ACTA
STOMATOLOGICA
CROATICA
www.ascro.hr
OPEN ACCESS

Acta stomatol Croat. 2026;60(2):253-267.
DOI: 10.15644/asc60/2/8
ORIGINAL SCIENTIFIC PAPER
IZVORNI ZNANSTVENI RAD

Paula Rebéca Rodrigues[1], Maria Clara Panciera[1], Ricardo Henrique Alves da Silva[2], Paulo Henrique Viana Pinto[*1,3]

Third Molar Impaction Influence on Dental Estimation: A Systemic Review

Utjecaj impakcije trećeg kutnjaka na dentalnu procjenu dobi: sustavni pregled

[1] Department of Pathology and Legal Medicine, Ribeirão Preto Medical School, USP - University of São Paulo, Ribeirão Preto, Brazil
USP – Sveučilište São Paulo, Medicinski fakultet Ribeirão Preto, Odjel za patologiju i pravnu medicinu, Ribeirão Preto, Brazil
[2] Department of Stomatology, Public Health and Forensic Odontology, Ribeirão Preto School of Dentistry, USP - University of São Paulo, Ribeirão Preto, Brazil
USP – Sveučilište São Paulo, Stomatološki fakultet Ribeirão Preto, Odjel za stomatologiju, javno zdravstvo i forenzičku odontologiju, Ribeirão Preto, Brazil
[3] Bahia State Scientific Police, Camaçari, Bahia, Brazil
Bahia State Scientific Police, Camaçari, Bahia, Brazil

Abstract
Background: Dental age estimation is a relevant procedure in forensic odontology, but it becomes increasingly challenging as age advances. In such cases, the use of third molars stands out, as they are the last teeth to complete the maturation process. However, it has been observed that these teeth have the highest rate of impaction. **Objectives:** The aim of this systematic review was to assess whether dental impaction influences the mineralization process of third molars and whether this condition affects the accuracy of age estimation methods. **Methods:** A search was carried out in the Embase, LILACS, PubMed/MEDLINE, SciELO, Scopus, and Web of Science databases, using terms related to the topic in Portuguese, English, and Spanish. Two independent evaluators applied eligibility criteria to select and evaluate the relevant articles. **Results:** After selection by title, abstract, and full-text reading, 11 articles were included. The risk of bias was analyzed using the checklist proposed by the Joanna Briggs Institute. Data extraction revealed that the populations studied were from India, Germany, Lebanon, Switzerland, China, Canada, South Africa, and Denmark. All studies were separated by sex, though in different sample sizes, except for one study, which used equal numbers of 260 orthopantomograms for each sex. Furthermore, all studies demonstrated that dental impaction, regardless of its degree, influences tooth mineralization. **Conclusion:** In conclusion, third molar impaction may delay the process of dental mineralization, raising concerns that these teeth, when impacted, should not be considered the first choice for age estimation methods.

Received: December 4, 2025
Accepted: March 29, 2026

Address for correspondence
Paulo Henrique Viana Pinto.
Av. do Café, s/n. USP- Faculdade de Medicina de Ribeirão Preto, Departamento de Patologia e Medicina Legal.
Campus da USP, Ribeirão Preto - SP, 14040-900.
paulohenriquevp@hotmail.com

MeSH Terms: Age Determination by Teeth
Author Keywords: Forensic Dentistry; Dental Age Estimation; Third Molar; Impacted Tooth; Tooth Calcification.

Paula Rebeca Rodrigues: ORCID: https://orcid.org/0009-0006-9657-0631
Maria Clara Panciera: ORCID: https://orcid.org/0000-0001-9192-2139
Ricardo Henrique Alves da Silva: ORCID: https://orcid.org/0000-0002-1532-1670
Paulo Henrique Viana Pinto: ORCID: https://orcid.org/0000-0003-0945-9566

Introduction

Age estimation is a relevant process in the forensic field. In cases involving living individuals, dental age estimation is important in situations such as immigration, missing persons' investigations, and the granting of social security benefits (1, 2). In deceased individuals, the construction of the biological profile is crucial, and age estimation is one of the key steps in this process (1, 2). In this context, among the anatomical structures that can be used to estimate age, teeth stand out as they allow for the analysis of morphological development over time, serving as an age biomarker (1).

However, the application of these methods becomes more challenging once the individual reaches the second decade of life, a period during which the permanent dentition is nearly complete and fully developed (1,2). Therefore, spe-

Uvod

Procjena dobi relevantan je proces u forenzičkom području. U slučaju da su uključene žive osobe, procjena dentalne dobi važna je u situacijama kao što su imigracija, potrage za nestalim osobama i dodjela naknada socijalnog osiguranja (1, 2). Za umrle osobe izrada biološkog profila je ključna, a procjena dobi jedan je od najvažnijih postupaka u tom procesu (1, 2). U tom kontekstu, među anatomskim strukturama koje se mogu primjenjivati za procjenu dobi, ističu se zubi jer omogućuju analizu morfološkog razvoja tijekom vremena i služe kao biomarker dobi (1).

Međutim, primjena tih metoda postaje izazovnija kada pojedinac dosegne drugo desetljeće života, razdoblje u kojemu je trajna denticija gotovo dovršena i potpuno razvijena (1, 2). Zato su razvijene specifične metode za procjenu dobi kod

cific methods have been developed to estimate age in adolescents and young adults, with particular emphasis on the third molar, the last tooth to complete its mineralization and development, thus becoming a potential indicator for age estimation (1-9).

The third molar has been employed in methodologies that use orthopantomographs to analyze dental development for age estimation in individuals within these age ranges. In 1994, Köhler *et al*. (10) proposed a method based on the evaluation of the root development stages of third molars (10). Subsequently, Gunst *et al.* (2003) presented a methodology also based on root development analysis through orthopantomographs, using ten developmental stages proposed by Köhler *et al*. (1994), (10) but assessing only a single third molar (10,11). In 2008, Cameriere *et al*. (12) exclusively used the lower third molar to calculate the Dental Maturity Index (I_3M), which measures root apex openings and tooth length (12).

Over the years, these methodologies have been validated across multiple populations and adapted to different demographic contexts; however, because they were developed for specific populations, they often require modifications to ensure greater accuracy in age estimation when applied to others (11,13).

The use of the third molar for age estimation has been questioned by studies such as those by Thorson and Hägg (1991), (14) and Mincer *et al*. (1993), (15). However, before drawing definitive conclusions, it is essential to consider various factors, such as small sample sizes, case reports, inadequate statistical analyses, and samples from different origins (11). Moreover, the mineralization process of the third molar can be influenced by intrinsic factors, such as mandibular size and retromolar space, as well as extrinsic factors, including diseases, medical treatments, habits, and nutrition (8).

However, there is disagreement among authors regarding the influence of impaction on the rate of mineralization or root development of the third molar (1, 10, 16). In this regard, studies such as Olze *et al*. (2012), (17) are important, as they assess these influences within each analyzed population and their differing results. Thus, the mineralization and eruption of third molars provide information that can be considered for age estimation. This was described by Köhler *et al*. (1994), (10) and Olze *et al*. (2012), (17) who demonstrated population-based age differences in third molar mineralization and eruption. Although there may be physiological variability in the mineralization of these dental elements among individuals, this process can also be influenced by dental impaction (10, 17).

Therefore, in order to consider impaction in age estimation, it is necessary to understand its effects on mineralization and whether it can effectively be regarded as a relevant factor in age estimation methods (10, 17, 18). The objective of this systematic review was to evaluate whether dental impaction influences the mineralization process of the third molar and whether this condition affects the accuracy of age estimation methods.

adolescenata i mladih odraslih osoba, s posebnim naglaskom na treći kutnjak, zub koji posljednji završava svoju mineralizaciju i razvoj te tako postaje potencijalni pokazatelj za procjenu dobi (1 – 9).

Treći kutnjak korišten je u metodologijama koje se koriste ortopanom za analizu dentalnoga razvoja radi procjene dobi kod osoba unutar tih dobnih raspona. Godine 1994. Köhler i suradnici (10) predložili su metodu temeljenu na procjeni faza razvoja korijena trećih kutnjaka (10). Nakon toga su Gunst i suradnici (2003.) (11) predstavili metodologiju također zasnovanu na analizi razvoja korijena na temelju ortopantomograma, a koristili su se s deset razvojnih faza koje su predložili Köhler i suradnici (1994.) (10), ali procjenjujući samo jedan treći kutnjak (10, 11). Godine 2008. Cameriere i suradnici (12) isključivo su se koristili donjim trećim kutnjakom za izračun indeksa zrelosti zuba (I_3M) kojim se mjere otvori vrha korijena i duljina zuba (12).

Tijekom godina te su metodologije validirane u više populacija, prilagođavane i testirane u različitim demografskim kontekstima zbog činjenice da su metode izvorno razvijene za specifične populacije i, kada se primjenjuju na skupine različite od izvornika, mogu zahtijevati prilagodbe ili dodatne modifikacije kako bi se osigurala veća točnost u procjeni dobi (11, 13).

Korištenje trećeg kutnjaka za procjenu dobi dovedeno je u pitanje u studijama poput onih Thorsona i Hägga (1991.) (14) te Mincera i suradnika (1993.) (15). No prije donošenja konačnih zaključaka, bitno je uzeti u obzir različite čimbenike kao što su mali uzorci, prikazi slučajeva, neadekvatne statističke analize i uzorci različitog podrijetla (11). Štoviše, na proces mineralizacije trećeg kutnjaka mogu utjecati unutarnji čimbenici, poput veličine mandibule i retromolarnoga prostora te vanjski čimbenici, uključujući bolesti, medicinske tretmane, navike i prehranu (8).

Međutim, postoji neslaganje među autorima u vezi s utjecajem impakcije na brzinu mineralizacije ili razvoj korijena trećeg kutnjaka (1, 10, 16). U tom smislu važne su studije poput one Olzea i suradnika (2012.) (17) zato što se u njima procjenjuju ti utjecaji unutar svake analizirane populacije i njihovi različiti rezultati. Dakle, mineralizacija i nicanje trećih kutnjaka pružaju informacije koje se mogu uzeti u obzir za procjenu dobi. To su opisali Köhler i suradnici (1994.) (10) i Olze i suradnici (2012.) (17) koji su pokazali razlike u mineralizaciji i nicanju trećeg kutnjaka temeljene na dobi među populacijama. Iako može postojati fiziološka varijabilnost u mineralizaciji tih zuba među pojedincima, na taj proces može utjecati i zubna impakcija (10, 17).

Zato, kako bi se impakcija uzela u obzir u procjeni dobi, potrebno je razumjeti njezine učinke na mineralizaciju i može li se smatrati relevantnim čimbenikom u metodama za procjenu dobi (10, 17, 18). Cilj ovoga sustavnog pregleda bio je procijeniti utječe li impakcija na proces mineralizacije trećeg kutnjaka i utječe li to stanje na točnost metoda za procjenu dobi.

Material and Methods

This systematic review was registered on the International Prospective Register of Systematic Reviews (PROSPERO) under registration number ID CRD420250652038 on March 11, 2025, following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (19).

PICO strategy was used: P – Individuals; I – Dental impaction; C – Absence of dental impaction; O – Age estimation, in order to frame the research question that guided this study: "Does third molar impaction influence dental mineralization and, consequently, estimation of a person's age?"

A systematic search for studies was conducted in the following databases: Embase (https://www.embase.com/search/quick), LILACS (https://lilacs.bvsalud.org/), PubMed/MEDLINE (https://pubmed.ncbi.nlm.nih.gov/), SciELO (https://www.scielo.br/), Scopus (https://www.scopus.com/search/form.uri?display=basic#basic), and Web of Science (https://www.webofscience.com/wos/woscc/smart-search). The search was conducted on February 10, 2025, and covered studies published since their inclusion in each database up to the date of the search, with no limitations on the publication period.

The searched keywords were: "Age Determination by Teeth," "Age Determination," "Wisdom Tooth," "Third Molar," "Tooth Calcification," and related terms in English, Portuguese, and Spanish. The search was conducted using the controlled vocabularies of Descriptors in Health Sciences (DeCS), Medical Subject Headings (MeSH), and Embase Subject Headings (Emtree). To construct the search equations for the studies, these keywords were combined using the Boolean operators "OR" and "AND" and each search equation was individually adjusted according to the requirements of each database (Table 1). Although the search terms were applied in these three languages, studies published in other languages, including German, were retrieved during the database searches and were therefore included in the analysis.

Studies were selected based on inclusion criteria, specifically those that addressed third molar mineralization, the presence of impacted third molars, and age estimation based on dental development in adolescent and young adult samples, as well as the potential influence of impaction on the mineralization process or third molar development. There were no restrictions regarding the language of the articles or the type of imaging examination used. Exclusion criteria included systematic reviews, meta-analyses, books or book chapters, papers that have been presented at a conference and subsequently included in that conference's published proceedings, dissertations, thesis, and case reports. In addition, *in vitro* studies, studies involving cells, animals, or drug interventions were excluded, as well as studies that analyzed teeth other than the third molar or included pediatric samples.

The studies retrieved from the database search were imported into the Rayyan application (https://www.rayyan.ai/) for duplicate removal and implementation of eligibility criteria. Subsequently, the study selection process was carried out

Materijali i metode

Ovaj sustavni pregled upisan je 11. ožujka 2025. u Međunarodni prospektivni registar sustavnih pregleda (PROSPERO) pod registracijskim brojem ID CRD420250652038, slijedeći smjernice Preferiranih stavki izvještavanja za sustavne preglede i metaanalize (PRISMA) (19).

Primijenjena je PICO strategija: P – pojedinci; I – zubna impakcija; C – odsutnost zubne impakcije; O – procjena dobi, kako bi se oblikovalo istraživačko pitanje na koje je usredotočena ova studiju: *Utječe li impakcija trećeg kutnjaka na mineralizaciju zuba i, posljedično, na procjenu dobi osobe?*

Sustavno pretraživanje studija obavljeno je u sljedećim bazama podataka: Embase (https://www.embase.com/search/quick), LILACS (https://lilacs.bvsalud.org/), PubMed/MEDLINE (https://pubmed.ncbi.nlm.nih.gov/), SciELO (https://www.scielo.br/), Scopus (https://www.scopus.com/search/form.uri?display=basic#basic) i Web of Science (https://www.webofscience.com/wos/woscc/smart-search). To je učinjeno 10. veljače 2025. i obuhvatilo je studije objavljene od njihova uključivanja u svaku bazu podataka do datuma pretraživanja, bez ograničenja razdoblja objave.

Pretraživane ključne riječi bile su: *određivanje dobi prema zubima*, *određivanje dobi*, *umnjak, treći kutnjak, kalcifikacija zuba* i srodni pojmovi na engleskome, portugalskome i španjolskom jeziku. Pretraživanje je provedeno korištenjem kontroliranih vokabulara Deskriptora u zdravstvenim znanostima (DeCS), Medicinskih predmetnih naslova (MeSH) i Embaseovih predmetnih naslova (Emtree). Za izradu jednadžbi pretraživanja za studije, ove ključne riječi kombinirane su s pomoću Booleovih operatora *ILI* i *I*, a svaka jednadžba pretraživanja pojedinačno je prilagođena prema zahtjevima svake baze podataka (tablica 1.). Iako su pojmovi za pretraživanje primijenjeni na tri navedena jezika, studije objavljene na drugim jezicima, uključujući njemački, pronađene su tijekom pretraživanja baze podataka i zato su uključene u analizu.

Studije su odabrane na temelju kriterija za uključivanje, posebno one u kojima su se autori bavili mineralizacijom trećeg kutnjaka, prisutnošću retiniranih trećih kutnjaka i procjenom dobi na temelju razvoja zuba u adolescentnim i mladim odraslim uzorcima, te potencijalnim utjecajem impakcije na proces mineralizacije ili razvoj trećeg kutnjaka. Nije bilo ograničenja kad je riječ o jeziku članaka ili vrsti korištenoga slikovnog pregleda. Kriteriji za isključivanje obuhvaćali su sustavne preglede, metaanalize, knjige ili poglavlja u knjigama, radove objavljene na znanstvenim konferencijama, disertacije, teze i prikaze slučajeva. Uz to, isključene su studije *in vitro*, studije koje uključuju stanice, životinje ili intervencije lijekovima, te one u kojima su analizirani zubi osim trećeg kutnjaka ili su bili uključeni pedijatrijski uzorci.

Studije preuzete iz pretraživanja baze podataka unesene su u aplikaciju Rayyan (https://www.rayyan.ai/) radi uklanjanja duplikata i implementacije kriterija prihvatljivosti. Nakon toga proveden je proces odabira studija na temelju naslova i sažetka. To su obavila dva neovisna recenzenta, a sva neslaganja među njima raspravljena su i riješena konsenzusom. Recenzenti su neovisno pročitali cijeli tekst uključe-

Table 1 Studies found by database, research language and equations used.
Tablica 1. Pronađene studije prema bazi podataka, jeziku pretraživanja i korištenim jednadžbama

Databases • Baza podataka	Search Language • Jezik pretraživanja	Search Equation • Jednadžba pretraživanja	Quantity of studies found • Broj pronađenih studija
PUBMED/ MEDLINE	English • Engleski	((((((((((„Forensic Odontology")) OR („Forensic Dentistry")) AND („Dental age estimation") OR („age determination by teeth") OR („Age Determination") AND („Molar, Third")) OR („wisdom tooth")) OR („wisdom teeth") OR („third molar")) AND („Tooth development")) OR („Tooth Calcification")))	2,036
	Portuguese • Portugalski	((((((((((„Odontologia Legal")) OR („Odontologia Forense")) AND („Estimativa da idade dental")) AND („Determinação da Idade pelos Dentes")) OR („Determinação da idade")) AND („Dente Serotino")) OR („Dente do Siso")) OR ("Dentes do siso")) OR („Terceiro Molar")) AND („Desenvolvimento dos dentes")) OR („Calcificação de Dente")	0
	Spanish • Španjolski	(((((((„Odontología Legal") OR („Odontología Forense")) AND („Estimación de la edad dental")) OR („Determinación de la Edad por los Dientes")) OR („Determinación de la edad")) AND („Tercer Molar")) OR („Muela de Juicio")) AND („Desarrollo de los dientes")) OR („Calcificación de Dientes") OR („Muela de Juicio") OR („Muelas del juicio") OR („tercer molar") AND („Desarrollo de los dientes") OR („Calcificación de Dientes")	1
WEB OF SCIENCE	English • Engleski	ALL=(„Forensic Odontology") OR ALL=(„Forensic Dentistry") AND ALL=(„Dental age estimation") OR ALL=(„age determination by teeth") OR ALL=(„Age Determination") AND ALL=(„Molar, Third") OR ALL=(„wisdom tooth") OR ALL=(„wisdom teeth") OR ALL=(„third molar") AND ALL=(„Tooth development") OR ALL=(„Tooth Calcification")	2,382
	Portuguese • Portugalski	ALL=(„Odontologia Legal") OR ALL=(„Odontologia Forense") AND ALL=(„Estimativa da idade dental") OR ALL=(„Determinação da Idade pelos Dentes") OR ALL=(„Determinação da idade") AND ALL=(„Dente Serotino") OR ALL=(„Dente do Siso") OR ALL=(„Dentes do siso") OR ALL=(„Terceiro Molar") AND ALL=("Desenvolvimento dos dentes") OR ALL=("Calcificação de Dente")	2
	Spanish • Španjolski	ALL=(„Odontología Legal") OR ALL=(„Odontología Forense") AND ALL=("Estimación de la edad dental") OR ALL=("Determinación de la Edad por los Dientes") OR ALL=("Determinación de la edad") AND ALL=("Tercer Molar") OR ALL=("Muela de Juicio") OR ALL=(„Muelas del Juicio") OR ALL=(„Tercer molar") AND ALL=("Desarrollo de los dientes") OR ALL=("Calcificación de Dientes")	2
LILACS	English • Engleski	(„Forensic Odontology") OR („Forensic Dentistry") AND („Dental age estimation") OR („age determination by teeth") OR („Age Determination") AND („Molar, Third") OR („wisdom tooth") OR („wisdom teeth") OR („third molar") AND („Tooth development") OR („Tooth Calcification")	20
	Portuguese • Portugalski	(„Odontologia Legal") OR („Odontologia Forense") AND („Estimativa da idade dental") OR („Determinação da Idade pelos Dentes") OR („Determinação da idade") AND („Dente Serotino") OR („Dente do Siso") OR („Dentes do siso") OR („Terceiro Molar") AND („Desenvolvimento dos dentes") OR („Calcificação de Dente")	0
	Spanish • Španjolski	(„Odontología Legal") OR („Odontología Forense") AND („Estimación de la edad dental") OR („Determinación de la Edad por los Dientes") OR („Determinación de la edad") AND („Tercer Molar") OR („Muela de Juicio") OR („Muelas del juicio") OR („tercer molar") AND („Desarrollo de los dientes") OR („Calcificación de Dientes")	0
SCOPUS	English • Engleski	"Forensic_Odontology" OR "Forensic_Dentistry" AND "Dental age estimation" OR "age determination_by_teeth" OR "Age Determination" AND "Molar, Third" OR "wisdom_tooth" OR "wisdom_teeth" OR "third molar" AND "Tooth_development" OR „Tooth Calcification"	375
	Portuguese • Portugalski	„Odontologia Legal" OR „Odontologia Forense" AND „Estimativa da idade dental" OR „Determinação da Idade pelos Dentes" OR „Determinação da idade" AND „Dente Serotino" OR „Dente do Siso" OR „Dentes do siso" OR „Terceiro Molar" AND „Desenvolvimento dos dentes" OR „Calcificação de Dente"	0
	Spanish • Španjolski	„Odontología Legal" OR „Odontología Forense" AND „Estimación de la edad dental" OR „Determinación de la Edad por los Dientes" OR „Determinación de la edad" AND „Tercer Molar" OR „Muela de Juicio" OR „Muelas del juicio" OR „Tercer molar" AND „Desarrollo de los dientes" OR „Calcificación de Dientes"	0
EMBASE	English • Engleski	((('forensic odontology' OR 'forensic dentistry') AND 'dental age estimation' OR 'age determination by teeth' OR 'age determination') AND 'molar, third' AND 'wisdom tooth' OR 'wisdom teeth' OR 'third molar') AND 'tooth development' OR 'tooth calcification')	496
	Portuguese • Portugalski	((('odontologia legal' OR 'odontologia forense') AND 'estimativa da idade dental' OR 'determinação da idade pelos dentes' OR 'determinação da idade') AND 'dente serotino' OR 'dente do siso' OR 'dentes do siso' OR 'terceiro molar') AND 'desenvolvimento dos dentes' AND 'calcificação de dente')	0
	Spanish • Španjolski	(('odontología legal' AND oror AND 'odontología forense' AND 'estimación de la edad dental' OR 'determinación de la edad por los dientes' OR 'determinación de la edad') AND 'tercer molar' OR 'muela de juicio' OR 'muelas del juicio' OR 'tercer molar') AND 'desarrollo de los dientes' OR 'calcificación de dientes')	0
SCIELO	English • Engleski	(„Forensic Odontology") OR („Forensic Dentistry") AND („Dental age estimation") OR („age determination by teeth") OR („Age Determination") AND („Molar, Third") AND („wisdom tooth") OR („wisdom teeth") OR („third molar") AND („Tooth development") OR („Tooth Calcification")	0
	Portuguese • Portugalski	(„Odontologia legal") OR ("Odontologia Forense") AND („Estimativa da idade dental") OR (Determinação da Idade pelos Dentes) OR ("Determinação da idade") AND („Dente Serotino") AND ("Dente do Siso") OR ("Dentes do siso") OR (Terceiro Molar") AND ("Desenvolvimento dos dentes") OR ("Calcificação de Dente")	0
	Spanish • Španjolski	(„Odontología Legal") OR („Odontología Forense") AND ("Estimación de la edad dental") OR ("Determinación de la Edad por los Dientes") OR („Determinación de la edad") AND ("Tercer Molar") AND (Muela de Juicio") OR („Muelas del juicio") OR („Tercer molar") AND ("Desarrollo de los dientes") OR ("Calcificación de Dientes")	0

based on title and abstract, respectively. The selection was performed by two independent reviewers, and any disagreements between them were discussed and resolved through consensus meetings. For the included studies, the reviewers independently conducted full-text reading, and any differences regarding the study selection were solved through discussions and analyses of eligibility criteria.

After screening by title, abstract, and full-text reading, the relevant extracted data were tabulated using Microsoft Excel© (Microsoft Corp., Redmond, WA, USA). The extracted information included: study identification, year of publication, study title, scientific journal, sample size, method, country of origin, sex, age, type of tooth and whether an influence of impaction on tooth mineralization was identified.

The risk of bias in the selected studies was independently assessed by the reviewers using the approach proposed by The Joanna Briggs Institute (JBI) (20). For a thorough analysis, the reviewers answered eight pre-established questions, each with four possible responses: "yes," "no," "unclear," or "not applicable." This process allows for a critical appraisal of the studies, ensuring that they meet quality methodological standards.

Accordingly, studies were classified as having a high risk of bias (when the percentage of "yes" responses was less than or equal to 49%), moderate risk of bias (between 50% and 69%), and low risk of bias (greater than 70%). In cases of disagreement between reviewers' responses, the divergences were discussed, resolved, and a consensus response was established. Finally, the risk of bias for each selected study was calculated.

Results

A total of 5,314 studies were identified across the six databases. Among these, 1,280 potential duplicates were identified, of which 715 were confirmed and removed, resulting in 4,599 studies to be screened by title. Following the initial analysis, there was disagreement between reviewers regarding the selection of 12 studies based on their titles. These cases were discussed and solved jointly using the eligibility criteria. As a result, 150 studies were included at this stage, and 4,449 were excluded. The next step was abstract screening, which resulted in 33 studies being selected for full-text reading.

Upon full-text reading, it was found that one study was a systematic review and another literature review; both were only identified at this stage. Access to two studies was requested from the corresponding authors, but no response was received, and ten studies were not fully available in databases, resulting in the exclusion of 14 studies. Thus, a total of 19 studies were initially included for the development of this systematic review. Of these, eight studies were excluded because they addressed the influence of third molar impaction from a purely clinical perspective, which did not align with the purpose of this systematic review. In the end, 11 articles met the inclusion and exclusion criteria and were selected for data extraction and tabulation using Microsoft Excel© (Microsoft Corp., Redmond, WA, USA) (Figure 1).

nih studija, a sve razlike u vezi s odabirom riješene su raspravom i analizom kriterija prihvatljivosti.

Nakon pregleda prema naslovu, sažetku i čitanja cijeloga teksta, relevantni izdvojeni podatci prikazani su u tablici s pomoću programa Microsoft Excel© (Microsoft Corp., Redmond, WA, SAD). Izdvojene informacije uključivale su identifikaciju studije, godinu objave, naziv studije, znanstveni časopis, veličinu uzorka, metodu, zemlju podrijetla, spol, dob, vrstu zuba i je li utvrđen utjecaj impakcije na mineralizaciju zuba.

Koristeći se pristupom koji je predložio Institut Joanna Briggs (JBI) (20), rizik od pristranosti u odabranim studijama neovisno su procijenili recenzenti. Zbog temeljite analize recenzenti su odgovorili unaprijed na osam utvrđenih pitanja, svako s četiri moguća odgovora: *da, ne, nejasno* ili *nije primjenjivo*. Taj proces omogućuje kritičku procjenu studija i osigurava da zadovoljavaju metodološke standarde kvalitete.

U skladu s tim studije su klasificirane kao one s visokim rizikom od pristranosti (kada je postotak odgovora *da* bio manji ili jednak 49 %), umjerenim rizikom od pristranosti (između 50 % i 69 %) i niskim rizikom od pristranosti (većim od 70 %). U slučaju neslaganja između odgovora recenzenata, razlike su raspravljene, riješene i utvrđen je konsenzus. Konačno, izračunat je rizik od pristranosti za svaku odabranu studiju.

Rezultati

Ukupno je identificirano 5314 studija u šest baza podataka. Među njima je identificirano 1280 potencijalnih duplikata od kojih je 715 potvrđeno i uklonjeno, što je rezultiralo s 4599 studija koje su pregledane prema naslovu. Nakon početne analize recenzenti se nisu složili s odabirom 12 studija na temelju njihovih naslova. O tim se slučajevima raspravljalo i zajednički ih se rješavalo korištenjem kriterija prihvatljivosti. Kao rezultat toga, u toj je fazi odabrano 150 studija, a 4449 je isključeno. Sljedeći postupak bio je pregled sažetaka, što je rezultiralo odabirom 33 studije za čitanje cjelovitoga teksta.

Nakon čitanja cjelovitoga teksta utvrđeno je da je jedna studija sustavni pregled, a druga pregled literature; obje su identificirane tek u toj fazi. Od odgovarajućih autora zatražen je pristup dvjema studijama, ali nije primljen odgovor, a deset studija nije bilo u cijelosti dostupno u bazama podataka, pa je isključeno njih 14. Zato je za ovaj sustavni pregled na početku odabrano ukupno 19 studija. Od toga je osam isključeno jer su se bavile utjecajem impakcije trećeg kutnjaka iz isključivo kliničke perspektive, što nije bilo u skladu sa svrhom ovoga pregleda. Na kraju je 11 članaka zadovoljilo kriterije za uključivanje i isključivanje te su odabrani za ekstrakciju podataka i tablični prikaz s pomoću programa Microsoft Excel© (Microsoft Corp., Redmond, WA, SAD) (slika 1.).

Table 2 Data extraction from each study included in the systematic review.
Tablica 2. Izdvajanje podataka iz svake studije uključene u sustavni pregled

Study identification • Studija	Year • odina	Study Title • Naslov	Scientific Journal • Znanstveni časopis	Sample Size • Veličina uzorka	Method • Metoda	
Friedrich *et al.* (6)	2003	The influence of wisdom tooth impaction on root formation.	Annals of anatomy	1,053 orthopantomograms	Demirjian (1973) (13)	
Knell and Schmeling (18)	2010	Influence of impaction on third molar mineralization	Springer-Verlag	1,260 orthopantomograms	Demirjian (1973) (13)	
Lauesen *et al.* (23)	2012	Association between third mandibular molar impaction and degree of root development in adolescents	Angle Orthodontist	132 orthopantomograms*	Haavikko (1970) (24)	
Olze, Otto and Tsokos (21)	2012	Influence of retention on the rate of mineralization of third molars	Springer-Verlag	1,198 orthopantomograms	Demirjian (1973) (13)	
Olze *et al.* (17)	2012	The influence of impaction on the rate of third molar mineralization in male black Africans	International Journal of Legal Medicine	553 orthopantomograms	Demirjian (1973) (13)	
Guo *et al.* (2)	2014	The influence of impaction to the third molar mineralization in northwestern Chinese population	International Journal of Legal Medicine	3,512 orthopantomograms	Demirjian (1973) (13)	
Marchiori *et al.* (8)	2016	Third-molar mineralization as a function of available retromolar space	Acta odontológica scandinavica	69 orthopantomograms	Demirjian (1973) (13)	
Balla *et al.* (22)	2022	Evaluation of the effect of impaction on the mineralization of mandibular third molars and forensic age estimation in a sample of south Indian children	International Journal of Legal Medicine	520 orthopantomograms	Cameriere (2008) (12)	
Gopalaiah *et al.* (25)	2022	Is there any difference in the development of mandibular third molars according to the type of impaction: An orthopantomographic study in south Indian children and adolescents	Legal Medicine	1,112 orthopantomograms	Demirjian (1973) (13)	
Meghana *et al.* (26)	2022	A test to study the influence of impaction on mandibular third molar development and forensic age estimation in a sample of south Indian children and young adults	Legal Medicine	915 orthopantomograms	Demirjian (1973) (13)	
Angelakopoulos *et al.* (27)	2023	Effect of impaction on third molar development and age estimation - A study in a Lebanese population	Morphologies	518 orthopantomograms	Demirjian (1973) (13)	

	Country of sample origin • Zemlja podrijetla uzorka	Sex • Spol	Age • Dob	Type of tooth • Vrsta zuba	Influence of impaction on tooth mineralization • Utjecaj impakcije na mineralizaciju zuba
	Germany	518 females and 513 males	14 - 24 years old	Upper third molar (Right and Left) • Gornji treći kutnjak (desni i lijevi) Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	There are statistically significant differences in root development between impacted and non-impacted third molars. • Postoje statistički značajne razlike u razvoju korijena između impaktiranih i neimpaktiranih trećih kutnjaka.
	1,137 - Switzerland 123 - European Countries	669 females and 591 males	15 - 23 years old	Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	Impacted molars show delayed development compared to teeth that have already erupted. • Impaktirani kutnjaci pokazuju odgođeni razvoj u usporedbi sa zubima koji su već iznikli.
	Denmark	61 females and 71 males	15 years old**	Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	There is a significant association between dental impaction and the developmental stage of the tooth's root structure. • Postoji značajna povezanost između impakcije zuba i razvojne faze korijenske strukture zuba.
	Germany	629 females and 569 males	15 - 40 years old	Upper third molar (Right and Left) • Gornji treći kutnjak (desni i lijevi) Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	Impacted third molars mineralize significantly more slowly than non-impacted ones. • Impaktirani treći kutnjaci mineraliziraju se znatno sporije od neimpaktiranih.
	South Africa	116 females and 437 males	10 - 16 years old	Upper third molar (Right and Left) • Gornji treći kutnjak (desni i lijevi) Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	Impacted lower third molars mineralize more slowly than non-impacted ones. • Impaktirani donji treći kutnjaci mineraliziraju se sporije od neimpaktiranih.
	China	2257 females and 1255 males	11 - 26 years old	Upper third molar (Right and Left) • Gornji treći kutnjak (desni i lijevi) Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	Impacted third molars exhibit a slower rate of mineralization compared to non-impacted third molars. • Impaktirani treći kutnjaci pokazuju sporiju stopu mineralizacije u usporedbi s neimpaktiranim trećim kutnjacima.
	Canada	37 females and 32 males	17 - 24 years old	Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	The mineralization of impacted third molars was significantly delayed in young adults • Mineralizacija impaktiranih trećih kutnjaka bila je značajno usporena kod mladih odraslih osoba.
	India	260 females and 260 males	15 - 21 years old	Upper third molar (Right and Left) • Gornji treći kutnjak (desni i lijevi) Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	Mineralization of impacted third molars was slower in comparison to that of non-impacted third molars. • Mineralizacija impaktiranih trećih kutnjaka bila je sporija u usporedbi s neimpaktiranim trećim kutnjacima.
	India	634 females and 478 males	15 - 22 years old	Upper third molar (Right and Left) • Gornji treći kutnjak (desni i lijevi) Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	There is a delay in the development of third molars based on the type of dental impaction • Postoji kašnjenje u razvoju trećih kutnjaka na temelju vrste zubne impakcije.
	India	543 females and 372 males	15 - 22 years old	Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	Mineralization of impacted lower third molars occurs at a slower rate compared to non-impacted lower third molars. • Mineralizacija impaktiranih donjih trećih kutnjaka sporija je u usporedbi s neimpaktiranim donjim trećim kutnjacima.
	Lebanon	229 females and 289 males	15 - 23.9 years old	Lower third molar (Right and Left) • Donji treći kutnjak (desni i lijevi)	The mineralization of lower third molars is slower in the presence of dental impaction. • Mineralizacija donjih trećih kutnjaka sporija je u prisutnosti zubne impakcije.

*The study began with 607 Danish school-aged children and, after 5 years (with annual visits), 249 patients completed the study. However, only 132 met the inclusion criteria. • Studija je počela sa 607 danske djece školske dobi i poslije 5 godina (s godišnjim posjetima) 249 pacijenata završilo je studiju. Međutim, samo 132 djeteta ispunila su kriterije za uključivanje.
**The patients were followed for 5 years, up to the age of 20. • Pacijenti su praćeni 5 godina, do dobi od 20 godina.

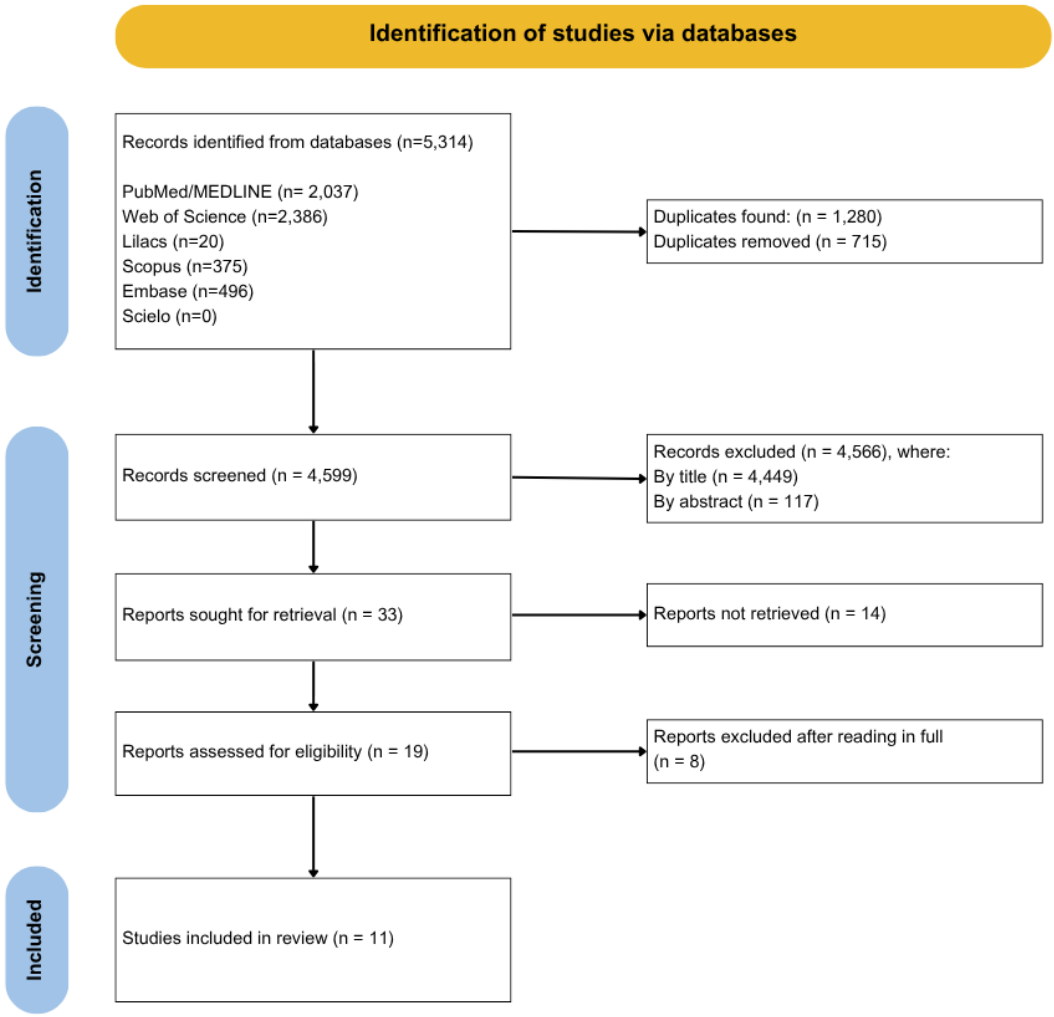

Figure 1 Flowchart adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[19]. The step-by-step process of article selection for inclusion in the systematic review is illustrated.
Slika 1. Dijagram toka prilagoden Preferiranim stavkama izvještavanja za sustavne preglede i metaanalize (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA)[19]; ilustriran je korak-po-korak postupak odabira članaka za uključivanje u sustavni pregled

After data extraction from the 11 studies, it was observed that all of them evaluated third molars. The difference lay in the position of the dental element: six studies assessed both upper and lower third molars, while five studies focused exclusively on lower third molars. Regarding the age range of the individuals analyzed in the article, it is relevant to highlight that the youngest age evaluated was 10 years in the article by Olze *et al.* (2012), (17) while the oldest was 40 years in the study by Olze, Otto and Tsokos (2012) (21). In this regard, it is important to emphasize that, although Olze, Otto, and Tsokos (2012) (21) included individuals up to 40 years of age in their sample, it is expected that by this age the third molar has already completed its development, regardless of whether it is impacted or not. In other words, impaction may cause a delay in the mineralization process, postponing the attainment of the final stage of development, but it does not prevent it from occurring.

Additionally, all studies categorized their samples by sex (female and male), although not in equal proportions except for Balla *et al.* (2022), (22) who presented 260 samples for

Nakon ekstrakcije podataka iz 11 studija, uočeno je da su se u svima procjenjivali treći kutnjaci. Razlika je bila u položaju zubnog elementa: autori njih šest procjenjivali su i gornje i treće donje kutnjake, a autori pet studija usredotočili su se isključivo na treće donje kutnjake. Kad je riječ o dobnoj skupini pojedinaca analiziranih u članku, važno je istaknuti da je najmlađa procjenjivana dob bila 10 godina u članku Olzea i suradnika (2012.) (17), a najstarija je imala 40 godina u studiji Olzea, Otta i Tsokosa (2012.) (21). U tom smislu važno je istaknuti, iako su Olze, Otto i Tsokos (2012.) (21) u svoj uzorak uključili osobe do 40 godina, da je do te dobi treći kutnjak već završio razvoj, bez obzira na to je li impaktiran ili ne. Drugim riječima, impakcija može prouzročiti kašnjenje u procesu mineralizacije i odgoditi završnu fazu razvoja, ali ne sprječava da se to dogodi.

Uz to, u svim studijama uzorci su bili kategorizirani prema spolu (ženski i muški), iako ne u jednakim omjerima, osim u onih Balla i suradnika (2022.) (22) koji su predstavili 260 uzoraka za svaki spol. Kad je riječ o zemlji podrijetla uzoraka, većina studija uključenih u ovaj sustavni pregled

each sex. Regarding the country of origin of the samples, most of the studies included in this systematic review were conducted in India (three studies) and Germany (two studies), while the remaining studies were from Lebanon, Switzerland, China, Canada, South Africa, and Denmark (Table 2).

Furthermore, all studies indicated that dental impaction influences the mineralization of the third molar, resulting in a slower mineralization process compared to non-impacted teeth. In this way, the method proposed by Demirjian *et al*. (1973), (13) was the most frequently used by the studies included in this systematic review. Only one study, conducted by Balla *et al*. (2022), (22) opted for the method proposed by Cameriere *et al*. (2008), (12) and Lausen *et al*. (2013), (23) employed the stages of tooth development by Haavikko *et al*. (1970), (24).

Regarding the type of imaging examination, all studies employed orthopantomographs in their methodology, providing adequate visualization of the maxillomandibular complex. This allows for the analysis of the location and developmental stage of the dental element, as well as the verification of whether impaction is present. Most studies evaluated a considerable quantity of samples, with the study by Guo *et al*. (2014), (2) having the largest sample size (3,512 orthopantomographs), and the smallest sample size was reported in the study by Marchiori *et al*. (2016), (8) which included only 69 samples (Table 2).

Regarding the risk of bias in the studies assessed using the approach proposed by JBI (20), after full-text reading and completion of the eight pre-established questions by the reviewers, it was found that eight studies presented a low risk of bias. Two studies were classified as having a moderate risk of bias, and one study was assessed as having a high risk of bias (Table 3).

Discussion

By the time an individual reaches adulthood, in the second decade of life, the eruptive process of the dentition has typically ceased except for the third molar, which has a prolonged period of development and maturation, and is also susceptible to impaction. According to Balla *et al*. (2022), (22) third molar impaction has a high prevalence in the Indian population, which is relevant when discussing the impact of mineralization on age estimation. In conducting this systematic review, some studies were selected that addressed the potential influence of impaction on the mineralization process or development of the third molar and its applicability in age estimation.

Dental impaction is a dental condition in which teeth do not erupt properly and fail to achieve correct positioning within the oral cavity (28, 29). In general, the third molar shows a higher prevalence of impaction in the lower dental arch (28-32), and it is believed that third molar impaction specifically occurs due to a reduction in mandibular size, thereby preventing proper positioning of the tooth within the dental arch (32).

In 1956, Björk *et al*. (33) investigated the causes of third molar retention using lateral cephalometric radiographs in Swedish male individuals. In the first phase of dental evalprovedena je u Indiji (tri studije) i Njemačkoj (dvije studije), a preostale su bile iz Libanona, Švicarske, Kine, Kanade, Južne Afrike i Danske (tablica 2.).

Nadalje, u svim studijama autori su istaknuli da impakcija zuba utječe na mineralizaciju trećeg kutnjaka, što rezultira sporijim procesom mineralizacije u usporedbi s neimpaktiranim zubima. Na taj način, metoda koju su predložili Demirjian i suradnici (1973.) (13) bila je najčešće korištena u studijama uključenima u ovaj sistematizirani pregled. Autori samo jedne studije, Balla i suradnici (2022.) (22), odlučili su se za metodu koju su predložili Cameriere i suradnici (2008.) (12) te Lausen i suradnici (2013.) (23) a koristila se fazama razvoja zuba koje su proveli Haavikko i suradnici (1970.) (24).

Što se tiče vrste slikovnoga pregleda, u svim su se studijama autori u metodologiji koristili ortopantomogramima jer pružaju adekvatnu vizualizaciju maksilomandibularnoga kompleksa. To omogućuje analizu lokacije i razvojnog stadija zuba te provjeru prisutnosti impakcije. U većini studija procijenjena je značajna količina uzoraka – u studiji Guoe i suradnika (2014.) (2) bilo je najviše uzoraka (3512 ortopantomograma), a najmanja veličina uzorka zabilježena je u studiji Marchiorija i suradnika (2016.) (8) – uključivala je samo 69 uzoraka (tablica 2.).

Kad je riječ o riziku od pristranosti u studijama procijenjenima korištenjem pristupa koji je predložio J.B.I. (20), nakon što su recenzenti pročitali cijeli tekst i odgovorili na osam unaprijed postavljenih pitanja, utvrđeno je da je osam studija u niskom riziku od pristranosti. Dvije studije klasificirane su kao one s umjerenim rizikom, a jedna je procijenjena kao studija s visokim rizikom od pristranosti (tablica 3.).

Rasprava

Do trenutka kada pojedinac dosegne odraslu dob, a to je u drugom desetljeću života, proces erupcije denticije obično prestaje, osim trećeg kutnjaka koji ima produljeno razdoblje razvoja i sazrijevanja te je također podložan impakciji. Prema Balli i suradnicima. (2022.) (22) impakcija trećeg kutnjaka ima visoku prevalenciju u indijskoj populaciji, što je relevantno kada se raspravlja o utjecaju mineralizacije na procjenu dobi. U provedbi ovoga sistematiziranoga pregleda odabrane su studije koje su se bavile potencijalnim utjecajem impakcije na proces mineralizacije ili razvojem trećeg kutnjaka i njegovom primjenjivošću u procjeni dobi.

Zubna impakcija stomatološko je stanje u kojemu zubi ne izniču pravilno i ne uspijevaju postići ispravan položaj unutar usne šupljine (28, 29). Općenito, treći kutnjak pokazuje veću prevalenciju impakcije u donjem zubnom luku (28 – 32), a pretpostavlja se da se impakcija trećeg kutnjaka posebno pojavljuje zbog smanjenja veličine mandibule, čime se sprječava pravilan položaj zuba unutar zubnoga luka (32).

Godine 1956. Björk i suradnici (33) istraživali su uzroke retencije trećeg kutnjaka koristeći se lateralnim kefalometrijskim rendgenskim snimkama švedskih muških ispitanika. U prvoj fazi stomatološke procjene sudionici su imali 12 godina, a u drugoj fazi 20 godina. Cilj je bio procijeniti je li mine-

Table 3 Risk of bias assessment of the selected studies based on the Joanna Briggs Institute Checklist (20), which comprises the following questions: Question 1) Were the criteria for inclusion in the sample clearly defined? Question 2) Were the study subjects and the setting described in detail? Question 3) Was the exposure measured in a valid and reliable way? Question 4) Were the objective, standard criteria used for measurement of the condition? Question 5) Were confounding factors identified? Question 6) Were the strategies to deal with confounding factors stated? Question 7) Were the outcomes measured in a valid and reliable way? Question 8) Was an appropriate statistical analysis used? Possible responses for each question: Yes, No, Unclear, or Not applicable.

Tablica 3. Procjena rizika od pristranosti odabranih studija na temelju kontrolne liste Instituta Joanna Briggs (20) koja sadržava sljedeća pitanja: Pitanje 1) Jesu li kriteriji za uključivanje u uzorak bili jasno definirani? Pitanje 2) Jesu li ispitanici i okruženje detaljno opisani? Pitanje 3) Je li izloženost mjerena na valjan i pouzdan način? Pitanje 4) Jesu li za mjerenje stanja korišteni objektivni, standardizirani kriteriji? Pitanje 5) Jesu li identificirani zbunjujući čimbenici? Pitanje 6) Jesu li navedene strategije za rješavanje zbunjujućih čimbenika? Pitanje 7) Jesu li ishodi mjereni na valjan i pouzdan način? Pitanje 8) Je li korištena odgovarajuća statistička analiza? Mogući odgovori za svako pitanje: DA, NE, Nejasno ili Nije primjenjivo.

Study • Studija	Question 1 • Pitanje 1	Question 2 • Pitanje 2	Question 3 • Pitanje 3	Question 4 • Pitanje 4	Question 5 • Pitanje 5	Question 6 • Pitanje 6	Question 7 • Pitanje 7	Question 8 • Pitanje 8	Percentage of "Yes" (%) • Postotak *da* (%)	Risk of bias • Rizik od pristranosti
Friedrich *et al.* (2003) (6)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	No • Ne	No • Ne	Yes • Da	62.5%	Moderate • Umjeren
Knell and Schmeling (2010) (18)	No • Ne	Yes • Da	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	Yes • Da	75.00%	Low • Nizak
Lauesen *et al.* (1970) (23)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	Yes • Da	Yes • Da	Yes • Da	87.5%	Low • Nizak
Olze, Otto and Tsokos (2012) (21)	No • Ne	Yes • Da	No • Ne	Yes • Da	No • Ne	No • Ne	No • Ne	No • Ne	25%	High • Visok
Olze *et al.* (2012) (17)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	No • Ne	No • Ne	No • Ne	50%	Moderate • Umjeren
Guo *et al.* (2014) (2)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	Yes • Da	Not applicable • Nije primjenjivo	Yes • Da	Yes • Da	87.5%	Low • Nizak
Marchiori *et al.* (2016) (8)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	No • Ne	Yes • Da	Yes • Da	75%	Low • Nizak
Balla *et al.* (2022) (22)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	Yes • Da	Not applicable • Nije primjenjivo	Yes • Da	Yes • Da	87.5%	Low • Nizak
Gopalaiah *et al.* (2022) (25)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	No • Ne	Yes • Da	Yes • Da	75%	Low • Nizak
Meghana *et al.* (2022) (26)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	No • Ne	Yes • Da	Yes • Da	75%	Low • Nizak
Angelakopoulos *et al.* (2023) (27)	Yes • Da	Yes • Da	Yes • Da	Yes • Da	No • Ne	No • Ne	Yes • Da	Yes • Da	75%	Low • Nizak

uation, the participants were 12 years old, and in the second phase they were 20 years old. The objective was to assess whether the mineralization of the retained teeth was significantly delayed (33). More recently, Idris *et al.* (2021), (32), emphasized that the causes of dental impaction may range from skeletal growth patterns to dietary habits.

According to Marchiori *et al.* (2016), there is a correlation between the lack of space in the dental arches for root development—particularly the absence of space in the retromolar region—and the impaction of the lower third molar. Furthermore, this study found that such impaction affects the rate of the mineralization process. Gopalaiah *et al.* (2022), (25) analyzed the relationship between eruption delay and the type of impaction, but this association proved to be weak and not significant in some of the developmental stages assessed. Other studies, such as those by Friedrich *et al.* (2003) (6), Meghana *et al.* (2022) (26), Guo *et al.* (2014) (2), Balla *et al.* (2022) (22), and Olze *et al.* (2010) (18), investigated additional contributing factors. These include the ralizacija retiniranih zuba značajno odgođena (33). Nedavno su Idris i suradnici (2021.) (32) istaknuli da uzroci zubne impakcije mogu varirati od modela rasta kostura do prehrambenih navika.

Prema Marchioriju i suradnicima (2016.) (8) postoji korelacija između nedostatka prostora u zubnim lukovima za razvoj korijena, posebno u retromolarnoj regiji, što rezultira impakcijom trećega donjeg kutnjaka i posljedično utječe na brzinu procesa mineralizacije. Gopalaiah i suradnici (2022.) (25) analizirali su odnos između odgode erupcije i vrste impakcije, ali ta se povezanost pokazala slabom i beznačajnom u nekim od procijenjenih razvojnih faza. U drugim studijama, poput onih Friedricha i suradnika (2003.), (6); Meghana i suradnika (2022.) (26); Guoa i suradnika (2014.) (2); Balla i suradnika (2022.) (22) i Olzea i suradnika (2010.) (18) istraživani su dodatni čimbenici koji tome pridonose, uključujući fazu mineralizacije trećeg kutnjaka, veličinu krune, položaj mandibule, genetske čimbenike, raspoloživi prostor i pojedinačne faze skeletalnog sazrijevanja. Dakle, iako su se

mineralization stage of the third molar, crown size, mandibular positioning, genetic factors, available space, and individual stages of skeletal maturation. Thus, although all studies addressed the prolonged time required for third molar development, the influence of dental impaction on mineralization rate remains a subject of ongoing debate, as discussed by the authors across different population groups and using varied methodologies (2, 6, 8, 18, 21-23, 25-27).

Lauesen *et al*. (2013), (23), applied the method proposed by Haavikko *et al*. (1970), (24), which evaluates 12 stages of dental development; six related to crown formation and six to root development. Meanwhile, Balla *et al*. (2022), (22), used the method introduced by Cameriere *et al*. (2008), (12), which estimates dental maturation by measuring tooth length and the openings of the root apices. The remaining studies applied the method proposed by Demirjian *et al*. (1973) (13), based on the process of tooth mineralization. This method was originally developed for dental age estimation using seven permanent mandibular teeth, excluding third molars. Its widespread use may be attributed to the possibility of assessing the effect of impaction at each developmental stage defined in the classification. However, it is important to distinguish between the original method and Demirjian's developmental scale (stages A–H), which describes general phases of tooth mineralization and is not tooth-specific. Thus, although the original method did not include third molars, the developmental scale can be applied to them, thereby extending the applicability of mineralization-based dental age estimation.

In total, eight studies adopted this methodology, applying the developmental scale described by Demirjian *et al*. (1973), (13) to evaluate the stage of development of the third molars (2,6,17,18,21,25,26,27). As shown in Table 2, most studies found an influence of dental impaction on mineralization. However, studies (2, 6, 17, 18, 21, 25, 26, 27) that applied the method proposed by Demirjian et al. (1973) (13) reported only small differences between developmental stages in both impacted and non-impacted teeth. The study conducted by Guo *et al*. (2022), (2) in a population from northwest China, which employed Demirjian's method (13), showed that the mean ages of individuals with impacted third molars at stages C-H were higher than those with non-impacted third molars. The results demonstrated that impacted third molars in the Chinese population reached mineralization stages C–H later than non-impacted molars, reflecting delayed mineralization associated with impaction. Similarly, Meghana *et al*. (2022), (26) demonstrated that there was a developmental delay in impacted molars compared to non-impacted ones in stages D-H of the Demirjian´s developmental scale method (13).

Thus, it is evident that each study demonstrated some degree of influence of impaction on the mineralization process, whether to a greater or lesser extent but at different stages of the Demirjian´s developmental scale method (13). These differences in the point at which impaction interfere with third molar mineralization may be attributed to sociogeographic variations among the populations analyzed (34, 35) (Table 2). Guo *et al*. (2014), (2) for example examined a population

autori svih studija bavili produljenim vremenom potrebnim za razvoj trećeg kutnjaka, utjecaj zubne impakcije na brzinu mineralizacije ostaje predmet rasprave, čime se bave autori u različitim populacijskim skupinama koristeći se različitim metodologijama (2, 6, 8, 18, 21 – 23, 25 – 27).

Lauesen i suradnici (2013.) (23) primijenili su metodu koju su predložili Haavikko i suradnici (1970.) (24) kojom se procjenjuje 12 faza razvoja zuba – šest se odnosi na formiranje krune, a šest na razvoj korijena. U međuvremenu su se Balla i suradnici (2022.) (22) koristili metodom koju su uveli Cameriere i suradnici (2008.) (12), a kojom se procjenjuje zrelost zuba mjerenjem njegove duljine i otvora vrha korijena. U preostalim studijama autori su primjenjivali metodu koju su predložili Demirjian i suradnici (1973.) (13), a temelji se na procesu mineralizacije zuba. Ta je metoda izvorno razvijena za procjenu dobi zuba korištenjem sedam donjih trajnih zuba, isključujući treće kutnjake. Njezina široka upotreba može se pripisati mogućnosti procjene učinka impakcije u svakoj razvojnoj fazi definiranoj u klasifikaciji. No važno je razlikovati izvornu metodu od Demirjianove razvojne ljestvice (faze A – H) koja opisuje opće faze mineralizacije zuba i nije specifična za zub. Dakle, iako izvorna metoda nije uključivala treće kutnjake, razvojna ljestvica može se primijeniti na njih, čime se proširuje primjenjivost procjene dobi zuba na temelju mineralizacije.

Ukupno je u osam studija usvojena ova metodologija i primijenjena je razvojna ljestvica koju su opisali Demirjian i suradnici (1973.) (13) za procjenu stupnja razvoja trećih kutnjaka (2, 6, 17, 18, 21, 25, 26, 27). Kao što se vidi u tablici 2., u većini studija otkriven je utjecaj impakcije zuba na mineralizaciju. Međutim, u studijama (2, 6, 17, 18, 21, 25, 26, 27) u kojima su autori primijenili metodu koju su predložili Demirjian i suradnici (1973.) (13) izviješteno je samo o malim razlikama između razvojnih stadija i kod impaktiranih i kod neimpaktiranih zuba. Studija koju su proveli Guo i suradnici (2022.) (2) u populaciji iz sjeverozapadne Kine, a u kojoj su se koristili Demirjianovom metodom (13), pokazala je da je prosječna dob pojedinaca s impaktiranim trećim kutnjacima u stadijima C – H bila viša od onih s neimpaktiranim trećim kutnjacima. Rezultati su pokazali da su impaktirani treći kutnjaci u kineskoj populaciji dosegnuli stadij mineralizacije C – H kasnije od neimpaktiranih kutnjaka, što odražava odgođenu mineralizaciju povezanu s impakcijom. Slično tomu, Meghana i suradnici (2022.) (26) pokazali su da postoji razvojno kašnjenje impaktiranih kutnjaka u usporedbi s neimpaktiranima u fazama D – H Demirjianove metode razvojne ljestvice (13).

Dakle, očito je da su autori svake studije pokazali određeni stupanj utjecaja impakcije na proces mineralizacije, bilo u većoj ili manjoj mjeri, ali u različitim fazama Demirjianove metode razvojne ljestvice (13). Te razlike u točki u kojoj impakcija ometa mineralizaciju trećeg kutnjaka mogu se pripisati sociogeografskim varijacijama među analiziranim populacijama (34, 35) (tablica 2.). Guo i suradnici (2014.) (2) ispitali su, primjerice, populaciju iz sjeverozapadne Kine i otkrili da se impaktirani treći kutnjaci mineraliziraju sporije od neimpaktiranih. Taj nalaz bio je sličan onima zabilježenim u europskim populacijama koje su proučavali Knell

from northwest China and found that impacted third molars mineralized more slowly than non-impacted ones. This finding was similar to those reported in European populations studied by Knell and Schmeling (2010), (18) in African male populations analyzed by Olze *et al*. (2012), (17) and in the Lebanese population investigated by Angelakopoulos *et al*. (2023), (27).

In addition, a difference in impaction between lower and upper third molars was observed in several studies (8, 17, 26, 27), with a higher prevalence of impaction in the lower third molars. Regarding the type of tooth selected for analysis, some studies focused exclusively on the lower third molars, such as those by Angelakopoulos *et al*. (2023), (27); Meghana *et al*. (2022), (26); Marchiori *et al*. (2016), (8) and Knell and Schmeling (2010), (18) (Table 2). Studies that examined all four third molars such as Gopalaiah *et al*. (2022),(25); Guo *et al*. (2014), (2); Friedrich *et al*. (2003), (6); Balla *et al*. (2022), (22); Olze *et al*. (2012), (17) and Olze, Otto and Tsokos (2012), (21) did not identify significant differences specifically in impacted upper third molars, but rather confirmed a tendency for impaction to occur more frequently in the lower third molars (22) (Table 2).

Friedrich *et al*. (2003), (6) analyzed all four third molars, focusing on the differences in root mineralization. Their study demonstrated that upper molars are more advanced than their antagonists, completing their full development approximately six months earlier.

The most recent study included in this review that met the eligibility criteria was conducted by Angelakopoulos *et al*. (2023), (27) using a sample from the Lebanese population, while the earliest study was by Friedrich *et al*. (2003), (6) based on a German population. Both studies confirmed the effect of impaction on third molar mineralization in their respective populations, the former in relation to the entire dental element, and the latter specifically in relation to the root. However, in the study by Angelakopoulos *et al*. (2023), (27) the difference in mineralization timing between impacted and non-impacted third molars was not statistically significant.

Furthermore, Angelakopoulos *et al*. (2023), (27) observed that dental impaction holds greater relevance for clinical practice in dentistry than for its application in dental age estimation. This is because, in forensic analysis, preference is given to non-impacted teeth, as they are more likely to exhibit normal developmental patterns, thereby allowing the chosen methodology to be applied with greater reliability (27).

It is evident that the mineralization process of the third molar in age estimation has been studied for a long time, using various methodologies and across different populations (2, 6, 17, 18, 21, 25, 26, 27, 36). Research such as Shi *et al.* (2024) (37) that compare the methods of Olze, Haavikko, and Demirjian show that methodological accuracy can vary considerably according to the population, thus highlighting the importance of specific validations for each group.

Therefore, when analyzing different populations, the applied methodology may or may not exhibit adequate compatibility and accuracy. Its precision can be influenced by factors such as geographic region, age range, and sex, as well as the presence of syndromes or other systemic conditions that

i Schmeling (2010.) (18), u afričkim muškim populacijama koje su analizirali Olze i suradnici (2012.) (17) i u libanonskoj populaciji koju su istraživali Angelakopoulos i suradnici (2023.) (27).

Uz to, razlika u impakciji između donjih i gornjih trećih kutnjaka uočena je u nekoliko studija (8, 17, 26, 27), s većom prevalencijom impakcije u donjim trećim kutnjacima. Kad je riječ o vrsti zuba odabranog za analizu, u nekim su se studijama autori usredotočili isključivo na treće donje kutnjake, poput Angelakopoulosa i suradnika (2023.) (27); Meghana i suradnika (2022.) (26); Marchiorija i suradnika (2016.) (8) te Knella i Schmeling (2010.) (18) (tablica 2.). Studije u kojima su ispitivana sva četiri treća kutnjaka poput Gopalaiaha i suradnika (2022.) (25); Guoa i suradnika (2014.) (2); Friedricha i suradnika (2003.) (6); Balla i suradnika (2022.) (22); Olzea i suradnika (2012.) (17) te Olzea, Otta i Tsokosa (2012.) (21) nisu utvrđene značajne razlike, posebno kod retiniranih gornjih trećih kutnjaka, nego je potvrđena tendencija češćeg pojavljivanja impakcije kod donjih trećih kutnjaka (22) (tablica 2.).

Friedrich i suradnici (2003.) (6) analizirali su sva četiri treća kutnjaka, usredotočujući se na razlike u mineralizaciji korijena. U svojoj su studiji pokazali da su gornji kutnjaci napredniji od svojih antagonista i dovršavaju svoj puni razvoj otprilike šest mjeseci ranije.

Najnoviju studiju uključenu u ovaj pregled koja je zadovoljila kriterije prihvatljivosti proveli su Angelakopoulos i suradnici (2023.) (27) koristeći se uzorkom iz libanonske populacije, a najraniju su proveli Friedrich i suradnici (2003.) (6) na temelju njemačke populacije. U objema je potvrđen učinak impakcije na mineralizaciju trećeg kutnjaka u ispitivanim populacijama, prva u odnosu na cijeli zub, a druga posebno u odnosu na korijen. No u studiji Angelakopoulosa i suradnika (2023.) (27) razlika u vremenu mineralizacije između impaktiranih i neimpaktiranih trećih kutnjaka nije bila statistički značajna.

Nadalje, Angelakopoulos i suradnici (2023.) (27) uočili su da je impakcija zuba važnija za kliničku praksu u stomatologiji nego za njezinu primjenu u procjeni dobi zuba. To je zato što se u forenzičkoj analizi prednost daje neimpaktiranim zubima jer je veća mogućnost da će pokazivati normalne razvojne modele, što omogućuje primjenu odabrane metodologije s većom pouzdanošću (27).

Očito je da se proces mineralizacije trećeg kutnjaka u procjeni dobi proučava već dugo i da se koriste različite metodologije i u različitim populacijama (2, 6, 17, 18, 21, 25, 26, 27, 36). Istraživanja poput Shija i suradnika (2024.) (37) u kojima se uspoređuju metode Olzea, Haavikka i Demirjiana pokazuju da metodološka točnost može znatno varirati ovisno o populaciji, ističući važnost specifičnih validacija za svaku skupinu.

Zato, tijekom analize različitih populacija, primijenjena metodologija može, ali i ne mora pokazati odgovarajuću kompatibilnost i točnost. Na njezinu preciznost mogu utjecati čimbenici poput geografske regije, dobne skupine i spola, te također prisutnost sindroma ili drugih sistemskih stanja koja utječu na razvoj zuba. Posljedično, specifične karakteristike populacije, poput regionalnih varijacija, razlika u do-

affect dental development. Consequently, specific population characteristics, such as regional variations, age differences, as observed in the study by Olze, Otto, and Tsokos (2012) (21); sexual dimorphism, or alterations associated with systemic diseases, may result in distinct patterns of third molar development. In this context, Pereira *et al.* (2019) (38) aimed to estimate the chronological age of a population with special needs, recognizing that certain syndromes and clinical conditions can modify the expected pattern of dental mineralization, which may impact the application and interpretation of age estimation methods.

Thus, impaction of this tooth and its associated slowing effect on mineralization may influence the accuracy of age estimation methods. Most of the studies included in this systematic review confirm this association, although the impaction occurs at different stages of dental development depending on the population analyzed (2, 6, 17, 18, 21-23, 25-27, 34).

However, the factor responsible for this effect on mineralization may be related to specific genetic or phenotypic characteristics of each population analyzed (2, 6,8,17, 21, 22, 25-27). Another perspective is the possibility that human evolution is moving toward the eventual disappearance of this organ. Studies such as those by Björk *et al*. (1956), (33); Carter and Worthington (2015), (39); Marchiori *et al*. (2016), (8); Raloti *et al*. (2013), (40); Scheiwiller *et al*. (2020), (41) and Kanavakis *et al*. (2024), (42) the retromolar space and how the reduction in mandibular size affects the eruption of this tooth into the dental arch, potentially resulting in impaction, dental anomalies, and agenesis of this tooth. Nevertheless, the exact determinant responsible for the differences observed among populations regarding mineralization stages, particularly the delayed development of impacted third molars, remains unclear (2,6,17,18,21-23,25-27,34-36,43).

A systematic review and meta-analysis conducted by Balla *et al*. (2025) (44) addressed the effect of impaction on the mineralization of third molars, with a focus on forensic age estimation. The study reached a conclusion similar to the present study: impaction delays the development of the lower third molar compared to non-impacted teeth. This delay in maturation time is consistently reported in the studies analyzed (2, 6, 8, 17, 18, 21, 22, 25-27).

Our systematic review and the study published by Balla *et al*. (2025), (44) address the same topic, although Balla *et al*. (2025), (44) formulated a different research question. Both investigations searched similar databases, including PubMed/MEDLINE, Embase, SciELO, Scopus, and Web of Science. The main methodological difference is that the present review also included the Lilacs database, whereas Balla *et al*. (2025), (44) consulted the Open Access Theses and Dissertations (OATD). Minor discrepancies in the number of retrieved articles are further explained by the use of different keywords in each search strategy. In our systematic review, a meta-analysis was not performed due to the limited number of articles identified and considered potentially eligible for such an analysis.

Despite these differences, it is important to highlight that both, our study and that of Balla *et al*. (2025), (44) demonstrate that impacted third molars exhibit a slower process of bi, kao što je uočeno u studiji Olzea, Otta i Tsokosa (2012.) (21); spolni dimorfizam ili promjene povezane sa sistemskim bolestima, mogu rezultirati različitim obrascima razvoja trećeg kutnjaka. U tom kontekstu su Pereira i suradnici (2019.) (38) imali za cilj procijeniti kronološku dob populacije s posebnim potrebama jer su prepoznali da određeni sindromi i klinička stanja mogu modificirati očekivani način mineralizacije zuba, što može utjecati na primjenu i tumačenje metoda za procjenu dobi.

Dakle, impakcija ovoga zuba i s njom povezani učinak usporavanja mineralizacije mogu utjecati na točnost metoda za procjenu dobi. U većini studija uključenih u ovaj sistematizirani pregled potvrđena je ta povezanost, iako se impakcija pojavljuje u različitim fazama razvoja zuba, ovisno o populaciji (2, 6, 17, 18, 21-23, 25-27, 34).

Međutim, faktor odgovoran za ovaj učinak na mineralizaciju može biti povezan sa specifičnim genetskim ili fenotipskim karakteristikama svake analizirane populacije (2, 6,8,17, 21, 22, 25-27). Druga perspektiva je mogućnost da se ljudska evolucija kreće prema konačnom nestanku ovog organa. Studije poput onih Björka i sur. (1956.), (33); Cartera i Worthingtona (2015.), (39); Marchiorija i sur. (2016.), (8); Ralotija i sur. (2013.), (40); Scheiwillera i sur. (2020.), (41) i Kanavakisa i sur. (2024.), (42) retromolarni prostor i kako smanjenje veličine mandibule utječe na nicanje ovog zuba u zubni luk, što potencijalno rezultira impakcijom, zubnim anomalijama i agenezom ovog zuba. Ipak, točan odrednik odgovoran za razlike uočene među populacijama u pogledu faza mineralizacije, posebno odgođenog razvoja retiniranih trećih kutnjaka, ostaje nejasan (2,6,17,18,21-23,25-27,34-36,43).

Sustavni pregled i meta-analiza koju su proveli Balla i suradnici (2025.) (44) bavili su se učinkom impakcije na mineralizaciju trećih kutnjaka, s naglaskom na forenzičku procjenu dobi. Studija je došla do zaključka sličnog sadašnjoj studiji: impakcija odgađa razvoj donjeg trećeg kutnjaka u usporedbi s neimpaktiranim zubima. Ovo kašnjenje u vremenu sazrijevanja dosljedno se navodi u analiziranim studijama (2, 6, 8, 17, 18, 21, 22, 25-27).

Naš sustavni pregled i studija koju su objavili Balla i sur. (2025.), (44) bave se istom temom, iako su Balla i sur. (2025.), (44) formulirali drugačije istraživačko pitanje. Oba istraživanja pretraživala su slične baze podataka, uključujući PubMed/MEDLINE, Embase, SciELO, Scopus i Web of Science. Glavna metodološka razlika je u tome što je sadašnji pregled također uključivao bazu podataka Lilacs, dok su Balla i sur. (2025.), (44) konzultirali teze i disertacije otvorenog pristupa (OATD). Manje razlike u broju pronađenih članaka dodatno se objašnjavaju korištenjem različitih ključnih riječi u svakoj strategiji pretraživanja. U našem sustavnom pregledu, meta-analiza nije provedena zbog ograničenog broja identificiranih članaka koji se smatraju potencijalno prikladnima za takvu analizu.

Unatoč tim razlikama, važno je istaknuti da i naša studija i ona Balle i suradnika (2025.), (44) pokazuju da impaktirani treći kutnjaci pokazuju sporiji proces razvoja i sazrijevanja zuba. Stoga se odgođena mineralizacija povezana s impakcijom trećeg kutnjaka mora uzeti u obzir kada se ovaj

dental development and maturation. Therefore, the delayed mineralization associated with third molar impaction must be taken into account when this tooth is used in age estimation methodologies. In other words, impacted third molars should not be preferred for analysis in forensic assessments, especially when other options are available (27). This delay in the mineralization process may influence the size of the pulp chamber, root pulp, root formation time, and apical closure, all of which are features commonly used in dental age estimation methods (2,6,17,18,21-23,25-27,36).

Methods such as those of Cameriere *et al*. (2008), (12) which perform measurements of root apex openings and tooth length; those of Köhler *et al*. (1994), (10) and Gunst *et al*. (2003), (11) both based on root development observed in orthopantomographs and on the classification of root formation stages and apical closure; and the method of Demirjian *et al*. (1973), (13) which uses crown and root formation stages, are proposed methods for age estimation based on the third molar tooth. The latter was adopted by most studies included in this systematic review to identify at which stage of development impaction acted as a factor in slowing down the mineralization process.

Conclusion

It can be concluded that third molar impaction may be associated with delayed dental mineralization, although the current scientific evidence remains inconsistent. Consequently, caution is advised when using impacted third molars as indicators for dental age estimation, as their use may lead to underestimation of chronological age.

Acknowledgments: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Funding Sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest: All authors declare that they have no conflict of interest.

Author Contributions: **PRR**: Writing – original draft, Data curation, Investigation, Visualization. **MCP**: Writing – original draft, Data curation, Investigation. **RHAS**: Conceptualization, Writing – review & editing, Formal analysis, Supervision. **PHVP**: Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision.

zub koristi u metodologijama procjene starosti. Drugim riječima, impaktirani treći kutnjaci ne bi trebali biti preferirani za analizu u forenzičkim procjenama, posebno kada su dostupne druge opcije (27). Ovo kašnjenje u procesu mineralizacije može utjecati na veličinu pulpne komore, korijenske pulpe, vrijeme formiranja korijena i apikalno zatvaranje, što su sve značajke koje se obično koriste u metodama procjene starosti zuba (2,6,17,18,21-23,25-27,36).

Metode poput onih Cameriere i suradnika (2008.), (12) koje provode mjerenja otvora korijenskog vrha i duljine zuba; one Köhlera i suradnika (1994.), (10) i Gunsta i suradnika (2003.), (11) obje temeljene na razvoju korijena uočenom na ortopantomografima i na klasifikaciji faza formiranja korijena i apikalnog zatvaranja; i metoda Demirjiana i suradnika (1973.), (13) koja koristi faze formiranja krunice i korijena, predložene su metode za procjenu starosti na temelju trećeg kutnjaka. Potonju je usvojila većina studija uključenih u ovaj sustavni pregled kako bi se utvrdilo u kojoj fazi razvoja je impakcija djelovala kao faktor usporavanja procesa mineralizacije.

Zaključak

Može se zaključiti da impakcija trećeg kutnjaka može biti povezana s odgođenom mineralizacijom zuba, iako su trenutačni znanstveni dokazi i dalje nedosljedni. Zato se savjetuje oprez pri korištenju impaktiranih trećih kutnjaka kao pokazatelja za dentalnu procjenu dobi jer njihova upotreba može rezultirati podcjenjivanjem kronološke dobi.

Zahvala: Ovu studiju djelomično je financirao Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – financijski kod 001.

Izvori financiranja: Ovo istraživanje nije dobilo nikakva posebna sredstva od agencija za financiranje u javnom, komercijalnom ili neprofitnom sektoru.

Izjava o sukobu interesima: Autori nisu bili u sukobu interesa.

Doprinos autora: **P. R. R.** – izvorni nacrt, kuriranje podataka, istraživanje, vizualizacija; **M. C. P.** – izvorni nacrt, kuriranje podataka, istraživanje; **R. H. A. S.** – konceptualizacija, pisanje teksta, uređivanje, formalna analiza, nadzor; **P. H. V. P.** – konceptualizacija, metodologija, formalna analiza, pisanje teksta, uređivanje, nadzor.

Sažetak

Dentalna procjena dobi relevantan je postupak u forenzičkoj stomatologiji, ali s godinama postaje sve izazovnija. U takvim slučajevima uzimaju se u obzir treći kutnjaci zato što su posljednji zubi koji završavaju proces rasta i razvoja. No uočeno je da ti zubi imaju najveću stopu impakcije. **Svrha rada:** Cilj ovoga sistematiziranoga pregleda bio je procijeniti utječe li impakcija na proces mineralizacije trećih kutnjaka i može li to stanje na utjecati na točnost metoda za procjenu dobi. **Metode:** Pretraživanje je obavljeno u bazama podataka Embase, LILACS, PubMed/MEDLINE, SciELO, Scopus i Web of Science, a koristili su se pojmovi povezani s temom na portugalskome, engleskome i španjolskom jeziku. Dva neovisna procjenjivača primijenila su kriterije prihvatljivosti za odabir i evaluaciju relevantnih članaka. **Rezultati:** Nakon odabira prema naslovu, sažetku i čitanju cijeloga teksta odabrano je 11 članaka. Rizik od pristranosti analiziran je s pomoću kontrolne liste koju je predložio Institut Joanna Briggs. Ekstrakcija podataka otkrila je da su proučavane populacije bile iz Indije, Njemačke, Libanona, Švicarske, Kine, Kanade, Južne Afrike i Danske. U svim studijama spolovi su bili odvojeni, iako su veličine uzorka bile različite, osim jedne u kojoj je korišten jednak broj od 260 ortopantomograma za svaki spol. Nadalje, u svim studijama istaknuto je da zubna impakcija, bez obzira na stupanj, utječe na mineralizaciju zuba. **Zaključak:** Zaključno, impakcija trećeg kutnjaka može odgoditi proces mineralizacije zuba, što upućuje na to da se ti zubi, kada su impaktirani, ne bi trebali smatrati prvim izborom za metode procjene dobi.

Zaprimljen: 4. prosinca 2025.
Prihvaćen: 29. ožujka 2026.

Adresa za dopisivanje
Paulo Henrique Viana Pinto
Av. do Café, s/n. USP- Faculdade de Medicina de Ribeirão Preto, Departamento de Patologia e Medicina Legal.
Campus da USP, Ribeirão Preto - SP, 14040-900.
paulohenriquevp@hotmail.com

MeSH pojmovi: određivanje dobi pomoću zubi; umnjak; uklješteni zub
Autorske ključne riječi: forenzička stomatologija, dentalna procjena dobi, treći kutnjak, impaktirani zub, kalcifikacija zuba

References

1. Lewis JM, Senn DR. Dental age estimation utilizing third molar development: a review of principles, methods, and population studies used in the United States. Forensic Sci Int. 2010 Sep;201(1-3):79-83.
2. Guo YC, Yan CX, Lin XW, Zhang WT, Zhou H, Pan F, et al. The influence of impaction to the third molar mineralization in northwestern Chinese population. Int J Legal Med. 2014 Jul;128(4):659-665.
3. Logan WHG, Kronfeld R. Development of the human jaws and surrounding structures from birth to the age of fifteen years. J Am Dent Assoc. 1933 Jan;20:37.
4. Nolla CM. The development of the permanent teeth. J Dent Child. 1960;27:254-266.
5. Clow IM. A radiographic survey of third molar development: a comparison. Br J Orthod. 1984 Feb;11:9-15.
6. Friedrich RE, Ulbricht C, von Maydell LA. The influence of wisdom tooth impaction on root formation. Ann Anat. 2003 Sep;185(5):481-492.
7. Moyers RE, Burdi AR. Development of the dentition and occlusion. In: Moyers RE, editor. Handbook of Orthodontics. 4th ed. Chicago: Year Book Medical Publishers; 1988. p. 99-146.
8. Marchiori DF, Packota GV, Boughner JC. Third-molar mineralization as a function of available retromolar space. Acta Odontol Scand. 2016 Oct;74(7):509-517.
9. Liversidge HM. Timing of human mandibular third molar formation. Ann Hum Biol. 2008 May-Jun;35:294-321.
10. Köhler S, Schmelzle R, Loitz C, Püschel K. Die Entwicklung des weisheitszahnes als kriterium der lebensaltersbestimmung. Ann Anat. 1994 Jul;176(4):339-345.
11. Gunst K, Mesotten K, Carbonez A, Willems G. Third molar root development in relation to chronological age: a large sample sized retrospective study. Forensic Sci Int. 2003 Sep;136(1-3):52-57.
12. Cameriere R, Ferrante L, De Angelis D, Scarpino F, Galli F. The comparison between measurement of open apices of third molars and Demirjian stages to test chronological age of over 18 year olds in living subjects. Int J Legal Med. 2008 Nov;122(6):493-497.
13. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973 May;45:211-227.
14. Thorson J, Hägg U. The accuracy and precision of the third mandibular molar as an indicator of chronological age. Swed Dent J. 1991;15:15-22.
15. Mincer HH, Harris EF, Berryman HE. The A.B.F.O. study of third molar development and its use as an estimator of chronological age. J Forensic Sci. 1993 Mar;38:379-390.
16. Kaban LB, Needleman HL, Hertzberg J. Idiopathic failure of eruption of permanent molar teeth. Oral Surg Oral Med Oral Pathol. 1976 Aug;42:155-163.
17. Olze A, Van Niekerk P, Schulz R, Ribbecke S, Schmeling A. The influence of impaction on the rate of third molar mineralisation in male black Africans. Int J Legal Med. 2012 Nov;126(6):869-874.
18. Knell B, Schmeling A. Einfluss der Retention auf die Weisheitszahnmineralisation. Rechtsmedizin. 2010 Dec;20(6):469-474.
19. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021 Mar;372:n71.
20. Joanna Briggs Institute. Checklist for analytical cross sectional studies [Internet]. 2020 [cited 2026 May 6]. Available from: https://jbi.global/critical-appraisal-tools
21. Olze A, Otto A, Tsokos M. Einfluss der Retention auf die Mineralisationsgeschwindigkeit dritter Molaren. Rechtsmedizin. 2012 Apr;22(2):110-114.
22. Balla SB, Kollata VRS, Bathala V, Ganapathy SK, Ch G, Vedula PBST, et al. Evaluation of the effect of impaction on the mineralization of mandibular third molars and forensic age estimation in a sample of South Indian children. Int J Legal Med. 2022 May;136(3):861-869.
23. Lauesen SR, Andreasen JO, Gerds TA, Christensen SSA, Borum M, Hillerup S. Association between third mandibular molar impaction and degree of root development in adolescents. Angle Orthod. 2013 Jan;83(1):3-9.
24. Haavikko K. The formation and the alveolar and clinical eruption of the permanent teeth. Suom Hammaslääk Toim. 1970;6:103-170.
25. Gopalaiah H, Gurram A, Chaitanya NCSK, Sharma S, Gattu A, Rathore K, et al. Is there any difference in the development of mandibular third molars according to the type of impaction? Legal Med. 2022 Jul;57:102055.
26. Meghana RV, Mallempalli P, Kondakamalli S, Boringi M, Vaddeswarapu RM, Kairamkonda CR, et al. A test to study the influence of impaction on mandibular third molar development and forensic age estimation in a sample of South Indian children and young adults. Legal Med. 2022 Jan;54:101998.
27. Angelakopoulos N, Franco A, Mula AP, Moukarzel M, Sharma S, Balla SB. Effect of impaction on third molar development and age estimation—A study in a Lebanese population. Morphologie. 2023 Dec;107(359):100607.
28. Shaari R, Bin Nawi MAA, Khaleel AK, AlRifai AS. Prevalence and pattern of third molars impaction: a retrospective radiographic study. J Adv Pharm Technol Res. 2023 Jan-Mar;14(1):46-50.
29. Malik NA. Minor oral surgical procedures. In: Malik NA, editor. Textbook of Oral and Maxillofacial Surgery. 3rd ed. New Delhi: Jaypee Brothers; 2012. p. 145-150.
30. Pedro FL, Bandeca MC, Volpato LE, Marques AT, Borba AM, Musis CR, et al. Prevalence of impacted teeth in a Brazilian subpopulation. J Contemp Dent Pract. 2014 Mar;15:209-213.
31. Chu FCS, Li TKL, Lui VKB, Newsome PRH, Chow RLK, Cheung LK. Prevalence of impacted teeth and associated pathologies. Hong Kong Med J. 2003 Jun;9:158-163.
32. Idris AM, Al-Mashraqi AA, Abidi NH, Vani NV, Elamin EI, Khubrani YH, et al. Third molar impaction in the Jazan Region: evaluation of the prevalence and clinical presentation. Saudi Dent J. 2021 Apr;33(4):194-200.
33. Björk A, Jensen E, Palling M. Mandibular growth and third molar impaction. Acta Odontol Scand. 1956;14(3):231-272.
34. Čuković Bagić I, Sever N, Brkić H, Kern J. Determination of dental age by reading from orthopantomograms. Acta Stomatol Croat. 2008 Mar;42(1):11-18.
35. Dervišević E, Selmanagić A, Milovanović P, Zelić-Mihajlović K. Age determination based on open apex measurement in the developing dentition: comparing the accuracy of the Belgrade Age Formula (BAF) with the European Formula on a Bosnian children population. Acta Stomatol Croat. 2024 Sep;58(3):209-217.
36. Olze A, Solheim T, Schulz R, Kupfer M, Schmeling A. Evaluation of the radiographic visibility of the root pulp in the lower third molars for forensic age estimation. Int J Legal Med. 2010 May;124(3):183-186.
37. Shi L, Banjšak L, Anić-Milošević S, Galić I. Legal age thresholds estimation in Croatian children and adolescents: accuracy of the Olze, Haavikko, and Demirjian methods. Acta Stomatol Croat. 2024 Sep;58(3):194-208.
38. Pereira CP, Russell LM, Fernandes MP, Silva RHA, Santos RFVS. Dental age estimation based on development dental atlas assessment in a child/adolescent population with systemic diseases. Acta Stomatol Croat. 2019 Dec;53(4):307-317.
39. Carter K, Worthington S. Morphologic and demographic predictors of third molar agenesis: a systematic review and meta-analysis. J Dent Res. 2015 Jul;94(7):886-894.
40. Raloti S, Mori R, Makwana S, Patel V, Menat A, Chaudhari N. Study of a relationship between agenesis and impacted third molar teeth. Int J Res Med. 2013;2:38-41.
41. Scheiwiller M, Oeschger ES, Gkantidis N. Third molar agenesis in modern humans with and without agenesis of other teeth. PeerJ. 2020 Dec;8:e10367.
42. Kanavakis G, Alamoudi R, Oeschger ES, Tacchi M, Halazonetis D, Gkantidis N. Third molar agenesis relates to human craniofacial form. Eur J Orthod. 2024 Feb;46(1):cjad057.
43. Augusto D, Pereira CP, Rodrigues A, Cameriere R, Salvado F, Santos R. Dental age assessment by I2M and I3M: Portuguese legal age thresholds of 12 and 14 year olds. Acta Stomatol Croat. 2021 Mar;55(1):45-55.
44. Balla SB, Ali SH, Mula AP, Tadakamadla SK, Rizky MB, Franco A, et al. The effect of impaction on the mineralisation of third molars and forensic age estimation: a systematic review and meta-analysis. Forensic Sci Int. 2025;378:112650.