangular shape was observed in 44 specimens, representing 64.7% of young female subjects. The higher prevalence of triangular morphology in young males suggests a potential influence of masticatory muscle activity, which tends to be more developed in this demographic, on coronoid process morphology.
Morphologically, mandibles presenting with a triangular coronoid process demonstrated tighter spatial proximity to the distal aspect of the maxillary third molar compared to the round variant. This reduced spatial clearance was particularly noted in cases where the maxillary third molar was distoangularly impacted, a configuration that significantly narrows the surgical corridor available for extraction or other surgical interventions. The close anatomical relationship observed in triangular coronoid processes highlights the importance of pre-operative radiographic assessment, as the reduced clearance may increase the risk of iatrogenic contact between surgical instruments and the coronoid process during maxillary third molar extraction procedures. In contrast, mandibles with round coronoid processes generally exhibited greater spatial separation from the maxillary third molar, providing a wider surgical corridor and potentially reducing the risk of operative complications.

Table 1: Frequency and Distribution of Coronoid Process Morphology

Demographic Parameter	**Category**	**Total Sample / Subgroup**	**Triangular Shape**	**Round Shape**
Overall Morphology	**Entire Study Population**	*n = 108*	*68.1%*	*31.9%*
Gender (Overall)	**Male**	*n = 53*	*67.8%*	*32.2%*
	Female	*n = 55*	*68.3%*	*31.7%*
Age Group	**Young Individuals**	*n = 85*	*70.8%*	*29.2%*
Young Subset by Gender	**Young Males**	*n = 41*	*78.8%*	*21.2%*
	Young Females	*n = 44*	*64.7%*	*35.3%*

Discussion
Radiographic studies consistently highlight the spatial relationship between the mandibular coronoid process and the maxillary third molar, emphasizing variations in anatomical positioning and morphology that may influence treatment decisions [4]. Understanding these anatomical relationships is crucial for surgical planning, particularly in cases involving impacted maxillary third molars or surgical approaches near the coronoid process. The close proximity between these structures means that even subtle variations in coronoid morphology can significantly affect the ease of surgical access, the risk of iatrogenic injury, and the overall predictability of the procedure.
Our study found the triangular morphology to be overwhelmingly prevalent, accounting for 68.1% of cases across both genders, and most frequent in young adults. This finding aligns with observations by Smith and colleagues, who noted a wide range of variations in the shape and position of the mandibular coronoid process among their study population [1]. These variations were shown to potentially influence the proximity to adjacent structures, including the maxillary third molars, highlighting the need for precise radiological evaluation prior to surgical intervention [22]. The consistency of these findings across different populations suggests that coronoid process morphology follows predictable patterns that can be anticipated based on demographic factors.

The high prevalence of the triangular shape in younger individuals may be linked to active masticatory forces and temporalis muscle development during late adolescence [16]. During this period of skeletal maturation, the functional demands placed on the mandible by the masticatory muscles are at their peak, and the coronoid process undergoes adaptive remodeling in response to these mechanical stimuli. The triangular morphology, with its pointed apex and defined borders, represents a more robust adaptation to tensile forces transmitted through the temporalis muscle tendon. As individuals age, changes in masticatory function, tooth loss, or alterations in muscle activity may contribute to morphological remodeling, potentially explaining the slight variation in shape distribution observed across different age groups.
The reduced spatial clearance observed with triangular coronoid processes can lead to increased surgical difficulty. Recent studies by Brown and colleagues highlighted cases where pathological conditions of the mandibular coronoid process led to complications during maxillary third molar surgeries [2]. These findings underscore the importance of pre-operative radiographic assessments to anticipate and mitigate potential risks [12, 18]. In cases where a triangular coronoid process is identified in close proximity to an impacted maxillary third molar, the surgeon may need to consider alternative surgical approaches, such as a more distal flap reflection, modified instrument trajectories, or even pre-surgical orthodontic movement of the third molar to create adequate working space. Radiological assessments provide critical information to anticipate potential complications such as impingement or obstructive patterns during surgical interventions, allowing the surgeon to adapt the procedure to the patient's specific anatomical configuration.

The evolution of imaging technologies, particularly cone beam computed tomography, has significantly improved the visualization and accuracy of assessing these anatomical structures, offering clinicians more detailed insights for treatment planning. In a comparative study conducted by Lee and colleagues, cone beam computed tomography was found to provide superior visualization of the coronoid process and its relationship with adjacent structures, including the maxillary third molars, compared to conventional two-dimensional imaging modalities [3]. This enhanced clarity is crucial for accurate treatment planning in complex surgical cases, as it eliminates the superimposition of anatomical structures that can obscure critical details on panoramic or periapical radiographs. The ability to view the coronoid process and maxillary third molar in three dimensions allows for precise measurement of distances, assessment of the angulation of the third molar, and identification of any bony irregularities that may complicate the procedure.
Despite the advancements in imaging technology, several challenges remain in the comprehensive assessment of this anatomical region. Further improvements in imaging resolution are needed to enhance the detailed visualization of intricate anatomical features, especially in cases involving complex relationships between the coronoid process and the maxillary third molar [10]. Higher resolution imaging would allow for better delineation of the fine trabecular architecture of the coronoid process and more accurate identification of the cementoenamel junction of the third molar, which serves as a critical landmark for spatial measurements. Additionally, clinical correlation is essential; more robust clinical studies are necessary to correlate radiological findings with surgical outcomes and patient prognosis, providing evidence-based guidelines for optimal treatment strategies [8]. Such studies would help establish threshold values for safe distances between the coronoid process and the maxillary third molar, guiding surgical decision-making and reducing the incidence of postoperative complications.
Future research directions should focus on longitudinal studies to track changes in the coronoid process and maxillary third molar relationship over time, considering factors such as growth, aging, and dental eruption patterns [16]. These studies would provide valuable insights into the dynamic nature of this anatomical relationship and help predict how it may evolve over the course of a patient's lifetime. Furthermore, investigating the impact of pathological conditions affecting the coronoid process, such as hyperplasia, osteomas, or traumatic injuries, on adjacent structures will refine treatment protocols and improve patient outcomes. Understanding how these pathological entities alter the spatial relationship with the maxillary third molar will enable clinicians to anticipate complications and develop appropriate management strategies. The integration of advanced imaging techniques with clinical outcome data will ultimately contribute to more personalized and effective surgical planning, reducing the risk of complications and improving the quality of care for patients undergoing procedures involving the maxillary third molar and mandibular coronoid process.

Conclusion

In conclusion, the radiological evaluation of the mandibular coronoid process in relation to the maxillary third molar is pivotal for enhancing clinical decision-making in oral and maxillofacial surgery. The high prevalence of the triangular coronoid process requires careful pre-operative assessment to avoid surgical impingement. By addressing current limitations and advancing research through innovative approaches and technology, we can further optimize diagnostic accuracy, treatment planning, and ultimately, patient care in this specialized area of dental radiology. This research underscores the collaborative efforts needed among radiologists, oral surgeons, and researchers to advance knowledge and clinical practices, ensuring the best possible outcomes for patients undergoing complex dental and maxillofacial procedures.

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