ISSN 2219-6749

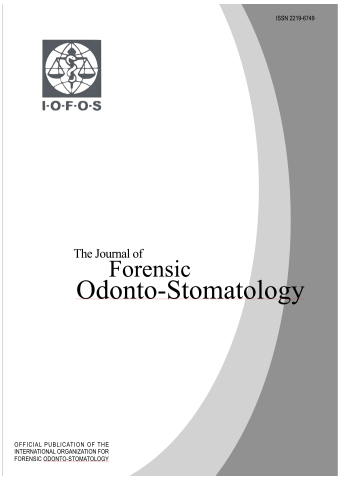
I·O·F·O·S

# The Journal of Forensic Odonto-Stomatology

Volume 43, n. 2 - Aug 2025

OFFICIAL PUBLICATION OF THE
INTERNATIONAL ORGANIZATION FOR
FORENSIC ODONTO-STOMATOLOGY

**JFOS**
**ISSN: 2219-6749**




# THE JOURNAL OF FORENSIC ODONTO-STOMATOLOGY

The Journal of Forensic Odonto-Stomatology (JFOS)is the official journal of the International Organization for Forensic Odonto-Stomatology (IOFOS) since 1983.

JFOS is an international journal dedicated to forensic odontology, legal odonto-stomatology, dental anthropology, translational research in forensic sciences, litigation in dentistry, dental ethics and law in the perspective of justice administration and legal rights protection.

JFOS is open-access free of charge for readers and authors, published three times per year (in April, August, and December). The quality of the publications is guaranteed by the blind review procedure by internationally accredited peer reviewers.

The Journal of Forensic Odonto-Stomatology (JFOS) is referenced and fully indexed in the largest databases such as PubMed-MEDLINE, PubMed Central, Scopus, and EBSCO.

The Journal welcomes international material for publishing. We would also like to encourage submissions from new authors, recognising the importance of first publications. All papers should comply with the "Guidance to Authors" document printed on the IOFOS.eu website.

I·O·F·O·S

# The Journal of Forensic Odonto-Stomatology

Vol 43 n. 2 Aug 2025

CONTENTS

# Late mandibular fracture after third molar extraction: a malpractice case or not?



Sara Bernardi [1], Eleonora Ricciuti[1], Sara Trichilo[1], Davide Gerardi[1], Fabiola Rinaldi[2] , Giuseppe Varvara[2] , Stefano Mummolo[1], Guido Macchiarelli[1], Serena Bianchi[1]

*[1]Department of Life, Health and Environmental Sciences, University of L'Aquila, L'Aquila, Italy.*
*[2]Department of Innovative Technologies in Medicine & Dentistry, Dental School, 'G. D'Annunzio' University of Chieti-Pescara, Chieti, Italy.*

**Corresponding author:**
**sara.bernardi@univaq.it**

The authors declare that they have no conflict of interest.

KEYWORDS

Third molar extraction; Mandibular fracture; Forensic dentistry; Pericoronitis

J Forensic Odontostomatol
2025. Aug;(43): 2 -2:11
ISSN :2219-6749
DOI: doi.org/10.5281/zenodo.15564456

## ABSTRACT

Fractures of the mandibular angle following surgical extraction of the third molar occur at an incidence ranging from 0.0034% to 0.0075%. The low incidence and the data present in the literature reveal how legal claims based on late mandibular fractures from third molar extractions are unlikely, being an uncommon clinical condition. The present case investigates the causal relationship between the fracture of the mandibular angle and the intervention of extraction of a dental element 3.8 in conditions of semi-inclusion and the possible hypothesis of dental malpractice. About two weeks after the extraction, the patient felt a noise like that produced by shattering glass, followed by severe and sudden pain along the area of the left mandibular joint and numbness. The following day, the patient underwent an orthopantomogram performed by the same medical team that carried out the operation in question, with an incorrect diagnosis of dislocation of the condyle, which is to be treated with muscle relaxants and anti-inflammatories. Upon further radiological investigations performed by different operators, it is concluded that the patient is suffering from a "fracture of the left mandibular angle". The patient, therefore, reported and sued the dentists for the crime of negligent personal injury who had extracted element 3.8. From medical history, clinical examination, and documentation produced by the patient, it can be said that the extraction of element 3.8 was necessary as the pericoronary sac had caused an untreatable periodontal lesion at the distal root of the 3.7. From a medico-legal point of view, it was established that the extraction maneuvers may have caused the fracture of the mandibular angle, but it can be excluded professional responsibility in the criminal field of the medical team that carried out the res judicata intervention, since the fact in itself represents a known complication of the extraction of mandibular third molars.

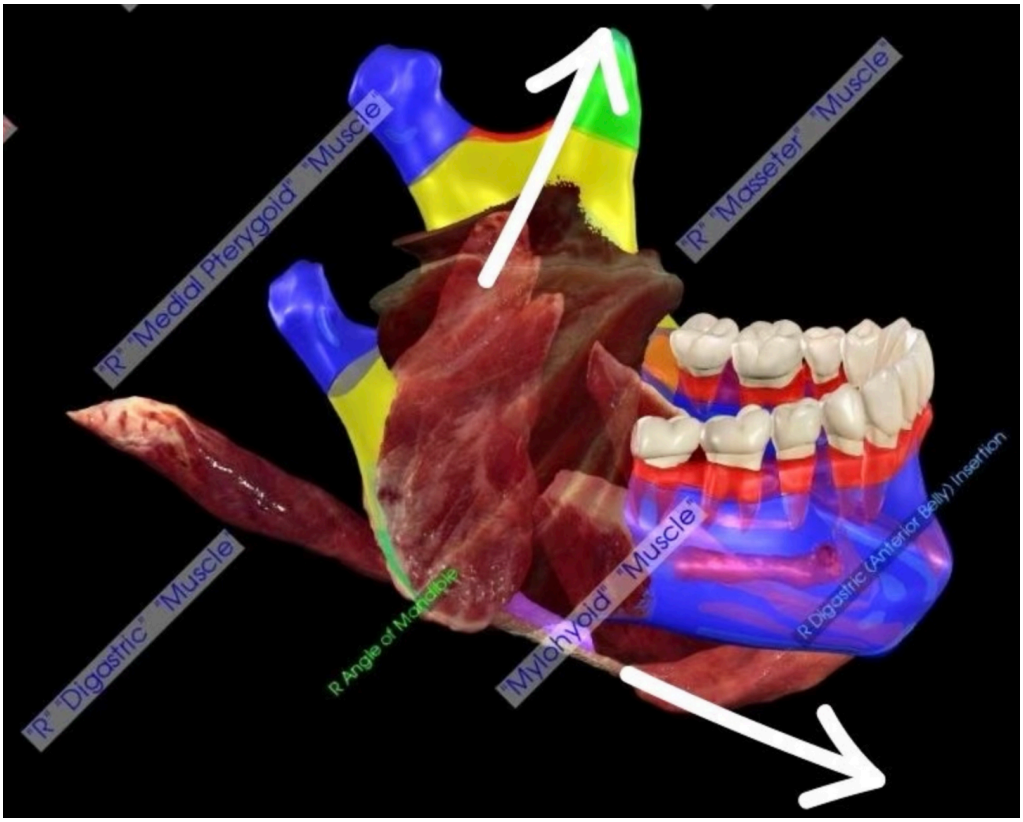
## INTRODUCTION

The dental inclusions, specifically the third inferior molar or supernumerary teeth, are classified as eruptive disorders[1]: during their extraction different complications could occur[2]. The inclusion and semi-inclusion of the mandibular third molar are primarily due to the mandibular angle anatomy region, which is unable to provide sufficient space for tooth eruption[3]. The surgical procedure for the extraction of

impacted lower third molars can be associated with both intraoperative and postoperative complications, including severe pain, significant bleeding, extensive edema, potentially permanent inferior alveolar nerve injury, and even rare but serious mandibular fractures.[4,5] These complications, particularly in weak areas of the mandible such as the angle region, condylar region, and symphysis, underscore the gravity of the clinical situation.[6]

The mandibular angle is particularly vulnerable due to the transitional nature of the zone between the toothed and non-toothed portion of the mandible[5] and solicited by the vectorial forces of the masticatory and suprahyoid muscles (Figure 1).

**Figure 1.** Anatomy of mandibular angle region with muscles inserted. Arrows show the vectorial forces developed during masticatory acts. Picture from Anatomage Inc. - Anatomage Table EDU. The 3D rendering of the donated body to science data is from Anatomage Table.




The third molar, often partially impacted, reduces bone mass, making the structure more vulnerable and increasing the fracture risk.[7] Mandibular fractures associated with the extraction of lower third molars account for approximately 75% of all cases.[5] Factors contributing to the risk of fracture include the level of impaction on the surrounding bone, dental anatomy, characteristics of dental roots, previous infections, age, sex, postoperative period, bruxism, drugs affecting bone metabolism, and the patient's athletic activity.[8] Despite the relatively low incidence of this complication, ranging from 0.0033% to 0.0036% for intraoperative fractures and 0.0042% to 0.0046% for postoperative fractures[9], it's crucial for clinicians to be aware of the risks associated with retained impacted teeth, emphasizing the need for vigilance and caution in these procedures. It's important to note that the occurrence of late mandibular fractures, particularly those that become the subject of malpractice lawsuits, is a rarity in the literature.[10]

Given the low incidence, forensic dentistry associates the late mandibular fracture after third molar extraction as an unforeseen and unpredictable complication, provided the oral surgeon has diligently evaluated the medical history, excluded any factors predisposing to the fracture, informed the patient comprehensively, and used the hand-piece and surgical instruments correctly, while also monitoring the patient in the post-operative period.[11]

The law regulating medical responsibility in Italy is the 24/2017 law. The text of the law regulates the

responsibility at the penal, civil, and administrative levels. Article 590 sexies of the Penal Code states, "When the lesion is due to incompetence, but the guidelines and literature indications are respected, liability is excluded".[12] The penal liability of the health operator (doctor, dentist) is excluded for technical errors but not for negligence (when the operator does not take the appropriate precautions for the case) and for imprudence (when the operator does not respect guidelines).[13-14] In cases such as late mandibular fracture after third molar extraction, the operator should not be prosecuted criminally if the lesion is due to technical errors.

Here, we report a case of a late mandibular fracture after third molar extraction. The operators and their professional actions have been investigated by technical consultants of the prosecutor's office to assess their eventual criminal responsibility.

## THE CASE

A 40-year-old male patient went to a private healthcare structure affiliated with an insurance company, reporting an episode of inflammation at the level of the left hemiarch of the mandible. After undergoing an orthopantomography (OPG) conducted by dentist "1", the patient underwent extraction of tooth 3.8 by dentist "2", operating in the same healthcare facility. The patient reported that the post-operative course was uneventful until seven days after the removal when, during lunch, he reported hearing a noise like "breaking glass," followed by intense pain. He stated that he contacted the healthcare facility and went there for a check-up. Furthermore, the patient reported that, after examination of the X-ray, a dislocation of the condyle was diagnosed; therefore, the treatment prescribed was based on anti-inflammatory drugs and muscle relaxants, and another appointment for the following day was scheduled.

On the same evening, the patient reported that, after a discussion with his wife, it seemed advisable to seek a second opinion and, therefore, contacted Dentist 3, his wife's physician. The next day, the patient went to Dentist 3's office and underwent further examination with OPG and Computerized Tomography (CBCT): the radiographic exams revealed a fracture of the angle of the left mandible, and Dentist "3" decided to treat it through arch ligation for four weeks. After four weeks, the previous treatment was ineffective, and a new treatment consisting of immobilization with metallic wire and brackets was scheduled. Due to the above-described events, the patient made a formal complaint to Dentists "1" and "2", suing for personal injuries.

### Technical consultation operations of the public prosecutor

Following the complaint filed by the patient, the public prosecutor proceeded to appoint their consultants to ascertain:

§ Any responsibilities for fault, malpractice, and negligence of the current suspects;

§ The necessary precautions by the individuals and/or medical personnel who have treated the patient; in affirmative case, the consultants must individuate expressly the negligent conduct (commission or omission) and the person responsible for it, as well as representing, according to medical science evaluations, the causal relationship between the negligent conduct (active and omissive) and the diagnosed injuries listed below:

a) Circular bone lesion of large dimensions as a result of osteotomy in position 4.8 and still the presence of well-represented radicular fragments;

b) Circular bone lesion of large dimensions as a result of osteotomy in position 3.8;

c) Fracture of the angle of the left mandible

§ The severity of the injuries suffered by the victim, including the relation to the days of prognosis, as direct consequences of any negligent or intentional conduct attributable to the suspects.

The Technical Consultation Operations were performed in the presence of the prosecutor's office's panel of technical consultants, the party's technical consultants, and the patient. After identifying the expert witness, anamnestic data were collected. The medical history resulted clear and without any peculiarities to report.

He reported taking painkillers three times a day in the period following the events in question and that he had taken psychotropic drugs for sleep until September 2021.

### Extraoral and intraoral examinations.

At the time of the expert operations, the patient reported a dull-discontinuous pain associated with a level 5 on the Visual Analogue Scale (VAS).

No asymmetries were appreciable (Fig. 2a, b, and 2c). Intraorally, an alveolar crestal bone resorption is present (Figure 3a, 3b), and mandibular dynamics appear congruent and functional (Fig. 4a, 4b).

**Figure 2.** a.b.c. Extraoral images showing the absence of visible asymmetries

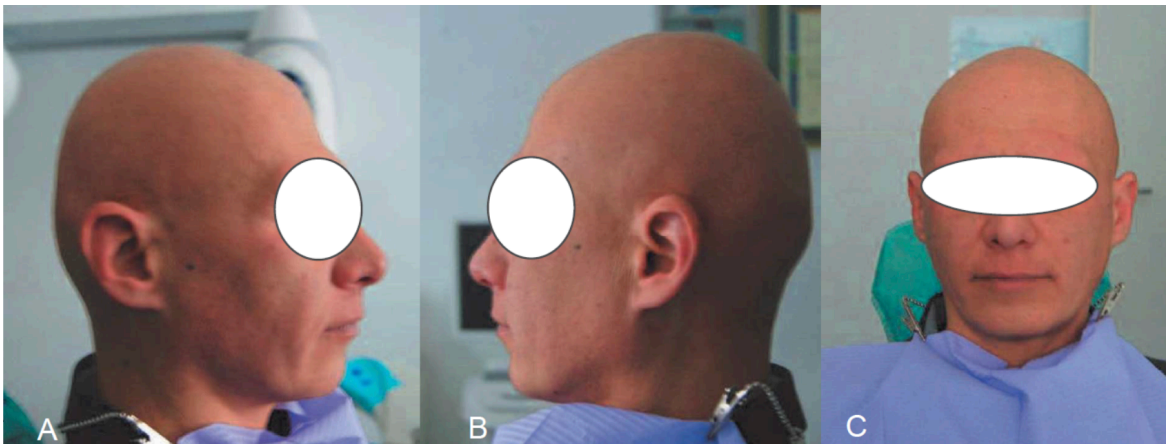



**Figure 3.** a.b. Intraoral images showing an area of resorption of the left alveolar ridge

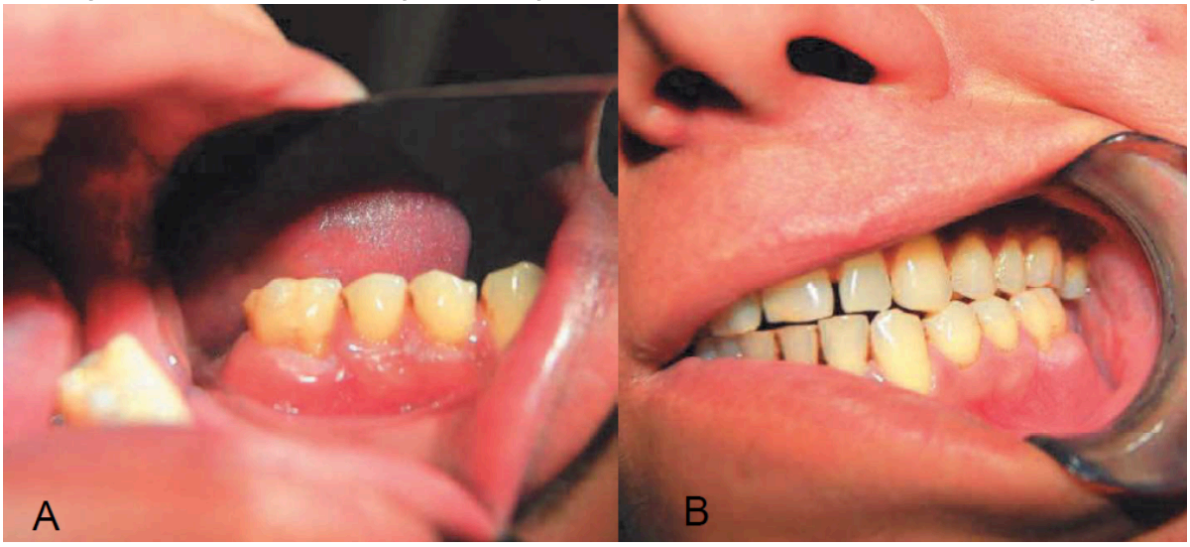
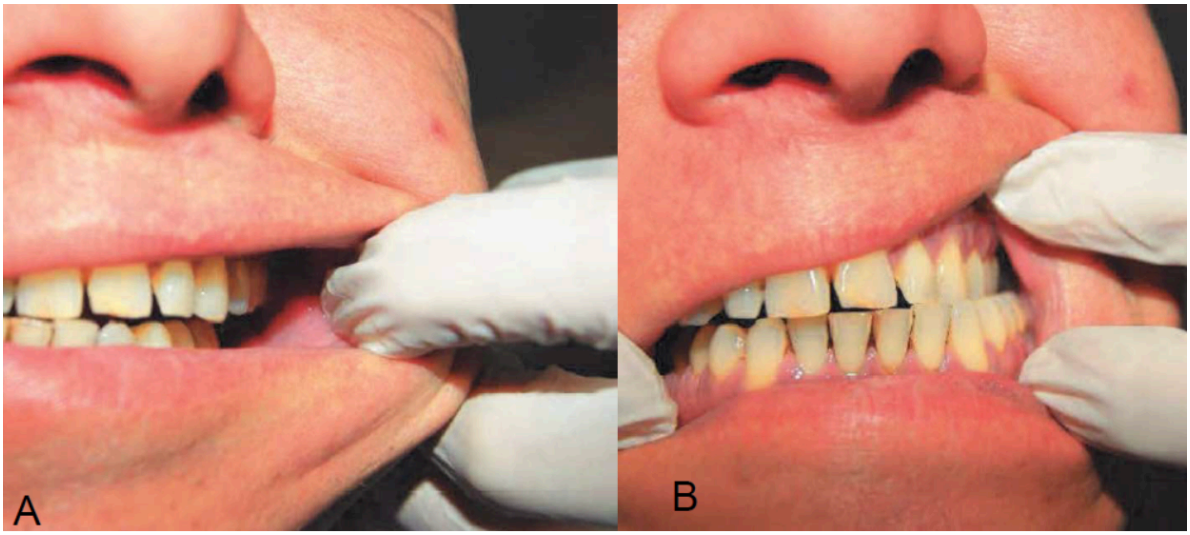



**Figure 4.** a.b. Examination of the lateralization function appearing congruent and functional



**Examination of the radiograms.**

The pre-operative OPG (Figure 5) showed the presence of the left inferior third molar in a state of semi-inclusion, class IB according to the Pell & Gregory classification. The pericoronal sac shows mesially to have caused resorption of the supporting bone tissue at the distal root of the seventh.

The OPG performed the day of onset of the symptoms showed a lack of continuity at the posterior border of the left mandible (Figure 6).

The CBCT showed the presence of the lack of continuity of the angle of the left mandible involving the lingual side as well (Figure 7).

the fracture is identified as an incomplete/nearly complete type, given the small amount of residual bone not involved at the level of the mandibular border. The classification of this fracture is therefore on the borderline between an incomplete and complete fracture type with minimal displacement of the fragments.

The OPG carried out more than two months later showed that the healing process of the fracture line is underway. The apices of the 4.7 are still within the bone (Figure 8).

**Figure 5.** Pre operative OPG. The circle and the arrow indicated the 3.8 tooth

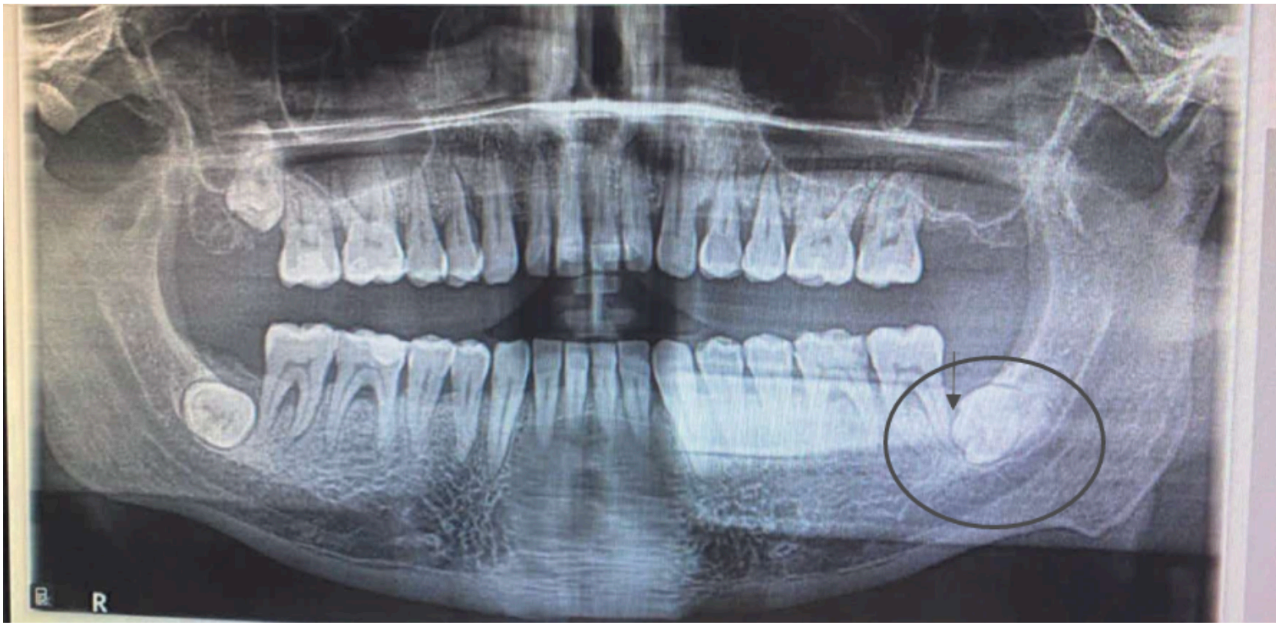



**Figure 6.** OPG performed after the onset of the post-operative symptoms. The circle indicated the fracture line

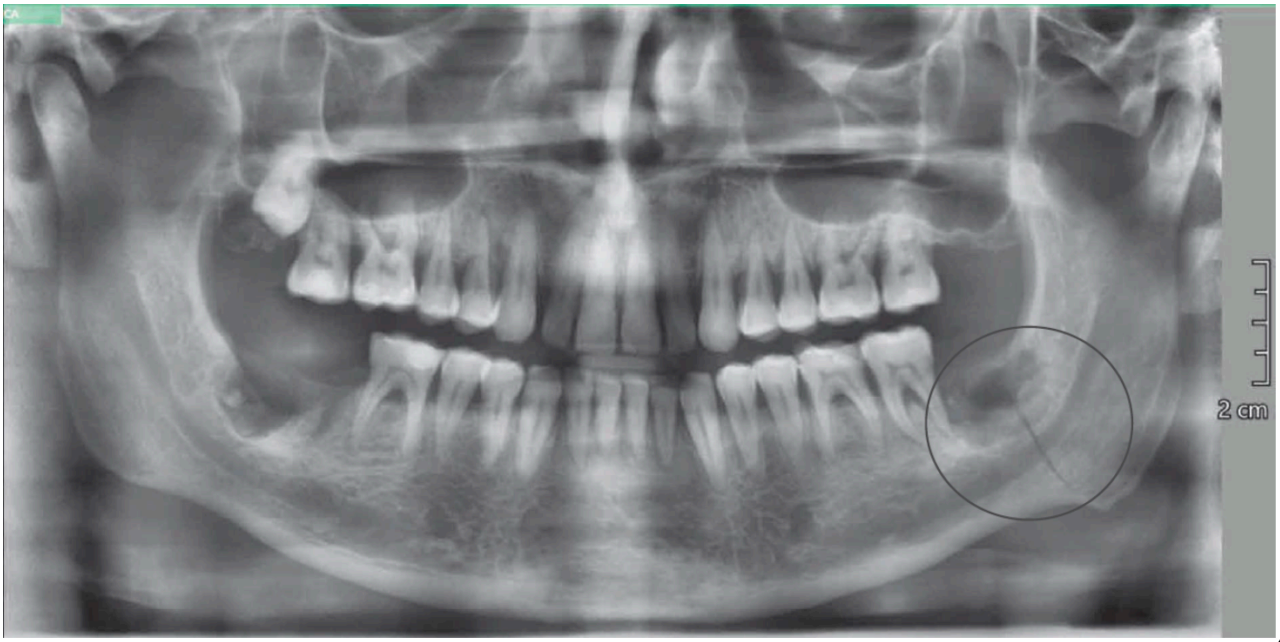


**Figure 7.** A) Axial projection where it is possible to appreciate the fracture line crossing the cortical bone sharply (arrow). B) Cross-sections: the fracture line crosses the cortical bone sharply and extends through multiple sections. C)-D)-E): 3D reconstruction showing how the fracture is identified as an incomplete/nearly complete type, given the small amount of residual bone not involved at the level of the mandibular border. The classification of this fracture is therefore on the borderline between an incomplete and complete fracture type with minimal displacement of the fragments

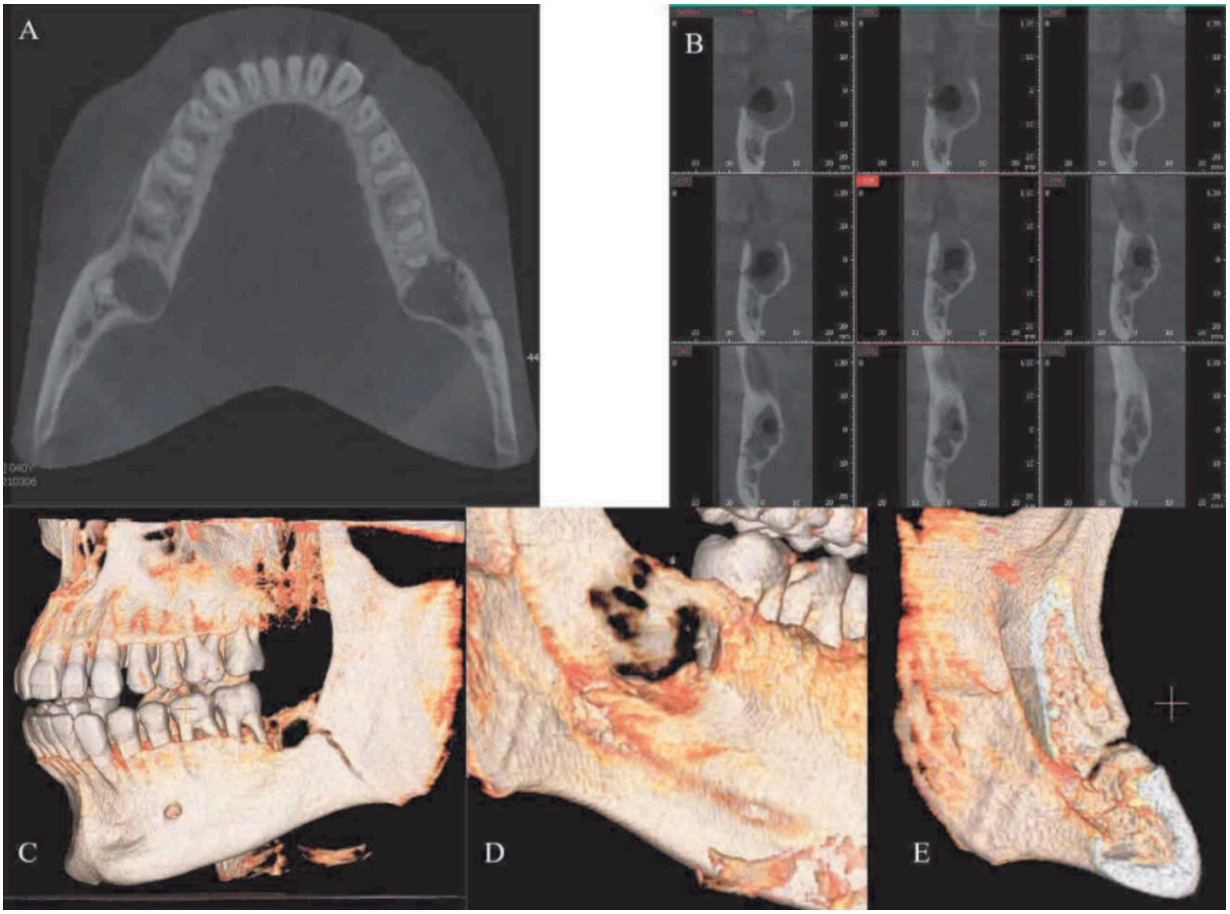



**Figure 8.** OPG carried out after two months after the treatment of the fracture

**Medico-legal considerations**

From the medical history, the clinical examination, and the documentation produced, as well as from the results of the new instrumental tests carried out during the appraisal, it is possible to state that:

1.The services provided by dentist 2 included the extraction of element 3.8, with the appearance of a fracture of the angle of the mandible after two weeks. As regards the services provided by dentist 1, they did not produce criminally relevant injuries to the patient;

2.From the examination of the pre-operative OPG, the extraction of the 3.8 was indicated as the pericoronary sac at the mesial level, showing that it has caused an untreatable periodontal lesion at the level of the distal root of the seventh. The prevention of infectious pathologies and the presence of signs of periodontal pathology are among the indications for extraction, according to the Italian Clinical Recommendations in Odonto-stomatology ed. 2017 [15];

3. The fracture of the angle, although it occurred unusually, i.e., without any prodromal and opening symptoms, is a complication of the extraction of the semi-impacted lower third molar which, although rare, can occur after the extraction[16];

4.The osteotomy results detected radiographically at sites 3.8 and 4.8 are compatible with the osteotomy maneuvers necessary for the extraction of impacted third molars[16];

5.As regards the roots remaining from 4.7, and still present at the OGT of the last follow-up, produced during the appraisal, given that these did not give inflammatory results, it does not constitute a harmful act.

Considering the second intervention by dentist 3, not conclusive, as the fracture did not appear to be a greenstick fracture but an actual fracture of the angle which would have required immediate intervention by a specialist in maxillofacial surgery, with block rigid intermaxillary or application of intermaxillary fixation screws (IMF) between the third and fourth tooth to allow a stable intermaxillary block and reduction of operating times[17], it was verified that the interruption of the causal link between the injury and the state of health suffered by the injured person and objectified during this medico-legal investigation.

Ultimately, the medico-legal analysis allows us to state that the extraction maneuvers may have caused the fracture of the mandibular angle, but that this event appears to be among the complications of the lower third molar extraction operation[8]. Since dentist 2 performed the operation according to clinical recommendations and good practices, it does not constitute criminally relevant personal injury.

## DISCUSSION

*The late mandibular fracture after third molar removal: a remote possibility or concrete probability*

The case presented offers a unique perspective on a relatively rare complication that can arise following a frequent surgical procedure. The incidence of mandibular fracture after third molar extraction (late fracture) is indeed rare, occurring in less than 1% of cases.[18-20] This rarity underscores the importance of understanding and managing this potential complication. In the literature, most authors report the onset of late fractures between the second and fourth week after surgical extractions, during chewing, especially during meals[18]. It has also been reported that male patients over 40 have a higher incidence of late mandibular fractures.[19-21] In the case presented, the fracture seems to have occurred in the abduction phase of the mandible. Usually, the fracture is associated with an atrophic mandible, an impacted lower third molar, a large tooth volume (associated or not with bone cysts or tumors)[19,22], poor surgical planning, poor technique (adequate, inadequate instrumentation, and excessive use of manual force instruments during the extraction procedure). In the case presented, from the clinical documentation presented, there is no evidence of an inadequate use of instruments or surgical instruments unsuitable for the operations.

A combination of forces from the masticatory muscles (masseter, medial pterygoid, and digastric) on a possible fragile jaw can increase the incidence of fractures.[19-21,23-25] Further causes, such as systemic disorders that cause bone fragility (osteoporosis,

hyperparathyroidism, rheumatism, osteogenesis imperfecta, and Pajet's disease), and local trauma with impact on the surgical site can lead to late mandibular fractures.[20-22,24] During the extraction, it is crucial to remember that meticulous surgical planning is always preferable, including performing as many dental sections as necessary, minimizing the osteotomy, and, consequently, reducing the fragility of the jaw and the incidence of fractures. [19, 26, 27] It is described in the literature that the use of the piezoelectric handpiece for osteotomy is indicated to re-duce excessive forces during tooth avulsion and reduce manipulation of neural structures, avoiding paresthesia.[28] Faced with the potential incidence of late mandibular fractures, patients must be informed to maintain a soft diet for at least 4 weeks.[25]

Another factor that predisposes to fractures is the position of the dental element and the side where it is positioned. Although the distoangular position is generally considered the most technically difficult compared to the others, it requires more extensive bone removal. In the study of Galvao et al., however, the mesioangular and vertical angulations have been associated with the highest incidence of fractures despite being the most accessible positions to operate on and requiring less bone removal.[29] In terms of tooth position, class II and III, B, and C cases were found to have a higher incidence of mandibular fracture than class I and A cases.[29] This is probably linked to a greater degree of extraction difficulty and removal of more extensive bone. There was also a higher incidence of mandibular fracture for ultimately impacted teeth (64.8%) than partially impacted teeth.[29] When the tooth is completely covered by bone, it typically occupies a more significant portion of the mandibular angle and requires more bone removal during surgery. Post-operatively, this leads to a smaller amount of residual cortical bone and, therefore, a more fragile mandibular angle, which can be a significant causal factor of late fracture.[8] It is crucial to educate patients about these potential risks and the importance of post-operative care, including maintaining a soft diet for at least 4 weeks, to minimize the incidence of late mandibular fractures.

As regards the hemimandible, the left side represents a possible risk factor that increases the incidence of fracture.

In the study by Wagner et al. (2005), teeth located on the left side of the mandible may require a major osteotomy due to the difficulty of visualization found in most right-handed operators.[30]

In cases where an extensive osteotomy is necessary, it is prudent to administer the patient a bland liquid diet, especially during the first four weeks. This is the most critical period, when there is a greater probability of post-operative mandibular fractures.[31]

In the case presented, in addition to being a 40-year-old male patient, the fracture occurred on the left side, in agreement with the few data in the literature

*The forensic dentistry point of view.*

The case, beyond to be a fortuitous finding of a rare complication of third molar surgery, is the subject of medical-legal litigation in the criminal field. Specifically, the errors which are the subject of the complaint and attributed to dentists 1 and 2 by the party's consultants are two: errors of a technical nature (not verifiable with absolute certainty from the clinical and radiographic documentation produced) and of a diagnostic omission type (non-radiographic diagnosis of the fracture). The medico-legal analysis of the documentation produced found compliance with the clinical recommendations in dentistry in the indication for the extraction of the lower third molar and could only assume but not as-certain a causal connection between a technical error and the harmful event. The failure to diagnose the fracture is also a technical error: upon reporting the symptoms, dentist 2 promptly carried out the radiographic examination as well as wanted to check the patient again the following day. The intervention of dentist 3 interrupted the causal link between the incorrect diagnosis and the state of illness, prolonging and worsening it. However, what can also be seen from the immediate change of doctor by the patient is a significant lack of attention on the part of the suspects towards correct information for the patient. The "hardest" litigation is not based exclusively on technical errors and the lack of clinical documentation demonstrating that all the best means available in the specific case were used, but on the lack of communication; every single intervention will require adequate support, calibrating this support on the type of

intervention and its complexity, as well as on the type of patient and his need to "know".[32] In this specific case, the patient reported that he had not been informed of this possible complication, although rare, nor had he received any prescriptions regarding its prevention.

The incorrect diagnosis that subsequently occurred severely damaged the doctor-patient relationship of trust, pushing the plaintiff first to change doctor within a few hours and subsequently to turn to criminal rather than civil law. The late onset of post-surgical mandibular fracture appears to be relatively rare, and the potential risks inherent to this complication, in the case of subjects with an unfavorable medical history for systemic bone pathologies, are often not explained to the patient. This case highlights the crucial role of active patient information in daily clinical practice, especially in cases of complex surgical interventions. Informed consent and a dialogue duly suited to the patient's level of understanding play a significant role in this scenario as a tool for clinical communication, self-awareness, guarantee of the right to self-determination, therapeutic alliance, and consolidation of the doctor-patient relationship of trust.

## CONCLUSION

If the mandibular third molars need to be removed, the oral surgeon should carefully evaluate the patient before performing the surgery, use appropriate instruments to minimize any potential complications, and spend enough time with the patient to explain the risks and complications that may arise after the surgery. One of the rarest post-operative complications is the fracture of the mandibular angle.

## REFERENCES


1. Bailey E, Kashbour W, Shah N, Worthington HV, Renton TF, Coulthard P. Surgical techniques for the removal of mandibular wisdom teeth. Cochrane Database Syst Rev. 2020; 7:CD004345. doi: 10.1002/14651858.CD004345.pub3.
2. Varvara G, Angiolani F, Rinaldi F, Gerardi G, Bernardi S, Rastelli S, Botticelli G, Pizzolante T. Complication of the extraction of maxillary anterior supernumerary teet: the accidental extraction of the permanent tooth bud. Bull Stomatol Maxillofac Surg. 2025; 21:29-35. doi:10.58240/1829006X-2025.1-29.
3. Wang D, He X, Wang Y, Zhou G, Sun C, Yang L, Bai J, Gao J, Wu Y, Cheng J. Topographic relationship between root apex of mesially and horizontally impacted mandibular third molar and lingual plate: cross-sectional analysis using CBCT. Sci Rep. 2016; 6: 39268. doi: 10.1038/srep39268.
4. Varvara G, Bernardi S, Piattelli M, Cutilli T. Rare and life-threatening complication after an attempted lower third molar extraction: Lemierre syndrome. Ann R Coll Surg Engl. 2019;101:e52-e54. doi: 10.1308/rcsann.2018.0190.
5. Mottl R, Kunderová M, Slezák R, Schmidt J. Iatrogenic Fracture of the Lower Jaw: A Rare Complication of Lower Molar Extraction. Acta Medica (Hradec Kralove). 2021;64:101-107. doi: 10.14712/18059694.2021.18.
6. Shivani N, Senthil Murugan P, Leelavathi L. Correlation of mandibular 3rd molars with angle fractures. Int J Dent Oral Sci 2021;8:1460-5.
7. Palmela Pereira C, Santos R, Santos A, Gonçalves C, Augusto D, Rodrigues A, Salvado F, Brilhante F. A systematic review and meta-analysis of oral and maxillofacial trauma. J Forensic Odontostomatol. 2022; 40: 2-21.
8. Pires WR, Bonardi JP, Faverani LP, Momesso GA, Muñoz XM, Silva AF, Panzarini SR, Bassi AP, Ponzoni D. Late mandibular fracture occurring in the postoperative period after third molar removal: systematic review and analysis of 124 cases. Int J Oral Maxillofac Surg. 2017;46:46-53. doi: 10.1016/j.ijom.2016.09.003.
9. Guillaumet-Claure MA, Juiz-Camps AM, Gay-Escoda C. Prevalence of intraoperative and postoperative iatrogenic mandibular fractures after lower third molar extraction: A systematic review. J Clin Exp Dent. 2022;14:e85-e94. doi: 10.4317/jced.58390.
10. Hupp JR. Legal implications of third molar removal. Oral Maxillofac Surg Clin North Am. 2007;19:129-36, viii. doi: 10.1016/j.coms.2006.11.008.
11. Giovacchini F, Paradiso D, Bensi C, Belli S, Lomurno G, Tullio A. Association between third molar and mandibular angle fracture: A systematic review and meta-analysis. J Craniomaxillofac Surg. 2018;46:558-565. doi: 10.1016/j.jcms.2017.12.011.
12. Cupelli C. La responsabilita penale degli operatori sanitari e le incerte novità della legge Gelli-Bianco. Cassaz. Penal. 2017, 1765–1778.
13. Scarpelli ML, Pinchi V, Fiore C. L'odontoiatria e la responsabilità professionale (dopo la legge Gelli/Bianco); Ariesdue, 2018; ISBN 8898789130.
14. Corte-Real A, Caetano C, Dias Pereira A, Rocha S, Alves S, Nuno-Vieira D. Risk and limits in dental practice: a Portuguese approach to medical-legal evaluation and professional liability. J Forensic Odontostomatol. 2020;38:2-7. .
15. Gherlone E, Allegrini S, Annibali S, Baggi L, Barbato E, Barone A, Berutti E, Braga G, Branchi R, Brenna F, Caiazzo A. Raccomandazioni cliniche in odontostomatologia. 2017.

16. Chiapasco M. Manuale illustrato di chirurgia orale-IV edizione.; Edra, 2020.
17. Baldisserri E, Bassi M, Benech A, Berrone S, Bertossi D, Bianchi A, Biglioli F, Bozzetti A, Briganti A, Brucoli M. Trattato di Patologia Chirurgica Maxillo-Facciale. In Trattato di Patologia Chirurgica Maxillo-Facciale; minerva medica, 2007 ISBN 8877115661.
18. Delantoni A, Antoniades I. The iatrogenic fracture of the coronoid process of the mandible. A review of the literature and case presentation. Cranio. 2010;28:200-4. doi: 10.1179/crn.2010.028.
19. Chrcanovic BR, Custódio AL. Considerations of mandibular angle fractures during and after surgery for removal of third molars: a review of the literature. Oral Maxillofac Surg. 2010;14:71-80. doi: 10.1007/s10006-009-0201-5.
20. Azenha MR, Kato RB, Bueno RB, Neto PJ, Ribeiro MC. Accidents and complications associated to third molar surgeries performed by dentistry students. Oral Maxillofac Surg. 2014;18:459-64. doi: 10.1007/s10006-013-0439-9.
21. Grau-Manclús V, Gargallo-Albiol J, Almendros-Marqués N, Gay-Escoda C. Mandibular fractures related to the surgical extraction of impacted lower third molars: a report of 11 cases. J Oral Maxillofac Surg. 2011;69:1286-90. doi: 10.1016/j.joms.2010.05.059.
22. Kao YH, Huang IY, Chen CM, Wu CW, Hsu KJ, Chen CM. Late mandibular fracture after lower third molar extraction in a patient with Stafne bone cavity: a case report. J Oral Maxillofac Surg. 2010;68:1698-700. doi: 10.1016/j.joms.2009.06.019.
23. Giovannetti F, Lupi E, Di Giorgio D, Scarsella S, Oliva A, Di Fabio D, Prata P, Petricca G, Valentini V. Impact of COVID19 on Maxillofacial Fractures in the Province of L'Aquila, Abruzzo, Italy. Review of 296 Patients Treated With Statistical Comparison of the Two-Year Pre-COVID19 and COVID19. J Craniofac Surg. 2022;33(4):1182-1184. doi: 10.1097/SCS.0000000000008468.
24. Novelli G, Sconza C, Ardito E, Bozzetti A. Surgical treatment of the atrophic mandibular fractures by locked plates systems: our experience and a literature review. Craniomaxillofac Trauma Reconstr. 2012 Jun;5(2):65-74. doi: 10.1055/s-0031-1300961.
25. Al-Belasy FA, Tozoglu S, Ertas U. Mastication and late mandibular fracture after surgery of impacted third molars associated with no gross pathology. J Oral Maxillofac Surg. 2009; 67(4):856-61. doi: 10.1016/j.joms.2008.09.007.
26. Bodner L, Brennan PA, McLeod NM. Characteristics of iatrogenic mandibular fractures associated with tooth removal: review and analysis of 189 cases. Br J Oral Maxillofac Surg. 2011;49(7):567-72. doi: 10.1016/j.bjoms.2010.09.007.
27. Pippi R, Solidani M, Broglia S, Cristalli MP. Prevention of mandibular fractures caused by difficult surgical extractions: report of a borderline case. J Oral Maxillofac Surg. 2010; 68(5):1162-5. doi: 10.1016/j.joms.2009.07.054.
28. Noetzel N, Fienitz T, Kreppel M, Zirk M, Safi AF, Rothamel D. Osteotomy speed, heat development, and bone structure influence by various piezoelectric systems-an in vitro study. Clin Oral Investig. 2019;23(11):4029-4041. doi: 10.1007/s00784-019-02838-8.
29. Galvão EL, da Silveira EM, de Oliveira ES, da Cruz TMM, Flecha OD, Falci SGM, Gonçalves PF. Association between mandibular third molar position and the occurrence of pericoronitis: A systematic review and meta-analysis. Arch Oral Biol. 2019; 107:104486. doi: 10.1016/j.archoralbio.2019.104486.
30. Wagner KW, Otten JE, Schoen R, Schmelzeisen R. Pathological mandibular fractures following third molar removal. Int J Oral Maxillofac Surg. 2005; 34(7):722-6. doi: 10.1016/j.ijom.2005.03.003.
31. Duarte BG, Assis D, Ribeiro-Júnior P, Gonçales ES. Does the Relationship between Retained Mandibular Third Molar and Mandibular Angle Fracture Exist? An Assessment of Three Possible Causes. Craniomaxillofac Trauma Reconstr. 2012;5(3):127-36. doi: 10.1055/s-0032-1313355.
32. Esposito N, Ferro S, Manchisi M, Mirenghi S, Paganelli P, Scarpelli ML. Prevenire e gestire il contenzioso in caso di insuccesso clinico; Quaderni ANDI Assicura, OrisBroker. 2015.

# Characteristics of Brazilian dental malpractice lawsuits in 2022 and 2023



Flavia Vanessa Greb Fugiwara [1], Patricia Nakasato Kondo[1], Deisy Satie Moritsugui [1], Rodolfo Francisco Haltenhoff Melani[1]

[1]*Department of Community Dentistry, School of Dentistry, University of São Paulo, São Paulo, SP, Brazil.*

**Corresponding author: flaviafugiwara@usp.br**

The authors declare that they have no conflict of interest.

KEYWORDS

Malpractice;
Forensic Dentistry,
Legal Liability;
Case Law

J Forensic Odontostomatol
2025. Aug;(43): 2 -12:20
ISSN :2219-6749
DOI: doi.org/10.5281/zenodo.16418708

## ABSTRACT

A survey was conducted of the dental professional liability cases adjudicated (post-appeal) throughout the Brazilian territory during the years 2022 and 2023. Data was retrieved from the Jusbrasil website (www.jusbrasil.com.br), and the characteristics of the lawsuits were assessed and compared with those reported in previous studies. The query entered into the "case law search" field was "dental professional liability". An assessment was conducted of 472 rulings referring to 2022 and 447 rulings referring to 2023 in which the dentist was convicted in 61% and 68% of the cases, respectively. There was no increase in the number of cases between the years included in the assessment; however, an increase did occur in the number of cases when compared to that reported in another methodologically similar study. An expert's report was solicited by the court in 75% of the cases. The most frequently involved specialties were implant dentistry and prosthodontics, and there was a tendency toward an increase in lawsuits involving companies as opposed to individuals. The amounts awarded for moral and aesthetic damages ranged from US$ 299.00 to US$ 19,960.00. The highest mean value awarded for moral damages involved the specialty of oral & maxillofacial surgery and traumatology, whereas the lowest mean value was associated with restorative dentistry. The amount most frequently awarded in convictions across the two years included in the survey was US$ 1,954.00. The adoption of preventive measures can potentially reduce the number of new cases, convictions and financial losses resulting from civil liability lawsuits.

## INTRODUCTION

For many years, dental practice primarily focused on diagnosing, preventing, and treating oral diseases. However, over the last decade, its scope has expanded and now carries a strong emphasis on ethical conduct, patients' right to information, and the meticulous documentation of clinical cases.

There has been an increasing emphasis and societal recognition of clinical outcomes, especially concerning their aesthetic aspect. While this aspect predominantly relies on subjective perception, it significantly influences patients' overall assessment of their treatment outcomes.

Professionals, influencers, and celebrities often post impressive dental treatment results on social media without considering

the technical limitations or even patient limitations involved, creating beauty standard expectations that are often unattainable.

When dentists fail to adequately explain treatment limitations, patients may become frustrated with unmet expectations regarding treatment outcomes, potentially leading to dissatisfaction. Consequently, patients may resort to legal action in an attempt to resolve disputes arising from perceived shortcomings in their treatment.

Health professionals may encounter adversities during the procedures they perform, which may or may not result in harm to patients. According to Article 927 of the Brazilian Civil Code of 2002, "Whoever causes damage to others by an unlawful act (Art. 186 and 187) is obliged to provide reparation for it." Furthermore, article 186 stipulates that "Anyone who violates the rights of others or causes them harm through voluntary action or omission, negligence, or imprudence commits an unlawful act, even if said harm is exclusively moral in nature."[1] Therefore, unless exculpatory circumstances are present, civil liability arises whenever harm is inflicted upon a patient due to culpable conduct on the part of the dentist and a causal link can be established between the harm and the conduct.

Civil liability aims to restore the moral and financial equilibrium that may have been disrupted due to the actions of a professional, thereby imposing an obligation to compensate[2] the injured party. This compensation serves the purpose of providing reparation for financial losses and/or for the infringement of the injured party's honor or image, thus characterizing harm to their physical integrity that could lead to embarrassment.[3]

Regional studies conducted over the past six years indicate that the dental specialties most commonly implicated in lawsuits were implant dentistry, prosthodontics, orthodontics, oral & maxillofacial surgery and traumatology, and endodontics.[4–9]These findings are consistent with nationwide surveys that analyzed data retrieved from the websites of State Courts of Justice spanning from 1974 to 2006,[10] from January 2006 to August 2011,[11] as well as data obtained from the Jusbrasil website pertaining to the year 2017.[12]

The aim of this study was to evaluate the features of nationwide cases adjudicated in 2022 and 2023 pertaining to dental professional liability. This assessment was conducted through a search on the Jusbrasil website, and the results obtained were compared with findings from previous studies.

## MATERIALS AND METHODS

This cross-sectional study gathered data on dental malpractice lawsuits from the publicly accessible Jusbrasil website (www.jusbrasil.com.br). The collected information encompassed lawsuits published between January 1, 2022, and December 31, 2023.

The search included decisions handed down after appeal concerning allegations of harm filed against individuals and/or companies across all State Courts of Justice in Brazil. The search query utilized in the "case law search" field was "dental professional liability."

The data collected by two researchers regarding the rulings assessed (appellate court panel decisions) included the following variables: state of the federation, date of publication, defendant (individual, clinic, private health insurer, educational institution, hospital, local government, or franchisor), dental specialty involved, trial court and appellate court decisions, expert opinion, and compensation amounts (if any) awarded for moral and/or aesthetic damages.

The exclusion criteria comprised cases involving refunds for treatments that were not administered, since the merit in these cases was not based on damage caused by the dental procedure itself. Additionally, cases returned to the first instance trial court and those redistributed to other courts were also excluded from the analysis.

Compensation amounts not explicitly stated in the ruling, as well as those based on the number of minimum wages or involving combined aesthetic and moral damages, were excluded from consideration.

The specialties involved were categorized by the researchers according to the information provided in the appellate court rulings, rather than relying on the classifications used within the decisions. This approach acknowledges the potential for inaccuracies in technical classifications employed by judicial bodies.

The specialties of orthodontics and functional jaw orthopedics were consolidated into a single category. Procedures for installing veneers and dental contact lenses were categorized under restorative dentistry. Bone grafting procedures conducted in preparation for implant installation

were attributed to implant dentistry, while tooth extractions were classified within oral & maxillofacial surgery and traumatology. The data were then tabulated and analyzed utilizing a Microsoft Excel spreadsheet.

## RESULTS

Information from 472 decisions in 2022 and 447 decisions in 2023 were assessed, resulting in a total of 919 rulings. The majority of these rulings originated from the state of São Paulo, followed by the state of Rio de Janeiro (Table 1).

As for individually involved defendants, a higher number of dentists (individuals) and clinics were observed (Table 2). When considering joint involvements, individuals were defendants in 275 cases in 2022 (58%) and 233 cases in 2023 (52%). Clinics were defendants in 265 cases in 2022 (56%) and 281 cases in 2023 (63%). However, when considering all companies involved, they were defendants in 313 cases in 2022 (66%) and 327 cases in 2023 (73%).

**Table 1.** Rulings of 2022 and 2023 according to Brazilian state

| State | Number of rulings 2022 | Number of rulings 2023 |
|---|---|---|
| São Paulo (SP) | 172 | 145 |
| Rio de Janeiro (RJ) | 71 | 84 |
| Rio Grande do SUL (RS) | 50 | 25 |
| Minas Gerais (MG) | 47 | 50 |
| Paraná | 40 | 28 |
| Federal District (DF) | 31 | 25 |
| Santa Catarina (SC) | 25 | 19 |
| Other | 36 | 71 |
| Total | 472 | 447 |

**Table 2.** Defendants involved in the rulings

| Defendant | 2022 | 2023 |
|---|---|---|
| Individual | 156 | 114 |
| Clinic | 153 | 173 |
| Clinic and dentist | 92 | 93 |
| Educational institution | 14 | 11 |
| Private health insurer and dentist | 10 | 11 |
| Clinic, dentist and private health insurer | 9 | 5 |
| City/State government | 8 | 6 |
| Private health insurer | 7 | 10 |
| Private health insurer and clinic | 7 | 2 |
| Franchisor and clinic | 4 | 5 |
| Other | 12 | 17 |
| Total | 472 | 447 |

Table 3 shows the number and percentage of rulings, whether a technical expert's report was commissioned, and the number and percentage of convictions for the two years included in the survey according to the seven specialties most frequently involved. Out of the 919 rulings scrutinized, convictions were recorded in 61% of cases in 2022 and in 68% of cases in 2023. Among the convictions in 2022, 250 (87%) involved compensation for moral damages, and 23 (8%), for aesthetic damages. In 2023, the corresponding figures were 282 (93%) and 28 (9%), respectively. Table 4 shows the average, minimum, and maximum amounts awarded for moral and aesthetic damages, categorized by specialty involved.

**Table 3.** Numbers of rulings, technical expert's report, and number of convictions according to specialty involved

| Specialties | 2022 | | | | | | | 2023 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rulings | | Expert's report | | | Convictions | | Rulings | | Expert's report | | | Convictions | |
| | N | % | Yes | No | Not reported | N | % | N | % | Yes | No | Not reported | N | % |
| Implant dentistry | 133 | 28 | 109 | 15 | 9 | 95 | 71 | 97 | 22 | 77 | 15 | 5 | 68 | 70 |
| Prosthodontics | 102 | 22 | 68 | 16 | 18 | 66 | 65 | 117 | 26 | 85 | 18 | 14 | 81 | 69 |
| Oral & maxillofacial surgery and traumatology | 64 | 14 | 49 | 8 | 7 | 41 | 64 | 75 | 17 | 58 | 9 | 8 | 44 | 59 |
| Orthodontics | 53 | 11 | 44 | 4 | 5 | 26 | 49 | 36 | 8 | 31 | 2 | 3 | 27 | 75 |
| Endodontics | 51 | 11 | 37 | 4 | 10 | 28 | 55 | 46 | 10 | 31 | 7 | 8 | 28 | 61 |
| Orofacial harmonization | 12 | 3 | 11 | | 1 | 3 | 25 | 5 | 1 | 3 | | 2 | 3 | 60 |
| Restorative dentistry | 11 | 2 | 6 | 3 | 2 | 6 | 55 | 15 | 3 | 11 | 1 | 3 | 12 | 80 |

**Table 4.** Amounts awarded (in US$) in convictions for moral and aesthetic damages, according to specialty involved

| Specialties | Number of cases | | Amounts awarded for moral damages | | | | | | Amounts awarded for aesthetic damages | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2022 | 2023 | 2022 | | | 2023 | | | 2022 | | | 2023 | | |
| | N | N | Min. | Max. | Mean | Min. | Max. | Mean | Min. | Max. | Mean | Min. | Max. | Mean |
| Implant dentistry | 133 | 97 | 573 | 9560 | 2284* | 399 | 15968 | 2435* | 382 | 4780 | 1584 | 399 | 9980 | 2107 |
| Prosthodontics | 102 | 117 | 382 | 8413 | 1600* | 299 | 15968 | 486* | 1147 | 1912 | 1656 | 399 | 1596 | 848 |
| Oral & maxillofacial surgery and traumatology | 64 | 75 | 764 | 9560 | 3096* | 798 | 19960 | 3165* | 956 | 956 | 956 | 998 | 5988 | 2661 |
| Orthodontics | 53 | 36 | 382 | 4780 | 2059* | 798 | 11976 | 1989* | 956 | 956 | 956 | 1197 | 9980 | 4391 |
| Endodontics | 51 | 46 | 382 | 5736 | 1867 | 399 | 5988 | 1988* | 1912 | 1912 | 1912 | 998 | 1996 | 1663 |
| Orofacial harmonization | 12 | 5 | 1147 | 4780 | 2613 | 2794 | 2994 | 2594 | 764 | 764 | 764 | | | |
| Restorative dentistry | 11 | 15 | 573 | 2294 | 1657* | 798 | 2395 | 1506 | 956 | 1912 | 956 | | | |

*Mode amounts of US$ 1,996 (2022) and US$ 1,912 (2023). Average commercial dollar exchange rate in 2022: R$ 5.23. Average commercial dollar exchange rate in 2023: R$ 5.01

## DISCUSSION

The rapid integration of new technologies and resources into the field of dentistry in recent years has brought about various impacts. These advancements present dentists with a significant challenge, as they necessitate ongoing investments of time and resources in continuing education to effectively incorporate them into daily practice. Furthermore, this challenge is compounded by the heightened risk of patients initiating lawsuits against dentists, prompting the adoption of precautionary measures such as acquiring civil liability insurance.[13]

These factors have been highlighted by the gradual increase in civil liability lawsuits involving dentists over the years.[4–7,9,10,14]This escalation may be attributed to several factors: (i) enactment of the Consumer Protection Code (Federal Law No. 8,078/1990), which, although not directly pertinent to healthcare, situates dentistry within the broader context of consumer relations;[15] (ii) the massification of dentistry;[16] (iii) the increased accessibility to information pertaining to potential harm experienced by patients, facilitated by greater internet accessibility;[14] and (iv) the inherent challenges in the patient-professional interpersonal relationship.[17] A survey conducted within the orthodontics specialty revealed that the primary reason underlying the grievances[18] was dissatisfaction directly linked to the failure to meet patient expectations.[19]

Another notable trend is the increase in the provision of free legal counsel, which peaked in 2022, marking the year with the highest number of plaintiffs benefiting from this provision since 2017.[20] Through this provision, the payment of court costs and expenses, across all instances, as well as attorney fees for the prevailing party (to be borne by the losing party), are suspended, thus encouraging the filing of lawsuits and appeals to higher courts.[20] The processing fee for appeal preparation in the state of São Paulo in 2023 amounted to 4% of the case value, with limits set at a minimum of US$ 34.19 and a maximum of US$ 20,515.00.[21] In other words, in a lawsuit valued at US$ 10,000.00, the attorney would be required to pay US$ 400.00 to file an appeal in an appellate court, unless free legal counsel had been granted.

The present study did not identify an increase in the number of civil liability cases in Brazil between the years surveyed, despite such an upward trend being noted in other, predominantly regional studies.[4–7,9,11] Nationwide studies, which examined cases up to 2012 by accessing the websites of State Courts of Justice [10,11] may suffer from incompleteness, given that the digitization of legal cases was only implemented in September of 2009. Although no significant disparity between the evaluated years was found, the number of cases was quite significant. To provide context within the international landscape, it is noteworthy that the city of Rome (Italy) experienced a decline in the number of lawsuits filed against dental service providers. [22]

This phenomenon could potentially be attributed to heightened caution among professionals regarding their patients, and to an increase in extrajudicial settlements.[22]

Lyra et al. conducted a nationwide study focusing on rulings from 2017[12] by utilizing the Jusbrasil website and employing the search query “civil liability and dentists.” We adopted the same platform in the present study due to the absence of standardized search systems across the websites of State Courts of Justice, which would otherwise impede efforts to establish methodological consistency and reproducibility.

Apart from the investigation carried out by Paula (2007),[10] which noted a higher number of cases in the state of Rio de Janeiro, the remaining studies, including the present one, indicated a higher prevalence of cases in the state of São Paulo. São Paulo is the most populous state in Brazil, home to over 44 million inhabitants (22% of the national population), followed by Minas Gerais (10%) and Rio de Janeiro (8%). Therefore, the high incidence of legal cases in this state could be explained by its higher number of inhabitants, along with its higher number of active registered dentists, totaling 114,142 (27% of active professionals), followed by Minas Gerais, with 51,227 (12%), and Rio de Janeiro, with 37,411 (9%).

An inversion is observed when analyzing the defendants involved in the lawsuits, i.e. a reduction in the number of rulings involving individual dentists and an increase in the number of rulings involving dental clinics. This change may be linked to an increase in dental clinic registrations in the country, which quadrupled between 2015 and 2023.[23] In contrast, DiLorenzo et al. found that individual dentists were involved in most cases in the Campania region (Italy).[24]

In the 2022 rulings analyzed, the specialty most commonly implicated was implant dentistry

(28%), followed by prosthodontics (21%), oral & maxillofacial surgery and traumatology (14%), orthodontics (11%), and endodontics (also 11%). In contrast, in 2023, the most frequently involved specialty was prosthodontics (26%), followed by implant dentistry (22%), oral & maxillofacial surgery and traumatology (17%), orthodontics (8%), and endodontics (10%).

Similar results were found in countries that, like Brazil, adhere to the Roman Germanic legal system (civil law), wherein written statutes serve as the primary source of law. Studies conducted in Italy[22] and Peru indicated that prosthodontics was the most frequently involved specialty,[25] whereas other studies have found that prosthodontics and implant dentistry were the specialties most commonly involved in the lawsuits.[24] A study conducted in Iran evaluated 64 rulings related to dental malpractice and observed that fixed prosthodontics was the specialty most frequently involved, followed by oral surgery. Another study conducted in the city of Tehran with 412 rulings arrived at the same conclusion.

In Brazil, implant dentistry was incorporated into the list of dental specialties in 1990. Possibly for this reason, it ranked fourth among the specialties most frequently involved in legal disputes by 2007.[10] By 2012, it had moved up to the top position,[11] and, thereafter, has consistently featured among the top three specialties most frequently involved in lawsuits.[4–9,11,12,26] Moreover, a significant number of cases examined in the present study involving the specialty of prosthodontics were found to be associated with harm stemming from treatment procedures involving implant-supported prostheses.

Another aspect evaluated in the study was the appointment of a judicial expert during trial court proceedings to aid the judge in rendering a decision. The analysis revealed that a technical expert's report was included in 75% of the lawsuits filed in 2022 and 2023. In 2022, 55 cases (11.6%) lacked an expert's report, with the dentist being convicted in 37 of them (67%). Similarly, in 2023, 59 cases (13.2%) had no expert's report, with the dentist being convicted in 37 of these cases (62%). In the remaining instances, this information was either ambiguous or not reported in the ruling. These figures stand in contrast to those documented in a previous study, which indicated the complete absence of an expert's report in 34% of the cases.[9] Consequently, it is plausible to assert that the absence of an expert's report does not inherently correlate with the conviction of the dentist. Thus, it becomes imperative to evaluate other evidence presented in the case, such as the existence of clinical records.

With regards to the conviction of dentists, Table 5 presents the findings of the present study juxtaposed with those of the research conducted by Loreto et al. (2023).

**Table 5.** Comparison of convictions: present study vs. Loreto et al. (2023)

| | **Loreto et al. [28]** | **Present study** | |
|---|---|---|---|
| Search source | State Court of justice | Jusbrasil | |
| Scope | Regional | National | |
| Period surveyed | 2003 to 2019 | 2022 | 2023 |
| Total rulings | 171 | 472 | 447 |
| Lawsuits in which the dentist was convicted | 68 (40%) | 288 (61%) | 302 (68%) |
| Dentist convictions for moral damages | 63 (93%) | 250 (87%) | 282 (93%) |
| Dentist convictions for aesthetic damages | 4 (6%) | 23 (8%) | 28 (9%) |

A survey in Peru found that the most frequently involved specialties were prothodontics, orthodontics, oral surgery, and implant dentistry, at equal rates. However, the conviction rate it found neared 85%, which was higher than the rates found in the present study (61% and 68%). This fact may be explained by the period covered in the Peruvian survey (2011-2016), as well as by an increased demand for implant treatments and broader access to knowledge about implants in Peru. A study carried out in Italy observed a conviction rate of 74%.[13], closer to but still higher than that found in the present study.

The assessment of compensation amounts is predicated on the distinction between material damage, which affects an asset with ascertainable economic value, and moral damage, which defies immediate quantification. The present study included figures for both moral and aesthetic damages.

Zanin et al. (2016) observed that compensation amounts for moral damages ranged approximately from US$ 1,000.00 to US$ 30,000.00.[17] The minimum amount found by these authors was higher than that found in the present study but lower than that reported by Loreto et al.[26] In contrast, the maximum amount recorded in 2016 was the lowest among the three studies. Notably, the present study revealed that the highest average compensation amount was associated with the specialty of oral & maxillofacial surgery and traumatology in 2022 (US$ 3,096.00), whereas the lowest average amount pertained to the specialty of restorative dentistry in 2023 (US$ 998.00). Additionally, it was found that US$ 1,912.00 (2022) and US$ 1,996.00 (2023) emerged as the most frequently awarded amount for moral damages over the two years covered by the survey.

Both aesthetic damages and moral damages entail non-pecuniary compensation and are predicated on the presence of an external injury causing subjective distress and/or social rejection. One plausible definition of aesthetic damage could be understood as “any enduring or permanent alteration in an individual's external appearance;” a change, whether discernible or not, that is irreversible and detrimental.[3] In cases of professional liability, the plaintiff may seek compensation for both material damages and moral and aesthetic damages within the same lawsuit, as evidenced in Digest #37 of the Superior Court of Justice (STJ): “Compensation for material damage and moral damage resulting from the same incident may be aggregated.” Additionally, STJ Digest #387 of January 9, 2009 confirms the admissibility of combining compensation for moral and aesthetic damages.

Table 5 shows a rise in convictions for aesthetic damages, which increased from 4 (6%)[26] to 28 (9%), indicating a lesser frequency of such claims up to 2019. This trend could be attributed to the 2002 Civil Code, which strengthened the possibility of cumulative aesthetic and moral damages.[3] In 2022, the highest amount awarded for aesthetic damages, which occurred more than once, was US$ 1,912.00. Each of the remaining amounts (US$ 2,294.00, US$ 3,824.00, US$ 4,780.00 and US$ 19,120.00) was awarded in only one ruling. In 2023, the sum of US$ 9,980.00 was observed in more than one case.

## CONCLUSION

Based on the findings of the present study, it was concluded that the amounts awarded by courts for moral and aesthetic damages in civil liability cases were substantial during both 2022 and 2023. However, there was no significant difference between these years in terms of the number of cases recorded. Continuing technical updating of dentists, humanized care, and adjusting the patient's expectations to treatment limitations can contribute to a reduction in the number of new lawsuits. Furthermore, Brazilian dentists ought to systematically document both the procedures they perform and their patients' history to ensure they have the necessary documentation to substantiate the appropriateness of their clinical management decisions. Finally, taking out civil liability insurance can mitigate the risk of sustaining substantial financial losses resulting from adverse judgments in civil liability litigation.

## REFERENCES


1. Brasil. Lei nº 10.406 de 10 de janeiro de 2002. Código Civil. 2002. Available from: http://www.planalto.gov.br/ccivil_03/leis/2002/l10406compilada.htm
2. Diniz MH. *Curso de direito civil brasileiro: responsabilidade civil.* 37th ed. Vol. 7. Saraiva; 2018.
3. Lopez TA. *O dano estético: responsabilidade civil.* 4ª. São Paulo: Editora Almedina Brasil; 2021.
4. Lino Junior HL, Terada ASSD, Silva RHA da, Soltoski MPC. Levantamento de processos de responsabilidade civil envolvendo a odontologia na comarca de Londrina, Paraná, Brasil. *Rev Juridica*. 2017 [cited 2023 Jan 10];1(46):515–31. Available from: http://revista.unicuritiba.edu.br/index.php/RevJur/article/view/2261
5. Mendes DAG, Faria PHP de, Reis JA de S, Galo R. Levantamento das Jurisprudências de Processos de Responsabilidade Civil contra Cirurgiões-Dentistas no Tribunal de Justiça do Estado de Minas Gerais, Brasil, 2014-2018. *Braz J Health Rev.* 2021 [cited 2023 Apr 17];4(1):2600–9. Available from: https://www.brazilianjournals.com/index.php/BJHR/article/view/24459/19532
6. Matteussi GT, Gorgatti IS, Vieira MA, Coltri MV, Silva RHA da. Análise de processos de responsabilidade civil envolvendo cirurgiões-dentistas de três munícipios do estado de São Paulo em período de cinco anos. *Rev Bras Odontol Leg.* 2020 Sep 1 [cited 2023 Apr 17];7(2). Available from: https://portalabol.com.br/rbol/index.php/RBOL/article/view/296
7. Silva RAT, Borges B, Silva RHA. Levantamento das ações de responsabilidade civil envolvendo a odontologia, Estado do Mato Grosso do Sul, Brasil, 2013-2017. *Rev Juríd.* 2017;1(46):515–31.
8. Canettieri ACV, Neves H de M. Estudo das decisões de processos de responsabilidade civil contra cirurgiões dentistas do Estado de São Paulo. *Rev Univap.* 2021;27(56). Available from: https://doi.org/10.18066/revistaunivap.v27i56.2568
9. Silva RHA da, Santos JBS dos, Borges BS. Levantamento e análise de processos de responsabilidade civil do cirurgião-dentista no município do Rio de Janeiro, RJ, Brasil, 2010-2017. *Braz J Health Rev.* 2020 [cited 2023 Apr 19];3(5):11645–58. Available from: https://www.brazilianjournals.com/index.php/BJHR/article/view/16078/13158
10. de Paula FJ. Levantamento das jurisprudências de processos de responsabilidade civil contra cirurgiões dentistas nos Tribunais do Brasil por meio da internet [Tese]. Faculdade de odontologia da Universidade de São Paulo; 2007 [cited 2023 Apr 17]. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.teses.usp.br/teses/disponiveis/23/23148/tde-10042008-183335/publico/TESEFJP2007bibliotecaFERNANDOJORGEDEPAULA.pdf
11. Lima RBW e, Moreira VG, Cardoso AMR, Nunes FMR, Rabello PM, Santiago BM. Levantamento das Jurisprudências de Processos de Responsabilidade Civil Contra Cirurgiões Dentistas nos Tribunais de Justiça Brasileiro. *Rev Bras Ciênc Saúde.* 2012 [cited 2023 Sep 25];16(1):49–58. Available from: https://periodicos.ufpb.br/ojs2/index.php/rbcs/article/view/12262
12. Lyra M da CA da R, Pereira MM de AF, Musse J de O. A obrigação de resultado nas ações de responsabilidade civil do cirurgião-dentista no Brasil, em 2017. *Rev Bras Odontol Leg.* 2019 [cited 2023 Apr 17];47–58. Available from: http://portalabol.com.br/rbol/index.php/RBOL/article/view/259/223
13. Terada ASSD, Galo R, Silva RHA da. Responsabilidade civil do cirurgião-dentista: conhecimento dos profissionais. *Arq. Odontol.* 2014 Jun;50(2):92–7. Available from: http://revodonto.bvsalud.org/scielo.php?script=sci_abstract&pid=S1516-09392014000200006&lng=pt&nrm=iso&tlng=pt
14. Garbin CAS, Garbin AJI, Rovida TAS, Saliba MTA, Dossi AP. A responsabilidade profissional do cirurgião-dentista segundo a opinião de advogados. *Rev Odontol UNESP.* 2009;38(2):129–34. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.revodontolunesp.com.br/article/5880188a7f8c9d0a098b4cc4/pdf/rou-38-2-129.pdf
15. Brasil. Lei nº 8078 de 11 de setembro de 1990. Código de Defesa do Consumidor. 2022. Available from: http://www.planalto.gov.br/ccivil_03/leis/l8078compilado.htm#:~:text=8%C2%B0%20Os%20produtos%20e,e%20adequadas%20a%20seu%20respeito.
16. Soriano EP, Batista MIH de M, Torres B de O, Carvalho MVD, Campello RIC, Almeida AC, et al. Processos de âmbito odontológico instaurados em órgão de defesa do consumidor na cidade de João Pessoa. *Derecho Cambio Soc.* 2012;
17. Garbin CAS, Garbin AJI, Lelis RT. Estudo da percepção de cirurgiões-dentistas quanto à natureza da obrigação assumida na prática odontológica. *Rev Odontol UNESP.* 2006 [cited 2024 Jan 11];35(2):211–5. Available from: http://www.revodontolunesp.com.br/article/588017da7f8c9d0a098b4940
18. Franco A, Lima AAS, Tanaka OM, França BHS. 2012. The orthodontist's responsibility and the bioethical aspects in the current jurisprudence. *Eur J Gen Dent.* 1(1):20–23.
19. Jackson JL, Chamberlin J, Kroenke K. Predictors of patient satisfaction. *Soc Sci Med.* 2001 Feb 1 [cited 2024 Jan 15];52(4):609–20. Available from: https://www.sciencedirect.com/science/article/pii/S0277953600001647
20. CNJ. 2023. Justiça em números 2023. Brasilia; chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.cnj.jus.br/wp-content/uploads/2023/08/justica-em-numeros-2023.pd.
21. TJSP. Taxa judiciária. https://www.tjsp.jus.br/IndicesTaxasJudiciarias/DespesasProcessuais/TaxaJudiciaria.
22. Manca R, Bruti V, Napoletano S, Marinelli E. A 15 years survey for dental malpractice claims in Rome, Italy. *J Forensic Leg Med.* 2018 Aug 1 [cited 2024 Jan 16]; 58:74–7. Available from: https://www.sciencedirect.com/science/article/pii/S1752928X18302749

23. Conselho Federal de Odontologia (CFO). Dados Estatísticos de Profissionais e Entidades Ativas Por Ano. [cited 2025 Mar 9]. Available from: https://website.cfo.org.br/dados-estatisticos-de-profissionais-e-entidades-ativas-por-ano/
24. Di Lorenzo P, Di Donna G, Casella C, Cortese R, Bianchi I, Policino F, et al. Professional liability in dentistry: structure and causes of judicial litigation. *J Forensic Odontostomatol*. 2024 Dec 30 [cited 2025 Mar 5]; Available from: https://zenodo.org/doi/10.5281/zenodo.14508746
25. Calla SR, Muñoz EA. Professional liability: assessment of court sentences for lawsuits against dentists in Peru. *J Forensic Odontostomatol*. 2021 Aug 1 [cited 2024 Jan 16];39(2):15–20. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8630455/
26. Loreto DBL, Barros BÁCD. Study of court decisions on dental errors in the state of Rio Grande do Sul, Brazil. *J Forensic Leg Med*. 2023 Jul [cited 2023 Jul 1];97:102555. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1752928X23000732

# Morphometric and volumetric analysis of the frontal sinus in a Brazilian population using Cone beam Computed Tomography: a forensic approach for sex, age and facial morphology estimation



Letícia Bego de Miranda[1], Beatriz Caio Felipe[2], Matheus Kawana Couto[1], Wilton Mitsunari Takeshita[3], Lilian Cristina Vessoni Iwaki[1], Mariliani Chicarelli da Silva[1]

*[1]Department of Dentistry, State University of Maringá - Maringá, Parana, Brazil, [2]Department of Oral Diagnosis, Piracicaba Dental School, State University of Campinas - Piracicaba, Sao Paulo, Brazil, [3]Departament of Surgery and Diagnosis, Araçatuba Dental School, Sao Paulo State University, Araçatuba, Sao Paulo, Brazil.*

**Corresponding author:**
**leticiabegomiranda2@gmail.com**

The authors declare that they have no conflict of interest.

KEYWORDS

Computed tomography, Frontal sinus, Forensic identification, Forensic dentistry.

J Forensic Odontostomatol 2025. Aug;(43): 2 -21:31
ISSN :2219-6749
DOI: doi.org/10.5281/zenodo.15564344

## ABSTRACT

The aim of this study was to evaluate the linear and volumetric measurements of the frontal sinus (FS), using cone beam computed tomography (CBCT) scans, for a discriminatory analysis of gender, age and facial skeletal pattern in a Brazilian population. A total of 300 CBCT scans were analyzed, measuring the height, width, length and volume of the FS. The measurements were divided into groups: sex, age (20-24.9, 25-29.9, 30-34.9, 35-39.9, 40-45.9, 46-49.9, 50-54.9, 55-59.9, and 60-64.9 years) and facial skeletal pattern classes I, II and III. The function values in the centroid group were 0.675 for male and -0.292 for female. A rule was established indicating that if the value of D is greater than 0.19, the sample will be classified as male. The results showed a significant difference in women, who had significantly lower volume, width and depth than men ( $p<0.001$, $p=0.003$, and $p<0.001$, respectively). No significant differences could be observed between the age and facial skeletal pattern groups. The results suggest that the FS measures of volume, height, width and depth have moderate discriminatory power for predicting gender in a Brazilian population. In conclusion, the results show that the FS has potential for assessing gender, but the accuracy of the method and its applicability for analyzing age and facial skeletal pattern were limited in our population.

## INTRODUCTION

Human identification plays a fundamental role humanitarianly and in procedural law, especially in civil and criminal cases. In the case of criminal investigations, natural disasters, plane crashes, cases of disappearances,[2,3] where it is not possible to apply conventional identification methods, the analysis of images of the anatomical structures of the skull becomes extremely important.[4] Because the skull, in addition to being considered the second best bone structure for age estimation, has the advantage of being highly resistant to damage.[4]

A particularly relevant anatomical structure in the cranial region is the frontal sinus (FS). It is characterized by a great variety and asymmetry and is unique to each individual.[4] Because it is protected by skull bones, it is resistant to trauma, presenting a high probability of remaining intact during catastrophes and mass accidents, thus allowing the identification of individuals and sex estimation. [5] In addition to sex estimation, assessing age and skeletal class are relevant aspects.

Globally, the literature is scarce in studies that explore the FS using cone beam computed tomography (CBCT) to estimate age,[6] sex or facial skeletal pattern. Although this topic has been little studied in the literature so far, only a limited number of studies addressing sex were found[7-9] and none of them investigated its relationship with forensic identification. Even though there are investigations in the area, to our knowledge, only two studies have evaluated the FS as an anatomical repair that can be used in human identification in a Brazilian population.[10,11]

The current literature regarding CBCT has reinforced the significant distinction in the morphological characteristics of FS in relation to sex.[1,4,12,13] However, there are studies that question this reliability of the FS with identification methods,[14-17] many of which employ bidimensional (2D) scans and in some cases, resort to the use of dry skulls.

According to what has been studied in the literature up to date, there have been few volumetric analyses of the FS in relation to the age of adult individuals, which showed an expansion up to 40 years of age and a tendency to decrease with aging.[18,19] Regarding the relationship between the FS and facial skeletal pattern, there are divergences in the literature. While Sawada et al. (2022) found no significant association, these results contrast with previous studies.[7-9]

Therefore, the objective of this work was to evaluate the linear and volumetric measurements of the FS using CBCT, in order to establish a discriminative functional analysis for estimating sex, age and facial skeletal pattern in a Brazilian population. This study aims to fill a significant gap in the literature by providing valuable stimuli for the practical application of FS in forensic science by contributing to forensic databases.

## MATERIALS AND METHODS

This work was sent and approved by the Permanent Ethics Committee for Research Involving Human Beings at the State University of Maringá (UEM) under number CAAE: 68966523.2.0000.0104. Due to the retrospective nature of this study, signed informed consent was not required by the Committee.

*Sample selection*

A total of 300 CBCT scans from anonymous Brazilian individuals were included in the research, divided into the following groups: sex, age (20-24.9, 25-29.9, 30-34.9, 35-39.9, 40-45.9, 46-49.9, 50-54.9, 55-59.9, and 60-64.9) and facial skeletal pattern (Class I (0 ° < ANB < 4°), Class II (ANB ≥ 4°) and Class III (ANB ≤ 0°) using Steiner classification.[19,20] The used scans belong to the archive of the Clinical Imaging Research Laboratory of the State University of Maringá (UEM) and were carried out as an indication for the most varied dental treatments.

The exclusion criteria were malformations, obliterations, pathologies and diseases, trauma, absence of the frontal sinus on one side and patients under 20 years of age.[21] As a result, 64 scans were excluded from the sample, therefore resulting in 235 scans to be analyzed. The final sample distribution is represented by tables 1 and 2.

**Table 1.** Sample division according to sex and age

| Group | Male | Female | Total |
|---|---|---|---|
| 20-24.9 | 23 | 37 | 60 |
| 25-29.9 | 11 | 39 | 50 |
| 30-34.9 | 7 | 13 | 20 |
| 35-39.9 | 7 | 19 | 26 |
| 40-45.9 | 6 | 13 | 19 |
| 46-49.9 | 6 | 19 | 25 |
| 50-54.9 | 5 | 11 | 16 |
| 55-59.9 | 4 | 6 | 10 |
| 60-64.9 | 3 | 6 | 9 |

**Table 2.** Sample division according to sex and facial skeletal pattern

| Sex | Facial Skeletal Pattern | | |
|---|---|---|---|
| | Class I | Class II | Class III |
| Male | n=35 | n=17 | n=20 |
| Female | n=54 | n=68 | n=43 |
| Total | n=89 | n=83 | n=63 |

*Image acquisition*

The scans were performed at the Clinical Imaging Research Laboratory (LIPC) of the Health Technology Center (CTS), of the Research Support Center Complex (COMCAP), located in the Department of Dentistry of the State University of Maringá (DOD/UEM) by the same oral and maxillofacial radiology team and are archived. They were obtained using the i-CAT Next Generation® equipment (Imaging Sciences International, Hatfield, PA, USA), with a volume of 300µ isometric voxel, FOV (Field of View) of 17 × 23 cm, tube voltage of 120 kVp and tube current of 3-8 mA. For the analysis, the Dolphin 3D Imaging software (Dolphin Imaging & Management Solutions®, Chatsworth, CA, USA) version 11.9 was used.

*Image analysis*

For FS analyses, CBCT scans were exported using the Digital Imaging extension in Communications in Medicine (DICOM) and were imported into the Dolphin 3D Imaging software (Dolphin Imaging & Management Solutions®, Chatsworth, CA, USA), version 11.9. For each scan, the reconstructions were oriented, positioning the Frankfurt plane (line that passes horizontally from the upper edge of the external auditory meatus to the lower orbital edge) parallel to the horizontal plane in the sagittal reconstruction before measurements.

The evaluators underwent calibration through 10 CBCT scans. These assessments took place individually, randomly and in a dark and silent environment. Calibration lasted two weeks to ensure its reliability. The results were compared and discussed among the evaluators before the official measurements began. Linear and volumetric measurements were performed on 236 CBCT scans by two independent oral and maxillofacial radiologists (with more than 5 years of experience), blind to details of age, sex and facial skeletal class. To avoid eye fatigue, the two examiners evaluated only 10 scans per day.In order to assess sex, age and facial skeletal class, the following measurements were defined: height, width and length. These linear measurements (height, width and length) were taken in the coronal and axial reconstructions in the widest area of the FS13, and the volume of the FS was acquired by delimiting its anatomy in the three reconstructions (axial, coronal, and sagittal), both using the Dolphin® software.[22,23] In the coronal reconstruction, the width was measured as the greatest distance between the medial and lateral walls of the FS, and the height as the greatest distance between the FS floor and ceiling (Figure 1). The depth was measured in the axial reconstruction as the distance from the anterior wall of the sinus to the posterior wall (Figure 2).[13]

To analyze the FS volume, the sinus/airway tool of the Dolphin® software was used as it allows reliable measurements, which produces a complete filling of the delimited region, preventing differences in area from interfering with the reliability of the data.[23] In order to correctly segment the entire FS, regardless of its anatomical variability, the first step was to delimit the region of interest with points (green dots) that consequently formed a line, on its anatomical border in the coronal reconstruction (Figure 3). Afterwards, the exact delimitations in the other planes were checked (Figures 4 and 5), if any point was outside the delimitation, it could be changed.[23] After this, "seed points" (yellow dots) were inserted in the frontal sinus, whose function is to expand within the airway, up to the selected limit, and when necessary, more "seed points" can be added.

**Figure 1.** Linear dimensions for supero-inferior (vertical line) and medio-lateral (horizontal line) length of the FS

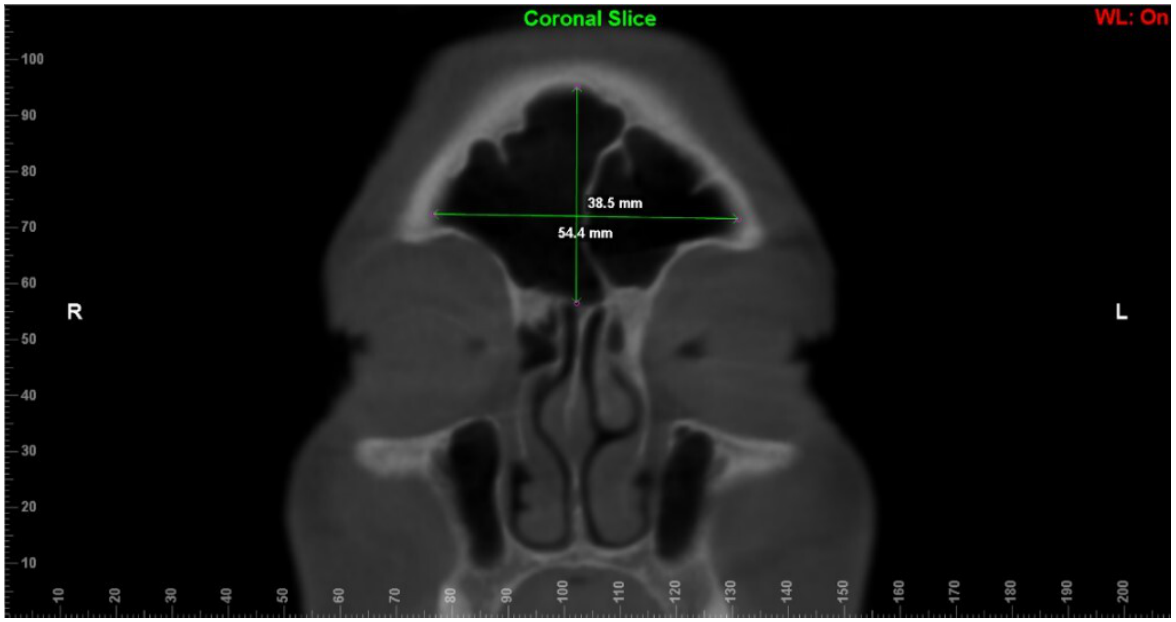
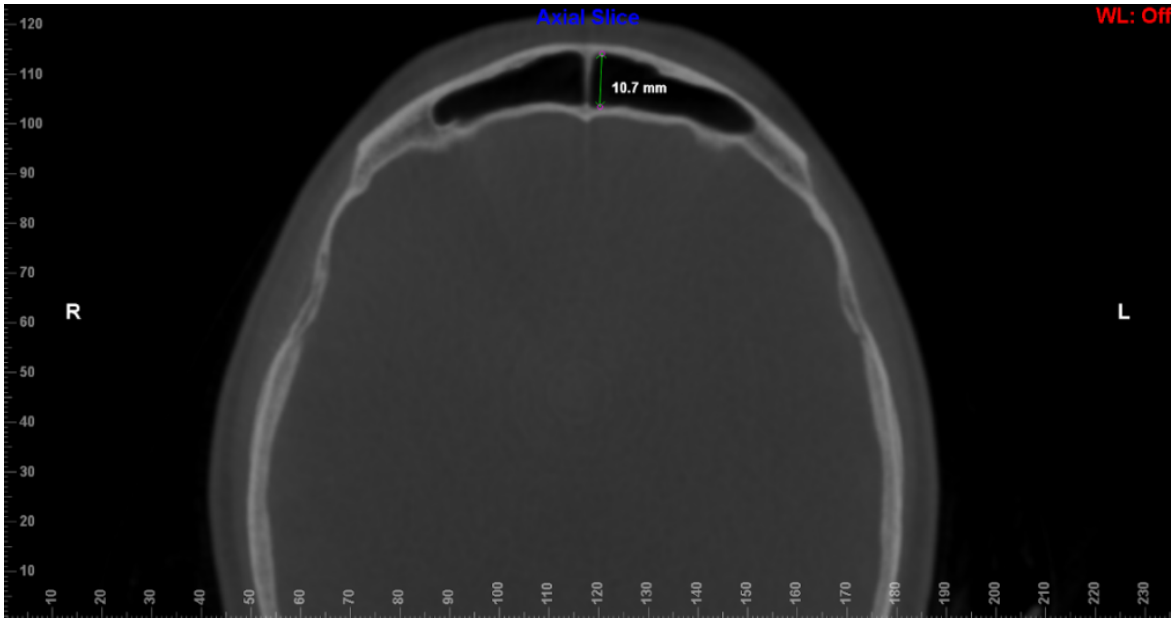



**Figure 2.** Linear dimension of the antero-posterior length of the FS




Before the final volumetric calculation, the sensitivity threshold was also adjusted in all image acquisitions, being a tool that controls the filling of the volume of the region of interest.[24] Although the sensitivity threshold is automatically determined by the Dolphin® software,[25] for the present study the average value was ±50, adapted for the FS.

After complete segmentation of the region of interest, the Dolphin® software automatically displayed the volume in cubic millimeters ($mm^3$) of the selected area and a three-dimensional (3D) model of the FS (Figure 6). All viewing plans were checked to ensure that the enclosed area had been completely filled.[27] All images were analyzed following the established sequence protocol: linear measurements, volumetric analysis and sex, age and facial skeletal class comparison with the patient's known data.

**Figure 3.** Delimitation of the anatomical borders of the FS in coronal reconstruction

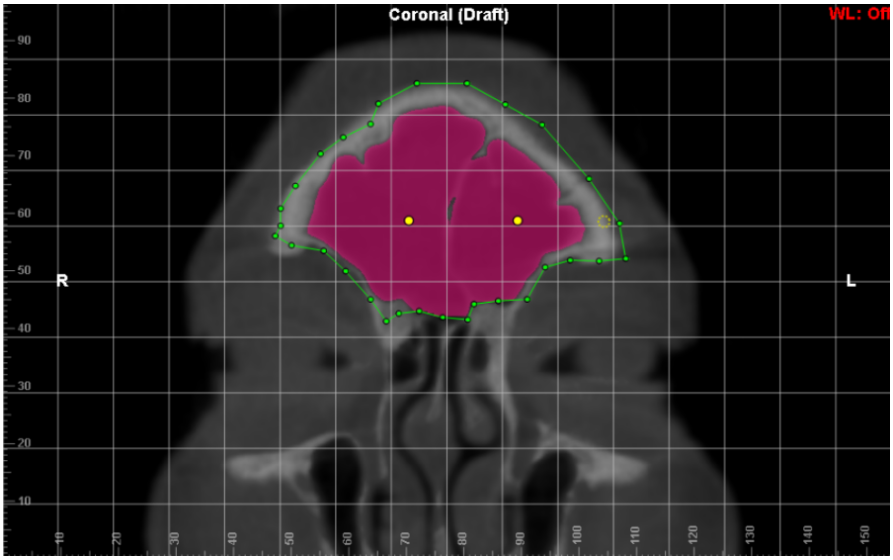



**Figure 4.** Delimitation of the anatomical borders of the FS in sagittal reconstruction

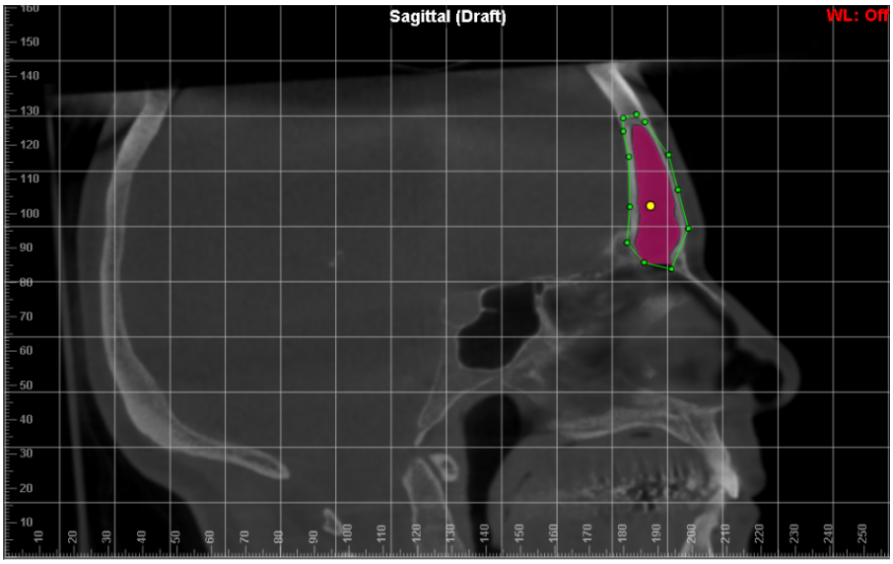



**Figure 5.** Delimitation of the anatomical borders of the frontal sinus in axial reconstruction

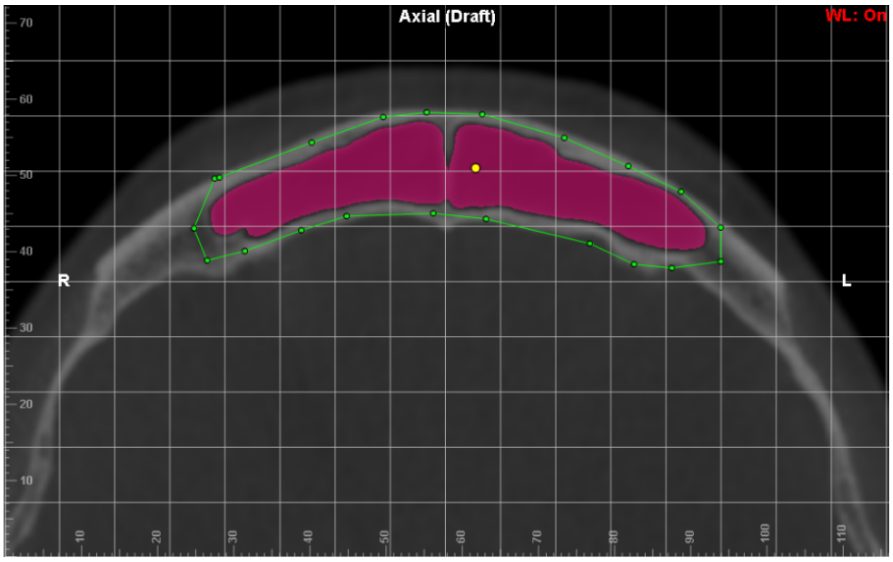
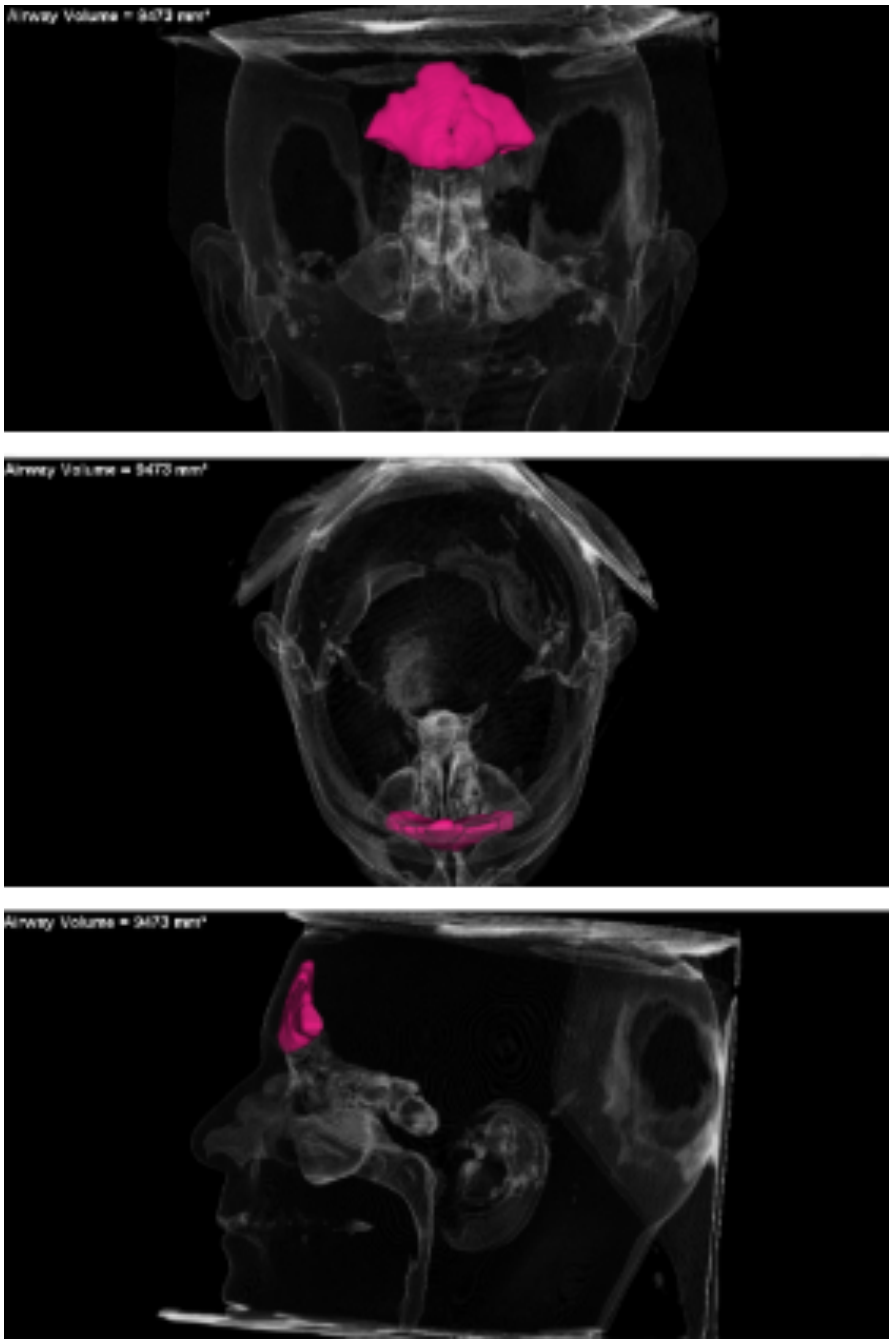


**Figure 6.** 3D model generated by the Dolphin 3D Imaging software



*Statistical analysis*

A database for qualitative and quantitative variables was organized to allow tabulation and statistical analysis. All statistical procedures were calculated using the statistical programs SPSS 25.0 (SPSS Inc., Chicago, IL, USA) and Bioestat 5.3 (Instituto Mamirauá, Pará, Brazil). Initially, a descriptive statistical analysis was carried out to obtain absolute and relative numbers.

The Intraclass Correlation Coefficient (ICC) was used to evaluate intra- and inter-observer agreement. To evaluate the Gaussian distribution of the data, the Shapiro-Wilk test was performed and the Mann-Whitney test was applied for independent variables, between sexes, for measurements of the FS region. Regarding the facial skeletal pattern, the analysis of variance (ANOVA) was applied to compare the different FS analyses. For the age, Kruskal-Wallis was applied to compare the different FS analyses. To develop a formula capable of estimating sex through FS measurements, a multivariate discriminant analysis was carried out using the direct method, and for this purpose, the Wilks' lambda and Box's M tests were applied.

## RESULTS

In table 3, it is possible to observe that the volume, width and depth of the FS showed significant differences between female and male. Female individuals exhibited significantly smaller volume, width and depth than men (p-value<0.001, 0.003 and <0.001, respectively).
In tables 4 and 5, no statistically significant differences were found between the groups separated by age and facial skeletal pattern.

**Table 3.** FS parameters according to sex

| | Sex | N | Mean | Median | SD | p-value |
|---|---|---|---|---|---|---|
| Volume ($mm^3$) | F | 164 | 4579.76 | 3966.00 | 2739.13 | <0.001* |
| | M | 71 | 7288.35 | 6344.00 | 4366.16 | |
| Height (mm) | F | 164 | 24.03 | 25.05 | 8.49 | 0.958 |
| | M | 71 | 24.26 | 25.50 | 7.74 | |
| Width (mm) | F | 164 | 38.04 | 40.55 | 11.55 | 0.003* |
| | M | 71 | 42.87 | 45.70 | 13.39 | |
| Depth (mm) | F | 164 | 7.34 | 7.30 | 2.19 | <0.001* |
| | M | 71 | 9.37 | 9.10 | 2.49 | |

Mann-Whitney test; SD (standard deviation); *p<0.05

**Table 4.** FS parameters according to sex

| | Group | N | Mean | Median | SD | p-value |
|---|---|---|---|---|---|---|
| Volume | 20-24.9 | 60 | 5662.03 | 5335 | 475.684 | 0.240 |
| | 25-29.9 | 50 | 5419.88 | 4262 | 503.215 | |
| | 30-34.9 | 20 | 6459.90 | 5509 | 939.075 | |
| | 35-39.9 | 26 | 6058.31 | 4302 | 842.146 | |
| | 40-45.9 | 19 | 5405.37 | 6070 | 690.354 | |
| | 46-49.9 | 25 | 4165.20 | 3769 | 543.905 | |
| | 50-54.9 | 16 | 3715.06 | 2823 | 783.026 | |
| | 55-59.9 | 10 | 5064.11 | 5056 | 785.282 | |
| | 60-64.9 | 9 | 5601.33 | 5433 | 712.646 | |
| Height | 20-24.9 | 60 | 24.53 | 26.8 | 1.043 | 0.127 |
| | 25-29.9 | 50 | 23.20 | 24.5 | 1.159 | |
| | 30-34.9 | 20 | 25.93 | 25.9 | 1.843 | |
| | 35-39.9 | 26 | 25.97 | 26.2 | 1.502 | |
| | 40-45.9 | 19 | 25.95 | 26.4 | 2.157 | |
| | 46-49.9 | 25 | 21.83 | 23.7 | 1.796 | |
| | 50-54.9 | 16 | 19.49 | 19.0 | 2.334 | |
| | 55-59.9 | 10 | 23.52 | 23.8 | 1.718 | |
| | 60-64.9 | 9 | 27.04 | 26.3 | 1.288 | |
| Width | 20-24.9 | 60 | 39.62 | 40.5 | 1.600 | 0.119 |
| | 25-29.9 | 50 | 39.61 | 41.1 | 1.581 | |
| | 30-34.9 | 20 | 43.79 | 42.5 | 2.516 | |
| | 35-39.9 | 26 | 40.57 | 41.3 | 2.365 | |
| | 40-45.9 | 19 | 40.18 | 43.3 | 3.288 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 46-49.9 | 25 | 35.61 | 40.9 | 2.668 | |
| | 50-54.9 | 16 | 32.61 | 34.0 | 3.536 | |
| | 55-59.9 | 10 | 40.48 | 43.3 | 3.711 | |
| | 60-64.9 | 9 | 44.20 | 43.4 | 1.843 | |
| Depth | 20-24.9 | 60 | 8.15 | 8.40 | 0.333 | 0.983 |
| | 25-29.9 | 50 | 8.00 | 8.15 | 0.386 | |
| | 30-34.9 | 20 | 7.99 | 8.40 | 0.482 | |
| | 35-39.9 | 26 | 8.07 | 7.45 | 0.491 | |
| | 40-45.9 | 19 | 7.51 | 8.30 | 0.547 | |
| | 46-49.9 | 25 | 7.80 | 7.80 | 0.498 | |
| | 50-54.9 | 16 | 7.53 | 8.25 | 0.632 | |
| | 55-59.9 | 10 | 8.12 | 8.80 | 0.695 | |
| | 60-64.9 | 9 | 7.67 | 7.20 | 0.480 | |

Kruskal-Wallis test; SD (standard deviation); *p<0.05

**Table 5.** FS parameters according to facial skeletal pattern

| | Class | N | Mean | SD | p-value |
|---|---|---|---|---|---|
| Volume ($mm^3$) | I | 89 | 5289.67 | 3176.82 | 0.932 |
| | II | 83 | 5443.00 | 3567.69 | |
| | III | 63 | 5492.13 | 3990.49 | |
| Height (mm) | I | 89 | 23.94 | 7.56 | 0.073 |
| | II | 83 | 25.54 | 8.70 | |
| | III | 63 | 22.40 | 8.38 | |
| Width (mm) | I | 89 | 39.70 | 12.06 | 0.980 |
| | II | 83 | 39.35 | 12.13 | |
| | III | 63 | 39.40 | 13.06 | |
| Depth (mm) | I | 89 | 7.91 | 2.50 | 0.084 |
| | II | 83 | 8.38 | 2.38 | |
| | III | 63 | 7.47 | 2.46 | |

ANOVA test; SD (standard deviation); *p<0.05

Table 6 shows the Wilks' Lambda test, applied to evaluate the ability of the discriminant equation to distinguish the sexes based on the values of the FS volume, height, width and depth analyses. The Wilks' Lambda value was 0.834, with a p-value of <0.001, indicating that the discriminant equation is statistically significant and has discriminatory power to distinguish the sexes. Furthermore, it is possible to observe that the overall percentage of precision in predicting gender was 74.5%, which indicates a moderate capacity for accuracy in identifying gender based on the measurements considered.

The function values in the centroid group were 0.675 for males and -0.292 for females. A rule was established indicating that if the D value is greater than 0.19, the sample will be classified as male. These results suggest that FS volume, height, width and depth measurements have moderate discriminatory power to predict sex in a Brazilian population.

**Table 6.** Discriminant analysis of sex, using the measures in discrimination

| **Total (sex)** | | | |
|---|---|---|---|
| D = -1.125 + 0.00*volume -0.005*height - 0.001*width + 0.12*depth | | | |
| Wilks' Lambda = 0.834, p<0.001 | | | |
| Percentage of accuracy in predicting sex | | | Overall |
| | | | 74.5% |
| Functions at centroid group | Male | Female | Male |
| | 0.675 | -0.292 | if D > 0.19 |

## DISCUSSION

To our knowledge, this is the first study to discuss morphometric measurements of FS in relation to age, sex and skeletal class in a Brazilian population. We observed that the FS showed significant differences between the sexes, with females exhibiting smaller volume, width and depth compared to males (p-value<0.001, 0.003 and <0.001, respectively). However, it was not possible to observe statistically significant differences in relation to age and skeletal class.

Although some studies have explored the volume of FS in assessing sex, its practical application in forensic anthropology is still in its infancy.[1] In the current scientific literature, based on helical computed tomography (CT) or CBCT, the significant distinction in the morphological characteristics of SF in relation to sex is reinforced.[1,4,12,13,28,29] Nevertheless, there are works that question the reliability of FS as a forensic identification method,[14-17] many of which employ 2D examinations and in some cases, resort to the use of dry skulls. In this present approach, using CBCT, the limitations of two-dimensional images can be surpassed, considering that 3D images provide details without superimposition, improving analysis and measurements, allowing more accurate results.[11]

Regarding age, our results did not indicate statistically significant correlations, suggesting a complex relationship between FS and aging. Even so, there are some studies that have shown growth of the FS until the age of 40, and its morphology can be influenced due to factors such as mechanical stress and growth hormones.[18,19] Our sample, with n=9 for the group over 60 years old, did not reflect this correlation. This points to the need for more comprehensive investigations involving different age groups.

Exploring the correlation between FS and facial skeletal pattern, the results of this research did not reveal statistically significant associations, similar to the pilot study by Sawada et al.[9] However, it differed from two previous studies.[7,8] Metin-Gürsoy et al. (2021) when performing linear measurements on CBCT with individuals aged 17 to 38 years, found that the anteroposterior dimension and width were significantly smaller in the hyperdivergent group compared to the hypodivergent, revealing a correlation between FS and craniofacial measurements. Rossouw et al. (1991) analyzed the FS using 2D cephalometry and concluded that there is a significant relationship between this structure and skeletal class. Therefore, our results suggest that FS may not be a reliable indicator for facial skeletal pattern, highlighting the complexity of these relationships and the need for additional investigations. It is worth highlighting that variations in the size and capacity of the FS may be related to its development during puberty, in parallel with craniofacial growth.[7]

The present study has some limitations, such as the convenience sample and individuals aged at least 20 years.[1] This age is considered the end of the FS growth. For this reason, measurements and comparisons were not considered in people of younger age.[1] Expanding the sample is necessary to better represent a population.[1] The present sample showed an inequality between the facial skeletal pattern and age groups, therefore requiring the expansion of the sample, following standardized protocols for different populations. However, the search for a reliable, accessible and accurate method for human identification motivates the continuation of these studies, providing valuable information for forensic science.

This analysis provided an accuracy of 74.5% in sex estimation using a single anatomical structure. This is a moderate index, but it can be used to estimate an individual's sex when other identification methods cannot be used. Furthermore, this expanded study not only corroborates the previous conclusions [30], but also deepens the discussion on the challenges and advances in FS forensic analysis. The application of CBCT and the volumetric assessment of FS show promise, but there is still the need for more comprehensive and diversified research to consolidate its role in forensic science, especially in populations as mixed as Brazil's.

## CONCLUSION

This analysis provided a moderate index of 74.5% in sex estimation using a single anatomical structure. It shows that it is possible to use the FS in forensic analysis for sex estimation when there are no other identification methods available. No statistically significant correlations were found between the FS and age or facial skeletal pattern. Future investigations with a broader age interval and more ethnically varied samples are recommended to improve the understanding of these relationships and consolidate the role of FS in forensic science.

## REFERENCES


1. Choi IGG, Duailibi-Neto EF, Beaini TL, Silva RLB, Chilvarquer I. The frontal sinus cavity exhibits sexual dimorphism in 3D cone-beam CT images and can be used for sex determination. J Forensic Sci. 2018 May;63(3):692-698. doi: 10.1111/1556-4029.13601.
2. Javaid Q, Usmani A. Anthropological significance of sexual dimorphism and the unique structural anatomy of the frontal sinuses: review of the available literature. J Pak Med Assoc. 2020 Apr;70(4):713-718. doi: 10.5455/JPMA.32528.
3. Ricardo ALF, Ogawa CM, Gomes JPP, Rosa CS, Lopes SLPC et al. Three-dimensional volumetric analysis of frontal ethmoidal cells and evaluation of influential factors: a helical computed tomography study. Tomography. 2022 Nov 24;8(6):2796-2805. doi: 10.3390-tomography8060233.
4. Čechová M, Dupej J, Bruzék J, Bejdová S, Horák M, Velemínská J. Sex estimation using external morphology of the frontal bone and frontal sinuses in a contemporary Czech population. Int J Legal Med. 2019 Jul;133(4):1285-1294. doi: 10.1007/s00414-019-02063-8.
5. Da Silva RF, Prado FB, Caputo IGC, Devito KL, Botelho TL, Daruge Júnior E. The forensic importance of frontal sinus radiographs. J Forensic Leg Med. 2009 Jan;16(1):18-23. doi: 10.1016/j.jflm.2008.05.016.
6. Yun IS, Kim YO, Lee SK, Rah DK. Three-dimensional computed tomographic analysis of frontal sinus in Asians. J Craniofac Surg. 2011 Mar;22(2):462-7. doi: 10.1097/SCS.0b013e3182074367.
7. Rossouw PE, Lomabard CJ, Harris AM. The frontal sinus and mandibular growth prediction. Am J Orthod Dentofacial Orthop. 1991 Dec;100(6):542-6. doi: 10.1016/0889-5406(91)70095-E.
8. Metin-Gürsoy G, Akay G, Tuncer BB. Frontal Sinus: is it a predictor for vertical malocclusions?. Anat Sci Int. 2021 Jan;96(1):62-69. doi:10.1007/s12565-020-00557-9.
9. Sawada M, Yamada H, Higashino M, Abe S, Tanaka E. Volumetric assessment of the frontal sinus in female adolescents and its relationship with craniofacial morphology and orthodontic treatment: a pilot study. Int J Environ Res Public Health. 2022;19(12):7287. doi: 10.339/ijerph19127287.
10. Falguera Jr, Falguera FPS, Marana AN. Frontal sinus recognition for human identification. Biometric Technology for Human Identification V. 2008 Mar 17. Available from: www.spiedigitallibrary.org/conference-proceedings-of-spie/6944/1/Frontal-sinus-recognition-for-human-identification/10.1117/12.777706.full [cited 28 November 2024]
11. Souza Junior LA, Marana AN, Weber SAT. Automatic frontal sinus recognition in computed tomography images for person identification. Forensic Sci Int. 2018 May;286:252-264. doi. 10.1016/j.forsciint.2018.03.029.
12. Hacl A, Costa ALF, Oliveira JM, Tucunduva MJ, Girondi JR, Nahás-Scocate ACR. Three-dimensional volumetric analysis of frontal sinus using medical software. J Forens Radiol Imaging. doi. 10.1016/j.jofri.2017.08.004.
13. Mendonça DS, Ribeiro EC, Silva PGB, Rodrigues AA, Kurita LM, Aguiar ASW et al. Diagnostic accuracy of paranasal sinus measurements on multislice computed tomography for sex estimation: a systematic review, meta-analysis and meta-regression. J Forensic Sci. 2022 Nov;67(6):2151-2164. doi: 10.1111/1556-4029.15117.
14. Yoshino M, Miyasaka S, Sato H, Seta S. Classification system of frontal sinus patterns by radiography. Its application to identification of unknown skeletal remains. Forensic Sci Int. 1987 Aug;34(4):289-99. doi: 10.1016/0379-0738(87)90041-7.
15. Besana JL, Rogers TL. Personal identification using the frontal sinus. J Forensic Sci. 2010 May;55(3):584-9. doi: 10.1111/j.1556-4029.2009.01281.x.

16. Goyal M, Acharya AB, Sattur AP, Naikmasur VG. Are frontal sinuses useful indicators of sex?. J Forensic Leg Med. 2013 Feb;20(2):91-7. doi: 10.1016/j.jflm.2012.04.028.
17. Verma S, Mahima VG, Patil K. Radiomorphometric analysis of frontal sinus for sex determination. J Forensic Dent Sci. 2014 Sep;6(3):177-82. doi: 10.4103/0975-1475.137052.
18. Tatlisumak E, Ovali GY, Asirdizer M, Aslan A, Ozyrut B et al. CT study on morphometry of frontal sinus. Clin Anat. 2008 May;21(4):287-93. doi: 10.1002/ca.20617.
19. Park JA, Lee YJ, Yeo IS, Koh KS, Song WC. Three-dimensional linear and volumetric computed tomography analysis of the frontal sinus. Anat Cell Biol. 2022 Jun30;55(2):142-147. doi: 10.5115/acb.22.037.
20. Steiner CC. Cephalometrics for you and me. Am J Orthod. 1953;39(10):729-755. doi: 10.1016/0002-9416(53)90082-7.
21. Gibelli D, Cellina M, Gibelli S, Oliva AG, Codari M et al. Volumetric assessment of sphenoid sinuses through segmentation on CT scan. Surg Radiol Anat. 2018 Feb;40(2):193-8. doi: 10.1007/s00276-017-1949-1.
22. Li Y, Xu C, Yu D, Xiong T, Zhao H, Xue H et al. Computer-aided superimposition of the frontal sinus via 3D reconstruction for comparative forensic identification. Int J Legal Med. 2021 Sep;135(5):1993-2001. doi: 10.1007/s00414-021002585-0.
23. Zhao H, Li Y, Xue H, Deng ZH, Liang WB, Zhang Lin. Morphological analysis of three-dimensionally reconstructed frontal sinuses from Chinese Han population using computed tomography. Int J Legal Med. 2021 May;135(3):1015-1023. doi: 10.1007/s00414-020-02443-5.
24. Aslier NGY, Zeybek G, Karabay N, Keskinoglu, Kiray A et al. The relationships between craniofacial structure and frontal sinus morphology: evaluation with conventional anthropometry and CT-bases volumetry. Ear Nose Throat J. 2020 Dec;99(10):637-647. doi: 10.1177/0145561319876927.
25. Cohen O, Warman M., Fried M, Shoffel-Havakuk H, Adi M et al. Volumetric analysis of the maxillary, sphenoid and frontal sinuses: a comparative computerized tomography based study. Auris Nasus Larynx. 2018 Feb;45(1):96-102. doi: 10.1016/j.anl.2017.03.003.
26. Buyuk SK, Karaman A, Yasa Y. Association between frontal sinus morphology and craniofacial parameters: a forensic view. J Forensic Leg Med. 2017 Jul;49:20-23. doi: 10.1016/j.jlfm.2017.05.007.
27. Wanzeler AMV, Alves Junior SM, Ayres L, Prestes MCC, Gomes JT, Tuji FM. Sex estimation using paranasal sinus discriminant analysis: a new approach via cone beam computerized tomography volume analysis. Int J Legal Med. 2019 Nov;133(6):1977-1984. doi: 10.1007/s00414-019-02100-6.
28. Kim DI, Lee UY, Park SO, Kwak DS, Han SH. Identification using frontal sinus by three-dimensional reconstruction from computed tomography. J Forensic Sci. 2012 May;58(1):5-12. doi:10.1111/j.1556-4029.2012.02185.x.
29. Michel J, Paganelli A, Varoquaux A, Piececchi-Marti MD, Adalian P et al. Determination of sex: interest of frontal sinus 3D reconstructions. J Forensic Sci. 2015 Feb;60(2):269-73. doi: 10.1111/1556-4026.12630.
30. Nikam SS, Gadgil RM, Bhoosreddy AR, Shah KR, Shirsekar VU. Personal identification in forensic science using uniqueness of radiographic image of frontal sinus. J Forensic Odontostomatol. 2015 Jul 1;33(1):1-7.

# Evaluation of dental and skeletal age among unilateral cleft lip and palate patients in an eastern Indian population



Manila Kannadasan[1], Surya Narayan Das[1], Rachna Rath[1], Surya Kanta Das[2], Geeta Sahu[3], Aishwariya Mohanty[1]

*[1]Department of Oral & Maxillofacial Pathology, SCB Govt. Dental College & Hospital, Cuttack, Odisha, India, [2]Department of Orthodontics and Dentofacial Orthopaedics, SCB Govt. Dental College and Hospital, Cuttack, Odisha, India, [3]Department of Forensic Medicine and Toxicology, SCB Medical College and Hospital, Cuttack, Odisha, India.*

**Corresponding author:**
**drrachna.rath@gmail.com**

The authors declare that they have no conflict of interest.

KEYWORDS

Unilateral cleft lip and palate,
Dental age,
Skeletal age,
Demirjian method,
G-P atlas technique,
Forensic age assessment.

J Forensic Odontostomatol
2025. Aug;(43): 2 -32:42
ISSN :2219-6749
DOI: doi.org/10.5281/zenodo.16486024

## ABSTRACT

Background: Unilateral cleft lip and palate affects dental and skeletal maturation, leading to delays that impact treatment planning and forensic age estimation. Understanding the correlation between dental age, skeletal age, and chronological age is essential for clinical and medico-legal applications.

Aim: To evaluate and compare dental and skeletal age in non-syndromic unilateral cleft lip and palate patients with an age- and gender-matched non-cleft control group.

Materials and Methods:

This cross-sectional study included 216 individuals (108 unilateral cleft lip and palate cases and 108 controls), aged 7 to 18 years. Dental age was assessed using Acharya's modified Demirjian method on panoramic radiographs, while skeletal age was estimated using the Greulich and Pyle Atlas from left hand-wrist radiographs. Statistical analyses were conducted to compare dental age, skeletal age, and chronological age.

Results: Skeletal age was more delayed than dental age, with males experiencing greater delays than females. Males had a mean skeletal delay of 0.92 years ($p < 0.001$), and females had a delay of 0.90 years ($p < 0.001$). Dental age delay was 0.28 years in males ($p = 0.016$) and 0.21 years in females ($p = 0.150$, not significant). The most significant delays were observed between ages 10 to 14 years, with a peak skeletal delay of 1.04 years at age 10 in females ($p < 0.001$).

Conclusion: Skeletal age is more delayed than dental age, with males experiencing greater delays. These findings highlight the need for individualized treatment planning and reinforce the importance of cleft-specific age estimation methods in forensic and legal contexts.

Clinical Significance: Accurate assessment of skeletal and dental age is essential for timely orthodontic and surgical interventions and for preventing age misclassification in forensic applications.

## INTRODUCTION

Cleft lip and palate (CL/P) represent one of the most common congenital anomalies, affecting approximately 1 in 700 live births globally, with prevalence varying across populations.[1] It is reportedly more frequent in Asian (1 in 500) than in European (1 in 1,000) and African (1 in 2,500) populations.[2] The prevalence of CL/P within Southeast Asia demonstrates significant variation across ethnic groups, with incidence rates

per 10,000 live births documented as 16.63 among Chinese,[3] 18.5 among Malays,[4] 13.0 among Indians,[5] and 21.73 in individuals of mixed ethnic heritage.[6] India reports 50,000–60,000 new cases annually,[7] with regional variations, including 1.09 per 1,000 in Andhra Pradesh,[8] 1 in 700 in Karnataka and Kerala,[9] and 0.73 per 1,000 in rural Gujarat.[10]

Children with CL/P may experience feeding, breathing, dental and skeletal abnormalities with delayed maturation, speech, hearing, and psychological challenges.[11,12] Previous studies have reported delayed dental and skeletal maturation in cleft patients compared to individuals without clefts.[2] Understanding a cleft patient's dental age (DA) and skeletal age (SA) which designate the biological age, is crucial as their growth pattern often does not align with chronological age (CA). This knowledge has significant applications in treatment planning, orthodontic interventions and cosmetic surgeries as it helps determine the optimal timing for corrective procedures that synchronize with the patient's growth and developmental stages. It is also crucial in forensic investigations to ensure they are not erroneously classified as minors when applying standard age reference models developed for non-cleft populations which holds importance in medico-legal contexts, where accurate age determination has serious implications.[13]

The Study Group on Forensic Age Diagnostics (AGFAD) recommends a comprehensive forensic age assessment, including physical examination, a hand X-ray, and dental evaluations using orthopantomograms (OPG).[14] SA estimation determines CA based on skeletal maturation, primarily assessed through hand-wrist ossification patterns.[12] The Greulich and Pyle (G-P) Atlas, a widely recognized methodology, evaluates left hand-wrist radiographs by referencing standardized age-specific radiographic templates.[15] Dental age estimation (DAE) utilizes various methods including Demirjian's,[16] Willems',[17] Cameriere's open apices [18] with selection based on age, dental status, radiographic quality, and precision needs. Demirjian's method, the most widely used, evaluated seven mandibular teeth across eight developmental stages, later incorporating third molars.[16] However, inaccuracies have been reported when employing the original method in other populations.[19,20] To address this, Acharya et al. modified the Demirjian's method, introducing Indian-specific formulae, that provided improved accuracy and reliability with a mean absolute error (MAE) of 1.29 years in the Indian population.[21]

Dental maturity may be impacted at various levels by the etiological factors associated with different cleft severities and types of CL/P each of which can have distinct effects on the cleft-affected region.[13] A subset of these cleft conditions is unilateral cleft lip and palate (UCLP) which stands out from other cleft types due to its higher prevalence of dental anomalies.[22] To the best of our knowledge, biological age assessment by investigation of skeletal development and dental development in a group of non-syndromic subjects with complete UCLP and its comparison with CA has hitherto not been performed in the Indian population. Therefore, the present study aimed to evaluate the same and to also compare the findings with an age and gender matched non-cleft control group. The current study solely involves patients with complete UCLP in order to minimize potential bias integration and to enable fair comparisons in future research. These insights are expected to improve clinical treatment strategies and enhance forensic age estimation for UCLP patients in this population.

## MATERIALS AND METHODS

*Ethical approval:*

The study was conducted following ethical guidelines, with Institutional Ethical Committee approval from SCB Dental College and Hospital, Cuttack (Ref. No: IEC/SCBDCH/155/2022).

*Study Sample:*

This cross-sectional comparative study (June 2022–October 2024) included 216 children and adolescents (7–18 years), comprising 108 UCLP cases and 108 age- and gender- matched non-cleft controls, with a maximum CA difference of 60 days per pair. Standardized OPGs and hand-wrist radiographs were obtained for all participants, and both imaging procedures were performed on the same day.

*Sample selection:*

The demographic, clinic and radiographic data related to forensic age estimation of the UCLP group were obtained from a specialized treatment center for cleft patients - Ashwini

Trauma Centre & Hospital, Cuttack - during the period from June 2022 to October 2024 following screening of all the cleft cases. The similar corresponding data for the age- and gender-matched non cleft control group was obtained from SCB Dental College & Hospital, Cuttack, comprising individuals in the pre-orthodontic phase of treatment. Data extracted from the patient's records included date of birth, gender, side affected by cleft, date of OPG taken and the presence of tooth agenesis. The study included individuals with complete non-syndromic UCLP (cleft group) who provided informed consent, had a full complement of mandibular left-side teeth, and possessed high-quality radiographs. Individuals were excluded if they had other cleft types, syndromic conditions, congenital anomalies, insufficient tooth mineralization, prior orthodontic or orthognathic treatment, grossly carious teeth in the lower left quadrant, systemic or metabolic disorders affecting growth, bilateral tooth agenesis, extractions outside the cleft area, dental crowding, or hand-wrist trauma impacting bone development. The subjects, selected as per inclusion and exclusion criteria, underwent a comprehensive intraoral clinical examination.

Standardized left hand-wrist radiographs were obtained and assessed for SA assessment. The G-P Atlas method was employed by two calibrated, blinded, independent observers, who had no prior knowledge of the subject's CA, or clinical condition.

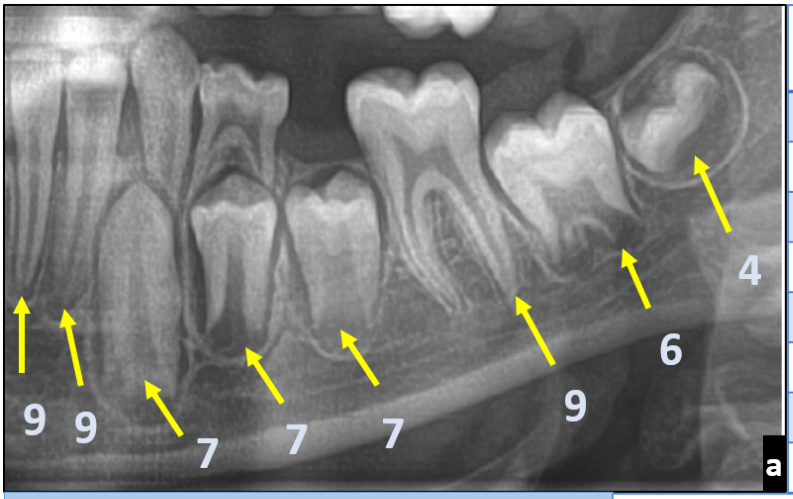
DA assessments were performed using standardized OPGs, digitized with a Scanjet G4050 scanner and HP software, and anonymized to minimize bias. The maxillary region was excluded to obscure cleft areas, ensuring objective measurements. Two blinded, forensic-trained oral pathologists independently assessed these images using Acharya's modification of Demirjian's method which evaluates the developmental stages of the eight left mandibular permanent teeth and assigns each tooth a stage, from initial calcification to apex closure. These stages correspond to gender-specific numerical scores. The scores of all eight teeth are summated to obtain a total maturity score, which is then applied to a gender-specific Indian formula (cubic functions) to calculate the DA (figure 1). To ensure reliability, intra-observer variation was evaluated by re-assessing 30 randomly selected samples by the same observer, from the UCLP and control groups after a period of 30 days, while inter-observer variation was also assessed to further validate the consistency of observations.

**Figure 1.** illustrates the estimation of DA using Acharya's modification of Demirjian's method

a) A male patient OPG demonstrating each of the eight left mandibular teeth being assigned a developmental stage as per Demirjian's tooth development chart

b) Table depicts individual tooth score allocation for each of the 8 teeth, in reference to Demirjian's maturity scoring tables and summating the scores to generate the total maturity score (TMS). TMS is substituted in Acharya's Indian specific formula to estimate DA.

c) The box depicts the Acharya Indian specific cubic function formulae used to estimate the dental age.




| Tooth | Score (Male) | Total maturity score |
|---|---|---|
| 31 | 10.68 | |
| 32 | 10.91 | |
| 33 | 7.59 | |
| 34 | 8.18 | 75.04 |
| 35 | 8.68 | |
| 36 | 11.22 | |
| 37 | 7.89 | |
| 38 | 9.89 | |

b

**Acharya's modification of Demirjian's method**

Males, Age = 27.4351 – (0.0097*S2) + (0.000089*S3)
Females, Age = 23.7288 – (0.0088*S2) + (0.000085*S3)

The estimated Dental age = 10.42 years.
Lower limit: 9.25 years
Upper limit: 11.59 years

c

*Statistical analysis:*
Data were entered into Microsoft Excel 2021 and analyzed using SPSS (IBM Corp., Version 27.0). Descriptive statistics were performed, with categorical variables presented as frequencies and percentages, while continuous variables were summarized as mean ± standard deviation. Paired t-tests and Wilcoxon tests were used for variable comparisons. Intra-class correlation coefficients (ICCs) assessed inter- and intra-observer reliability. A p-value <0.05 was considered statistically significant.

## RESULTS

The study sample of 216 individuals comprised 112 (51.9 %) males and 104 (48.1 %) females. Table 1 shows distribution of CA categorized into three age groups of <10y, 10-15y, 16-18y for both males and females. Among the cases, majority had cleft lip/palate on the left side (67.6%, n=73), while 32.4% (n=35) had it on the right.

The UCLP group demonstrated a significantly lower mean DA than the corresponding matched controls (Table 2), with a more pronounced delay in males (0.28 years) (Table 3, Figures 2 and 3). Although dental maturation lagged across most age groups, statistical significance varied. (Table 4).
SA was lower in the UCLP group (Table 2) compared to controls, though the overall difference was not statistically significant. However, both males and females exhibited significant skeletal delays (Table 5, Figures 4 and 5). Age-specific analyses revealed a marked delay in females at ages 10, 11, and 12, while no significant differences were observed at other ages. In males, skeletal maturation remained comparable to controls across all age groups except at age 11, where a statistically significant difference was observed (p= 0.015) (Table 6).

**Table 1.** Distribution of study sample according to chronological age (CA)

| Age group | Female | Male | Total |
|---|---|---|---|
| <10 | 24(11.1%) | 4(1.9%) | 28(13 %) |
| 10-15 | 76(35.2%) | 108(50%) | 184(85.6%) |
| 16-18 | 4(1.9%) | 0(0.0%) | 4(1.9%) |
| **TOTAL** | 104 | 112 | 216 |

**Table 2.** Comparison of dental and skeletal Age Between UCLP Cases and Controls

| | Case | | Control | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean difference** | **95%CI** | ***t-value*** | ***p-value*** |
| Dental Age | 11.45 | 1.59 | 12.03 | 1.82 | 0.58 | 0.12, 1.04 | 2.498 | 0.013 |
| Skeletal Age | 10.78 | 1.9 | 11.24 | 1.97 | 0.46 | -0.06, 0.98 | 1.793 | 0.083 |

**Table 3.** Comparison of Dental Age with Chronological Age for Male and Female Cases Using MDA Method

| Case | CA (Mean±SD) | DA (Mean±SD) | Mean Difference (M.D) | *t-value* | 95% CI of Mean Difference | *p-value* |
|---|---|---|---|---|---|---|
| Male | 12.04±1.75 | 11.77±1.38 | -0.28 | 2.493 | -0.54 to -0.015 | 0.016 |
| Female | 11.33±2.27 | 11.13±1.68 | -0.21 | 1.390 | -0.015 to 0.47 | 0.150 |

**Figure 2.** Box plot comparing Chronological Age (Blue), Dental Age (Red), and Skeletal Age (Green) in male control subjects. In male controls, the alignment of the median values for chronological age, dental age, skeletal age suggests generally synchronized development across parameters

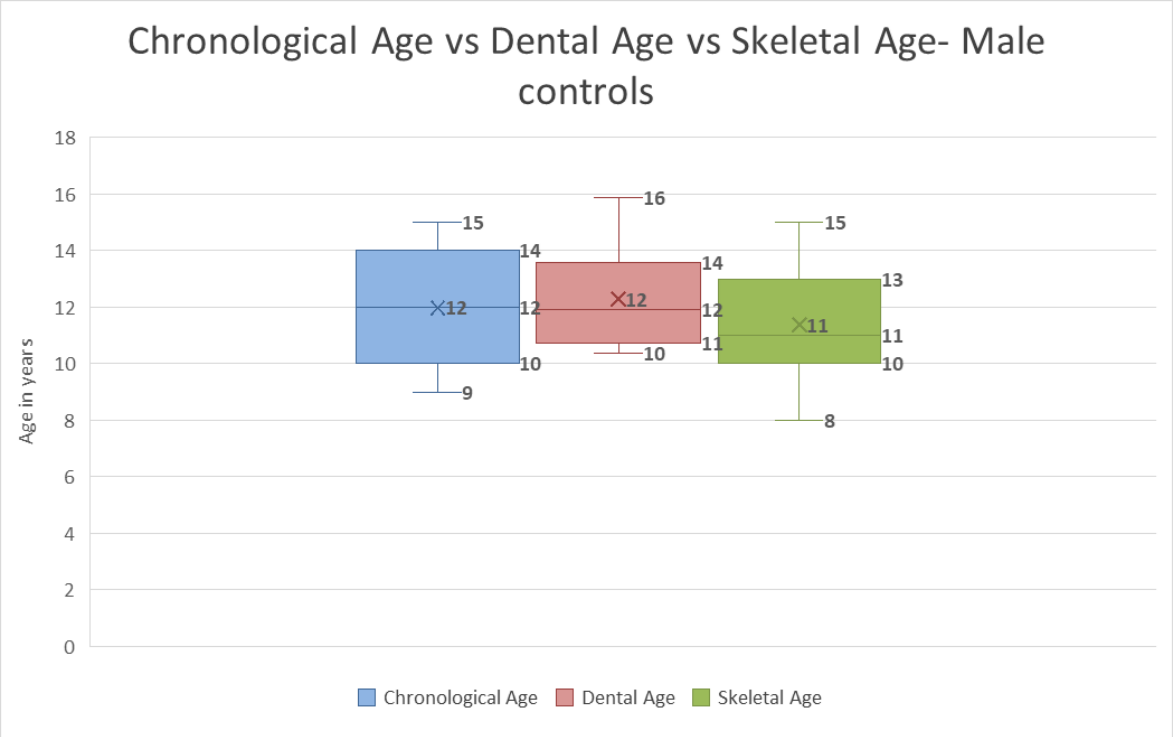



**Figure 3.** Box plot comparing Chronological Age, Dental Age, and Skeletal Age in female control subjects. In female controls, the alignment of the median values for chronological age, dental age, skeletal age suggests generally synchronized development across parameters

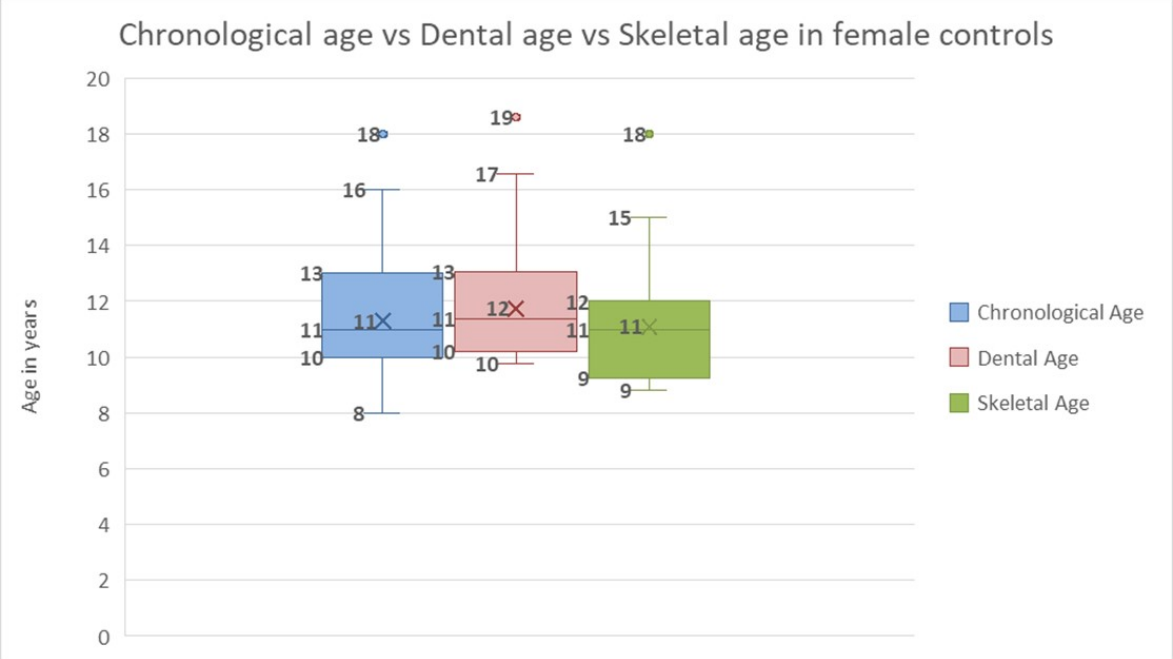


**Table 4.** Mean difference in dental age between control and UCLP patients at different ages

| Age | Mean Difference (MD) Females | 95% CI | SE of MD | *t-value* | *p-value* | Mean difference Males | 95%CI | SE of MD | *t-value* | *p-value* |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 0.02 | -0.10, 0.15 | 0.05 | 0.460 | 0.659 | - | - | - | - | - |
| 9 | 0.06 | -0.18, 0.31 | 0.11 | 0.545 | 0.595 | -0.10 | -6.81, 6.61 | 0.53 | -0.190 | 0.881 |
| 10 | 0.27 | -0.00, 0.54 | 0.13 | 2.067 | 0.053 | 0.17 | -0.047, 0.38 | 0.10 | 1.592 | 0.123 |
| 11 | 0.61 | 0.09, 1.12 | 0.24 | 2.534 | **0.022** | 0.48 | -0.13, 1.09 | 0.28 | 1.701 | 0.115 |
| 12 | 0.89 | 0.11,1.67 | 0.34 | 2.549 | **0.029** | 0.79 | 0.36, 1.21 | 0.20 | 3.848 | **0.001** |
| 13 | 1.30 | 0.39, 2.20 | 0.37 | 3.505 | **0.013** | 0.64 | 0.2,1.09 | 0.20 | 3.153 | **0.008** |
| 14 | 1.48 | 0.98,1.98 | 0.23 | 6.417 | **<0.001** | 0.81 | 0.24,1.37 | 0.27 | 2.973 | **0.008** |
| 15 | 0.93 | -0.18, 2.04 | 0.26 | 3.593 | 0.069 | 0.90 | 0.3,1.45 | 0.24 | 3.714 | **0.006** |
| 16 | 1.35 | - | - | - | - | - | - | - | - | - |
| 18 | - | - | - | - | - | - | - | - | - | - |

**Table 5.** Comparison of skeletal age with chronological age for Male and Female Cases Using G-P atlas Method

| Case | CA (Mean±SD) | SA (Mean±SD) | SE of Mean Difference | Mean Difference (M.D) | *t-value* | 95% CI of Mean Difference | *p-value* |
|---|---|---|---|---|---|---|---|
| **Male Case** | 12.04±1.75 | 11.13±1.82 | 0.07 | -0.92 | 12.064 | 0.75-1.05 | <0.001 |
| **Female Case** | 11.33±2.27 | 10.43±2.07 | 0.09 | -0.90 | 10.154 | 0.72-1.07 | <0.001 |

**Figure 4.** Box plot comparing Chronological Age, Dental Age, and Skeletal Age in male UCLP cases. In male UCLP cases, both skeletal and dental ages were lower than the chronological age, indicating delayed biological development. The median skeletal age was 11 years, compared to 12 years for both chronological and dental ages. The lower quartile of skeletal age extended to 8 years, further highlighting a trend toward delayed skeletal maturation

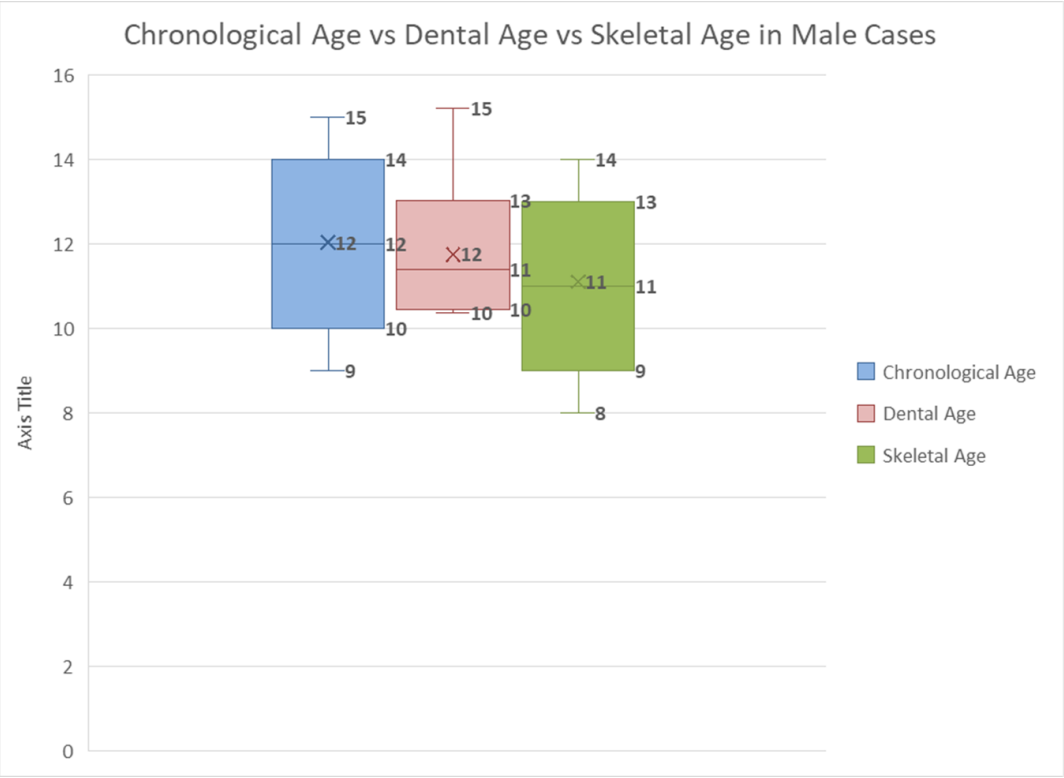


**Figure 5.** Box plot comparing Chronological Age, Dental Age, and Skeletal Age in female UCLP cases. Female UCLP cases exhibited the most pronounced developmental discrepancy, with median skeletal and dental ages (10 and 11 years, respectively) falling below the chronological age median of 11 years. The skeletal age range extended to a low of 8 years, reinforcing the presence of developmental delay in skeletal maturation

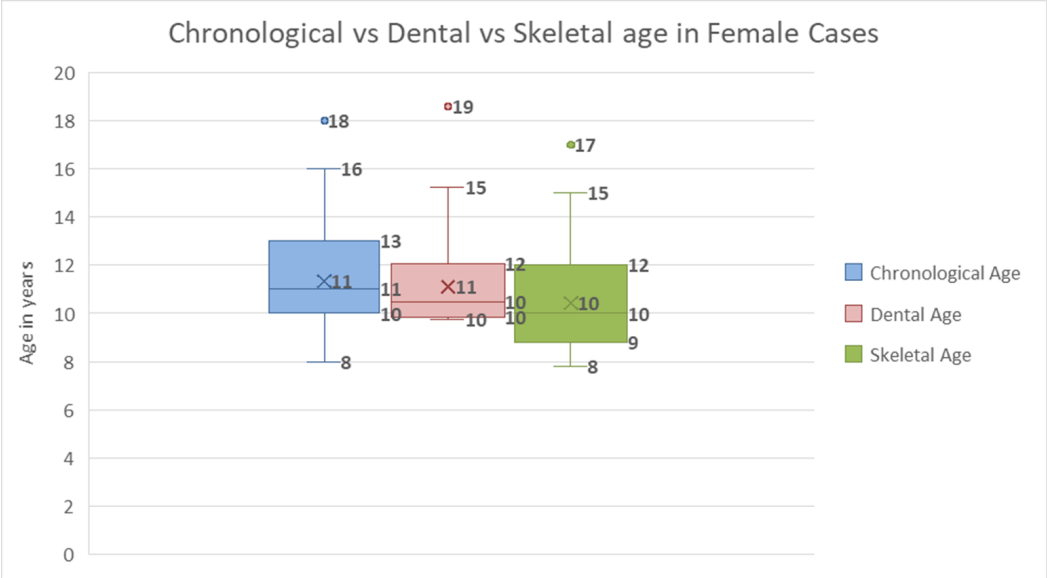



**Table 6.** Mean difference in skeletal age between control and UCLP patients at the different ages

| Age | MD Females | 95% CI | SE of MD | *t-value* | *p- value* | MD Males | 95% CI | SE of MD | *t-value* | *p- value* |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 0.5000 | -0.09,1.09 | 0.2535 | 1.972 | 0.089 | - | - | - | - | - |
| 9 | 0.4036 | -0.02,0.83 | 0.1983 | 2.035 | 0.063 | - | - | - | - | - |
| 10 | 1.0400 | 0.61,1.46 | 0.2033 | 5.115 | **<0.001** | 0.3333 | -0.05,0.71 | 0.1886 | 1.768 | 0.088 |
| 11 | 0.5556 | 0.11,0.99 | 0.2079 | 2.673 | **0.017** | 0.5714 | 0.13, 1.01 | 0.2020 | 2.828 | **0.015** |
| 12 | 0.8333 | 0.14,1.51 | 0.3073 | 2.712 | **0.022** | 0.6682 | -0.21, 1.54 | 0.4213 | 1.586 | 0.129 |
| 13 | 0.5000 | -0.36,1.36 | 0.3536 | 1.414 | 0.207 | 0.0714 | -0.38,0.52 | 0.2103 | 0.340 | 0.740 |
| 14 | 0.5714 | -0.15,1.30 | 0.3350 | 1.706 | 0.114 | 0.1000 | -0.48,0.68 | 0.2789 | 0.359 | 0.724 |
| 15 | 1.0000 | -1.15,3.15 | 0.5000 | 2.000 | 0.184 | -0.1000 | -0.33, 0.13 | 0.1000 | -1.000 | 0.347 |
| 16 | 0.0000 | - | - | - | - | - | - | - | - | - |
| 18 | 1.0000 | - | - | - | - | - | - | - | - | - |

In right-sided cleft patients, no statistically significant differences were observed between CA and either DA or SA (Table 7). The mean differences for both comparisons remained minimal across genders. In the left-sided cleft subgroup, a statistically significant delay in dental maturation was observed in both sexes, with CA exceeding DA ($p = 0.048$ in males; $p = 0.005$ in females, Table 8).

CA correlated strongly with DA and SA in both groups ($p < 0.001$). In controls, CA correlates more strongly with DA ($r = 0.965$) and SA ($r = 0.949$) than in cases ($r = 0.902$ and $r = 0.957$, respectively). In UCLP cases, SA exhibits a higher correlation. The reliability between the two observers for DA and SA assessment was excellent, as reflected by a high Intraclass Correlation Coefficient (ICC > 0.9, $p < 0.001$). Excellent intra-observer reliability for both dental and skeletal age assessments was demonstrated as indicated by intraclass correlation coefficient (ICCs) between 0.995 to 1.00, $p < 0.001$.

**Table 7.** Comparison of chronological age with dental and skeletal age in right-sided cleft patients

| Group | MD (DA) | SD (DA) | 95% CI (DA) | *p-value* | MD (SA) | SD (SA) | 95% CI (SA) | *p-value* |
|---|---|---|---|---|---|---|---|---|
| Male | 0.28 | 0.85 | -0.15 to 0.70 | 0.184 | 0.35 | 0.82 | -0.20 to 0.90 | 0.160 |
| Female | 0.017 | 1.14 | -0.57 to 0.60 | 0.950 | 0.12 | 1.05 | -0.50 to 0.74 | 0.660 |
| Overall | 0.15 | 0.995 | -0.19 to 0.49 | 0.374 | 0.24 | 0.94 | -0.30 to 0.78 | 0.330 |

**Table 8.** Comparison of chronological age with dental and skeletal age in left sided cleft patients

| Group | MD (DA) | SD (DA) | 95% CI (DA) | *p-value* | MD (SA) | SD (SA) | 95% CI (SA) | *p-value* |
|---|---|---|---|---|---|---|---|---|
| Male | 0.26 | 0.78 | 0.0026 to 0.52 | 0.048 | 1.00 | 0.62 | 0.79 to 1.20 | <0.001 |
| Female | 0.38 | 0.84 | -0.05 to 0.81 | 0.005 | 0.93 | 0.55 | 0.74 to 1.12 | <0.001 |
| Overall | 0.27 | 0.86 | 0.07 to 0.47 | 0.009 | 0.96 | 0.59 | 0.83 to 1.10 | <0.001 |

## DISCUSSION

CL/P is one of the most prevalent craniofacial anomalies, presenting profound challenges in terms of aesthetics, function, and overall growth and development.[23] These conditions arise from failure of fusion among the structures that form the upper lip or palate during prenatal development which is influenced by a complex interplay of genetic and environmental factors.[23] Among the various subtypes, UCLP is particularly notable for its impact on craniofacial structures, often resulting in aesthetic challenges, asymmetry and developmental delays.[22] These delays can affect both dental and skeletal maturation, adding complexity to orthodontic and surgical planning.[11]

Dental and skeletal maturity assessments are crucial in effectively managing UCLP patients, especially in forensic investigations.[13] Demirjian's method, a widely used radiographic age estimation technique, evaluates seven or eight left mandibular teeth using panoramic radiographs, offering a comprehensive view of development and eruption.[16] Extensively studied worldwide, it provides a precise, objective approach with standardized criteria, schematic illustrations, and gender-specific maturity scores, eliminating the need for detailed tooth measurements.[16] However, the original Demirjian 8-teeth method, incorporating Chaillet's modification, has been found to underestimate age in various non-Canadian populations.[24] To improve accuracy, Acharya et al. developed an Indian-specific modification using cubic functions, which performed better across Indian subsets.[21] Therefore, the present study adopted Acharya's method for precise DA estimation.

For SA assessment, radiographs of the hand-wrist, elbow joint, pelvis, and shoulder joint are commonly utilized, with left-hand radiographs preferred for their strong correlation with pubertal growth.[25] The preference for left-hand and wrist radiographs in bone age assessment is based on practical and historical considerations, as the dominant right hand is more prone to injuries, potentially affecting skeletal evaluation accuracy.[15] The G-P method is the most widely accepted reference standard, demonstrating strong correlation with chronological age in modern populations.[12] Therefore, the present study adopted the G-P method despite the lack of Indian normative data.

202 UCLP cases were initially included in the study. Of these, 94 cases were excluded for not meeting the inclusion criteria, namely the absence of bony crypts (37/94), prior orthodontic treatment (19/94), poor-quality radiographs (17/94), non-UCLP clefts (12/94), and gross dental caries (9/94). Similar criteria have been applied in previous studies to ensure sample integrity.[2,11,26] Thus, the final case sample totaled 108 subjects following which 108 age- and gender-matched controls were included, resulting in a total sample of 216.

CA in the current study ranged from 7 to 18 years, with most subjects (185/216) between 10 and 15 years, and 12.5% (27/216) under 10 years. Literature highlights challenges in evaluating younger cohorts (<10 years) due to delayed third molar mineralization and absence of bony

crypts, restricting their inclusion in this study. Tan et al. reported delayed dental mineralization in cleft children aged 5–9 years,[27] while Ribeiro et al. demonstrated significantly retarded third molar mineralization in cleft populations.[28] These constraints necessitate the selection of the 7–18-year age range, ensuring the presence of well-defined dental and skeletal maturation markers for robust comparative analyses between cleft and non-cleft groups.

In the UCLP cases, males (51.9%) outnumbered females (48.1%), aligning with existing literature reporting a male predominance in UCLP cases.[1] The cleft defect mostly affected the left side (67.6%), aligning with prior studies reinforcing the left-side predominance.[1,2,13]

The UCLP patients exhibited a significant delay of 0.58 years in dental development compared to age- and gender-matched controls ($p = 0.013$). This delay may stem from shared genetic pathways between cleft formation and odontogenesis, with genes such as TGFβ, TGFβ3, and MSX1 playing critical roles.[29] Beyond genetic influences, craniofacial growth disruptions associated with clefts may contribute to this delay. Van Dyck et al. systematically reviewed CL/P children (6–20 years) and reported a significant dental delay of 0.56 years ($p < 0.0001$), ranging from 0.2 to 0.9 years, compared to controls.[30] Similarly, Tan et al. found a significant delay of 0.55 years ($p < 0.001$) in 5–9-year-olds, while delays in older age groups (9–13 years) were not significant ($p = 0.744$). This suggests potential catch-up growth over time.[27] Ying Guo et al. observed a significant underestimation of DA (0.319 years, $p = 0.013$) in UCLP patients.[11] A greater delay in DA was noted among UCLP males (0.28 years, $p = 0.016$) than females (0.21 years, $p = 0.150$), though the difference was not statistically significant across all age groups. This aligns with previous studies indicating greater delays in males, likely due to their slower somatic and dental development. Hyuskens et al. reported significant delays in UCLP males at ages 5 (1.31 years, $p < 0.001$) and 14 (1.74 years, $p < 0.001$), while females showed smaller but significant delays (0.73 years, $p < 0.001$; 0.67 years, $p = 0.02$).[31] Conversely, Van Dyck et al. found greater delays in females, particularly at age 13 (1.411 years, $p < 0.0001$).[13]

SA assessment provides a complementary perspective on maturation alongside DA. While controls exhibited minimal SA differences (Males: MD = -0.03, $p = 0.09$; Females: MD = -0.02, $p = 0.112$), UCLP patients showed significant delays (Males: 0.92 years, $p < 0.001$; Females: 0.90 years, $p < 0.001$). Notably, SA delays in females were significant at ages 10–12 ($p < 0.05$), whereas males displayed a more consistent delay across all ages. Akcam et al. reported an overall mean SA delay of 0.9 years in UCLP cases, with males showing greater delays (2.4 years) than females (1.7 years).[12] MS Ravi et al. found significant delays in males aged 10–13 years ($p = 0.019$), but not in older groups ($p = 0.277$)[32] suggesting that factors such as genetic predisposition, cohort characteristics, and methodological variations may influence skeletal maturation.

Since DAE was conducted using the left mandibular dentition as per Demirjian's method, a subgroup analysis for both left- and right-sided clefts was performed to assess the effect of laterality on dental and skeletal development. However, substitution of right mandibular teeth for any missing left mandibular teeth was not done in the present study, as the inclusion criteria mandated the presence of all eight left mandibular teeth. In the left-sided cleft subgroup, a statistically significant delay in dental maturation was observed in both sexes, with CA exceeding DA ($p = 0.048$ in males; $p = 0.005$ in females, Table 8). Similarly, SA lagged significantly behind CA in both males and females ($p < 0.001$, Table 9), indicating overall developmental delay. These findings highlight a consistent pattern of developmental delay in both dental and skeletal parameters on the cleft-affected (left) side. In contrast, no significant difference was found between DA and CA in right-sided clefts ($p = 0.374$), suggesting that developmental delays may be localized to the cleft-affected side despite clefts being maxillary anomalies. These delays may result from malnourishment, limited eruption space, impaired vascularization due to surgical fibrosis, and mandibular adaptation to maxillary deficiency.[33] Previous studies report conflicting findings with most exhibiting no significant differences. Tan et al.[27] reported delayed development on the cleft side. These findings challenge Demirjian's method's substitution approach for UCLP cases, as developmental asymmetry may affect age estimation accuracy. Similarly, SA comparisons in right-sided clefts

(left hand-wrist analysis) showed no significant differences (p = 0.330), further supporting the notion that growth disturbances are cleft-side specific. Future studies should directly compare dental and skeletal development bilaterally in larger cohorts to refine age estimation protocols.

CA revealed strong positive correlations with both DA (r = 0.902, r = 0.965) and SA (r = 0.957, r = 0.949) in cases, and controls respectively (p < 0.001). SA exhibited a slightly stronger association in cases, whereas DA had a marginally higher correlation in controls. Similar findings by Ying Guo et al. reinforce that developmental patterns differ between UCLP and non-UCLP individuals, underscoring the need for group-specific considerations in age estimation.[11]

The study has limitations, including the lack of comparison between dental and skeletal development on the cleft and non-cleft sides within individual UCLP patients, which could have provided insights into intra-individual variations. The exclusion of patients with unerupted third molars lacking bony crypts or insufficient mineralization may have influenced the assessment of late-stage dental development. Additionally, since the cleft is a maxillary anomaly, evaluating only mandibular teeth may not fully capture its impact. The study also focused solely on UCLP cases, and the findings may not be applicable to other cleft types, necessitating further research.

Future studies should explore intra-individual variations between cleft and non-cleft sides to clarify asymmetric growth and its impact on treatment. Research should also extend to Bilateral Cleft Lip and Palate and isolated clefts to evaluate differences in biological maturation across cleft types. Additionally, maxillary assessment for age estimation could further elucidate growth variations and their effects on dental development.

## CONCLUSION

UCLP cases exhibited developmental delays, with both dental and skeletal maturation lagging behind CA as compared to matched controls. Our study demonstrated that SA showed a more pronounced delay compared to DA, with males experiencing greater delays. Given these delays, skeletal assessments should take precedence over CA for treatment planning, refining orthodontic and secondary bone grafting strategies. Beyond clinical applications, standard age estimation methods may misclassify UCLP patients in forensic, legal, and sports contexts, leading to inaccurate legal decisions and administrative discrepancies. This underscores the need for condition-specific reference tables to enhance accuracy across clinical, forensic, and regulatory domains. Until further research clarifies the influence of cleft laterality on dental and skeletal maturation delays in this population, substitution of missing teeth using the contralateral side, as per Demirjian's method should be approached with caution or potentially avoided, to preserve accuracy in age estimation.

## REFERENCES


1) Dewinter G, Quirynen M, Heidbüchel K, Verdonck A, Willems G, Carels C. Dental abnormalities, bone graft quality, and periodontal conditions in patients with unilateral cleft lip and palate at different phases of orthodontic treatment. Cleft Palate Craniofac J. 2003 Jul;40(4):343-50. doi: 10.1597/1545-1569_2003_040_0343_dabgqa_2.0.co_2
2) Almotairy N, Pegelow M. Dental age comparison in patients born with unilateral cleft lip and palate to a control sample using Demirjian and Willems methods. Eur J Orthod. 2018 Jan 23;40(1):74-81. doi: 10.1093/ejo/cjx031.
3) Dai L, Zhu J, Mao M, Li Y, Deng Y, Wang Y, Liang J, Tang L, Wang H, Kilfoy BA, Zheng T. Time trends in oral clefts in Chinese newborns: data from the Chinese National Birth Defects Monitoring Network. Birth Defects Research Part A: Clinical and Molecular Teratology. 2010 Jan;88(1):41-7.
4) Goh PP. Major congenital anomalies in livebirths in Alor Star General Hospital during a three year period. Med. J. Malaysia. 1988;43:138-49.
5) Allagh KP, Shamanna BR, Murthy GV, Ness AR, Doyle P, Neogi SB, Pant HB, Wellcome Trust-PHFI Folic Acid project team. Birth prevalence of neural tube defects and orofacial clefts in India: a systematic review and meta-analysis. PloS one. 2015 Mar 13;10(3):e0118961.
6) Putri FA, Pattamatta M, Anita SE, Maulina T. The Global Occurrences of Cleft Lip and Palate in Pediatric Patients and Their Association with Demographic Factors: A Narrative Review. Children. 2024 Mar 8;11(3):322.
7) Deutsche Cleft Kinderhilfe. Deutsche Cleft Kinderhilfe's [Internet]. Freiburg: Deutsche Cleft Kinderhilfe; Available from: https://www.spaltkinder.org/en/
8) Reddy SG, Reddy RR, Bronkhorst EM, Prasad R, Ettema AM, Sailer HF, Bergé SJ. Incidence of cleft lip

and palate in the state of Andhra Pradesh, South India. Indian journal of plastic surgery. 2010 Jul;43(02):184-9.
9) Samuel S, Prasad BR, Kumari S, Tejaswi SS, Sanal TS. A clinical study of incidence and distribution and co-relating factors of cleft lip and cleft palate among karnataka & kerala population. Journal of Health and Allied Sciences NU. 2014 Sep;4(03):066-9.
10) Khajanchi MU, Shah H, Thakkar P, Gerdin M, Roy N. Unmet burden of cleft lip and palate in rural Gujarat, India: a population-based study. World journal of surgery. 2015 Jan;39:41-6.
11) Guo Y, Yang H, Pan J, Ren Q, Yang C, Ji F. Dental and skeletal maturation of Chinese male children with unilateral cleft lip and palate. Journal of Clinical Pediatric Dentistry. 2024 Mar 1;48(2).
12) Uslu-Akcam O. Evaluation of skeletal maturation in individuals with cleft lip and palate. Australasian Orthodontic Journal. 2017 Jan 1;33(2):194-8.
13) Van Dyck J, Begnoni G, Willems G, Laenen A, Thevissen P, Verdonck A, Cadenas de Llano-Perula M. Dental development in patients with and without unilateral cleft lip and palate (UCLP): a case control study. Clinical Oral Investigations. 2021 May;25:2619-31.
14) Schmeling A, Geserick G, Reisinger W, Olze A. Age estimation. Forensic science international. 2007 Jan 17;165(2-3):178-81.
15) Greulich WW, Pyle SI. Radiographic atlas of skeletal development of the hand and wrist. The American Journal of the Medical Sciences. 1959;238(3):393.
16) Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973 May;45(2):211-27.
17) Willems G, Van Olmen A, Spiessens B, Carels C. Dental age estimation in Belgian children: Demirjian's technique revisited. Journal of forensic sciences. 2001 Jul 1;46(4):893-5.
18) Cameriere R, Ferrante L, Cingolani M. Age estimation in children by measurement of open apices in teeth. Int J Legal Med. 2006 Jan;120(1):49–52. doi: 10.1007/s00414-005-0047- 9. Epub 2005 Nov 10.
19) Liversidge HM, Speechly T, Hector MP. Dental maturation in British children: are Demirjian's standards applicable? International Journal of Paediatric Dentistry. 1999 Dec;9(4):263-9.
20) Koshy S, Tandon S. Dental age assessment: the applicability of Demirjian's method in south Indianchildren. Forensic science international. 1998 Jun 8;94(1-2):73-85.
21) Acharya AB. Age estimation in Indians using Demirjian's 8-teeth method. Journal of forensic sciences. 2011 Jan;56(1):124-7.
22) Rizell S, Bellardie H, Karsten A, Sæle P, Mooney J, Heliövaara A, Küseler A, Brinck E, Skaare P, Mølsted K, Chalien MN. Scandcleft randomized trials of primary surgery for unilateral cleft lip and palate: dental anomalies in 8-year-olds. European journal of Orthodontics. 2020 Jan 27;42(1):8-14.
23) Muzammil K, Nasir N, Hassan A, Padda P, Siddiqui Z, Mahmood SE, Zafar K, Abbas H. Epidemiological Aspects of Cleft Lip and Cleft Palate. Journal of Evolution of Medical and Dental Sciences. 2021 Sep 6;10(36):3178-83.
24) Chaillet N, Demirjian A. Dental maturity in South France: A comparison between Demirjian's method and polynomial functions. Journal of forensic sciences. 2004 Sep 1;49(5):JFS2004037-8.
25) Hashim HA, Mansoor H, Mohamed MH. Assessment of skeletal age using hand-wrist radiographs following Bjork system. Journal of International Society of Preventive and Community Dentistry. 2018 Nov 1;8(6):482-7.
26) Cesur E, Arslan C, Münevveroğlu AP, Altuğ AT. Evaluation of dental age in İndividuals of different ages with unilateral cleft lip and palate. Turkish Journal of Orthodontics. 2020 Jun;33(2):103.
27) Tan EL, Kuek MC, Wong HC, Yow M. Longitudinal dental maturation of children with complete unilateral cleft lip and palate: A case-control cohort study. Orthodontics & Craniofacial Research. 2017 Nov;20(4):189-95.
28) Ribeiro EC, Lacerda RH, da Silva LG, Santiago BM, da Costa CH, Almeida MS. An analysis of third molar mineralization in Brazilian patients with cleft lip and palate. Acta Odontologica Scandinavica. 2020 Jul 3;78(5):384-9.
29) Zhang Z, Song Y, Zhao X, Zhang X, Fermin C, Chen Y. Rescue of cleft palate in Msx1-deficient mice by transgenic Bmp4 reveals a network of BMP and Shh signaling in the regulation of mammalian palatogenesis.
30) Van Dyck J, Cadenas de Llano-Pérula M, Willems G, Verdonck A. Dental development in cleft lip and palate patients: A systematic review. Forensic Sci Int. 2019;300:63-74.
31) Huyskens RW, Katsaros C, Van't Hof MA, Kuijpers-Jagtman AM. Dental age in children with a complete unilateral cleft lip and palate. The Cleft palate-craniofacial journal. 2006 Sep;43(5):612-5.
32) Ravi MS, Ravikala S. Assessment of skeletal age in children with unilateral cleft lip and palate. International Journal of Clinical Pediatric Dentistry. 2013 Sep;6(3):151.
33) Seo YJ, Park JW, Kim YH, Baek SH. Initial growth pattern of children with cleft before alveolar bone graft stage according to cleft type: unilateral cleft lip and alveolus, unilateral cleft lip and palate, and cleft palate. The Angle Orthodontist. 2011 Nov 1;81(6):1103-10.