Prevalence of impacted teeth and associated pathologies based on panoramic radiographs in kosovar population

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DOCTORAL DISSERTATION

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UČESTALOST IMPAKTIRANIH ZUBA I PRIDRUŽENIH PATOLOŠKIH PROMJENA ANALIZOM ORTOPANTOMOGRAMA U KOSOVSKOGA STANOVNIŠTA

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To our family's princess Bella.

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I dedicate this PhD thesis to the woman my father is lucky enough to call his wife,

and to whom myself, Tori and Niti are the luckiest to call her our Mother,

Mum, my heart worships you…

PREVALENCE OF IMPACTED TEETH AND ASSOCIATED PATHOLOGIES BASED ON PANORAMIC RADIOGRAPHS IN KOSOVAR POPULATION

SUMMARY

Tooth impaction is a frequent dental condition, often reported in the scientific literature. An impacted tooth is a tooth that fails to erupt into the dental arch within the expected time. There is considerable variation in the prevalence and distribution of impacted teeth in different regions of the maxilla and the mandible, also, the prevalence varies in different reports around the world. There are certain pathologies associated with tooth impaction.

This research aimed to determine the prevalence of impacted teeth and associated pathologies, to determine commonly found impacted teeth and, also, to assess the pattern of impacted third molars and factors such as age, sex, angulation, type and depth of impaction in a Kosovar population. For this research, 5550 panoramic radiographs were analysed, which were randomly selected from the 15000 PANs obtained at the University Dentistry Clinical Center of Kosovo between 2011 and 2015. PANs were retrieved as digitalized images from the UDCCK database, exported to JPEG and subsequently analyzed with Corel Draw. During analysis, 'Magnify', 'Ruler' and 'Angulation' tools were used.

The results of this study showed that the prevalence of impacted teeth in a total number of 5550 PAN samples was 17.6%, with no sex predilection, in the Kosovo population. They also showed no predisposition to maxilla or mandible, with highest frequency of impacted teeth in the groups from 18–30 years of age. In a total number of impacted teeth, third molars had the highest prevalence of 73.7%, with no sex and jaw predisposition. The mesio angular position was the most frequent one in almost all of the records (33.8%) and class C showed the highest frequency for depth of impaction (62.3%).Second most often impacted teeth in a Kosovar population were impacted canines with the prevalence of 21.0%, followed by premolars with the prevalence of 3.7%, incisors with the prevalence of 1.4% and impacted first and second molars with the prevalence of only 0.2%.

The highest prevalence rates of pathologies were reported for root resorption of adjacent tooth (25.2 %), while increased coronal radiolucency had the lowest prevalence of pathologies of 1.1% and occurred only in impacted third molars.

Key Words: Impaction, panoramic radiographs, mesial angulation.

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PROŠIRENI SAŽETAK

Uvod

Impaktirani zubi su relativno česta pojava u dostupnoj znanstvenoj literaturi. Impaktirani zub je onaj zub koji nije iznikao u zubnom luku u okviru očekivanog vremena.
Postoji znatna razlika u prevalenciji i distribuciji impaktiranih zubi u različitim dijelovima maksile i mandibule. Isto tako, varira i njihova prevalencija u različitim istraživanjima širom svijeta. Na stupanj impakcije zuba može utjecati dob, vrijeme nicanja, radiološki kriteriji i definicija impakcije.

S druge strane, postoje određene patološke promjene povezane s impakcijom zuba.

Cilj

Cilj ovog istraživanja bio je odrediti učestalost impaktiranih zuba i pridruženih patoloških promjena u kosovskoga stanovništva analizom ortopantomograma izrađenih u Sveučilišnom Stomatološkom kliničkom centru Kosovo. Osim toga, cilj je bio utvrditi najčešće impaktirane zube i utvrditi obrazac impaktiranih trećih kutnjaka te čimbenike kao što su dob, spol, angulacija, vrsta i dubina impakcije u kosovskoj populaciji.

Materijali i metode

Ovo je istraživanje provedeno na 5550 ortopantomograma koji su odabrani metodom slučajnog odabira između 15000 ortopantomograma u UDCCK tijekom 2011. i 2015. godine. Ortopantomogrami su poslužili kao osnova za analizu impaktiranih zuba i patoloških promjena vezanim uz njih. Ortopantomogrami su bili snimljeni standardnim postupkom. Svi su pacijenti potpisali informirani pristanak da se njihove rendgenske snimke mogu koristiti jedino u obrazovne i istraživačke svrhe. Protokol istraživanja su odobrili Etičko povjerenstvo UDCCK-a i Etičko povjerenstvo Stomatološkog fakulteta Sveučilišta u Zagrebu. Panoramske su snimke preuzete kao digitalizirane snimke iz baze podataka UDCCK-a. Digitalizirane snimke prebačene su u JPEG format pomoću računalnog programa za obradu slika Sidexis, inačica 2,4R, integrirana s I-Max Touch Lineom: 220-240V-7A 50/60Hz, maksimalno vrijeme ekspozicije 15 s, proizvođača Owandy (OWANDY 6, allee Kepler 77420 Champs-sur-Marne - Francuska). Ortopantomograme smo analizirali pomoću Corel Drawa i tijekom analize korišteni su ‘Magnify’, ‘Ruler’ i ‘Angluation’.

Kriteriji za uključivanje u istraživanje bili su pacijenti u dobi od 14 godina ili stariji ispitanici oba spola sa svim oblicima impakcije. Kriteriji za isključenje iz analize su bili ortopantomogrami loše kvalitete, impaktirani zubi s nepotpuno formiranim korijenima, prisutnost anomalija ili sindroma, na primjer, bolesnici s kraniofacijalnim anomalijama ili sindromima kao što su Down sindrom, Cleidocranial Dysostosis i drugim. Zabilježeni su podatci o datumu rođenja i spolu pacijenata.
Anglucaije trećih kutnjaka određene su Winterovom klasifikacijom ovisno o kutu koji se formira između uzdužne osi drugog kutnjaka i impaktiranog trećeg kutnjaka. Klasifikacija po Winteru je korištena za treće kutnjake u maksili i mandibuli.

Izračunati kutovi između uzdužnih osi drugog i trećeg molara bili su:

1. Vertikalna impakcija (10 ° do -10 °)
2. Mezioangularna impakcija (11 ° do 79 °)
3. Horizontalna impakcija (80 ° do 100 °)
4. Distoangularna impakcija (-11 ° do -79 °)
5. Bukolingvalna impakcija (zub usmjeren u bukolingvalnom smjeru s krunom koja prekriva korijene)
6. Ostalo (111 ° do -80 °)

Dubina impaktiranih trećih kutnjaka zabilježena je pomoću Pell-Gregoryjeve klasifikacije na digitalnim panoramskim snimkama, gdje je dubina trećih kutnjaka određena kao odnos okluzijske ravnine trećih kutnjaka prema okluzijskoj ravnini drugog kutnjaka.

Klasa A - Okluzijska ravnina impaktiranog trećeg kutnjaka bila je na istoj razini kao i okluzijska ravnina drugog kutnjaka

Klasa B - Okluzijska ravnina trećeg kutnjaka je u razini između okluzijske ravnine i cervikalne linije drugog kutnjaka.

Klasa C - Impaktirani treći kutnjaci su bili ispod cervikalne linije drugog kutnjaka

Kutovi drugih impaktiranih zubi (očnjaci, pretkutnjaci i sjekutići) analizirani su prema Winterovoj klasifikaciji prema kutovima između uzdužnih osovina trećih kutnjaka i susjednog zuba. Kutovi su klasificirani kao: mezijalno kutni, distalno kutni, vertikalni ili horizontalni.

Kriteriji za dijagnosticiranje patoloških promjena povezanih s impakiranim zubom u maksili i mandibuli na ortopantomogramu su:
Karijes imapktiranog i / ili susjednog zuba;
Gubitak parodontne kosti veći od 5 mm distalnoga dijela drugoga kutnjaka izmjeren od caklinsko-cementnog spojišta do razine marginalnoga dijela kosti.
Resorpcija korijena susjednoga zuba uz treći kutnjak uz vidljiv gubitak tkiva korijena drugog kutnjaka u obje čeljusti zbog izravnoga kontakta između trećeg kutnjaka i susjednoga zuba.
Povećanje perikoronarnoga prostora zubnog folikula većega od 4 mm izmjereno oko impaktiranoga trećeg kutnjaka.

Rezultati

Prema rezultatima analize svih ortopantomograma otkriveno je 1777 impaktiranih zuba koji potječu iz 970 ortopantomograma. Polovima (51%) ortopantomograma ima samo jedan impaktirani zub, 30% dva, 10% tri i 6% četiri. Pet do osam impaktiranih zuba sadržava samo 3% ortopantomograma. Distribucija broja impaktiranih zuba po ortopantomogramu podjednaka je za oba spola što pokazuje rezultat χ^2 testa ($\chi^2 = 3.74$, df = 4, p = 0.442). Pojava broja impaktiranih zuba po ortopantomogramu podjednaka je njihovom omjeru spolova, što iznosi približno 4:6.

Najveći udio imapktiranih zuba čine treći kutnjaci (73.7%) i očnjaci s udjelom od 21.0%. Ostale skupine impaktiranih zuba javljaju se u ukupno 5,3% preostalih impaktiranih zuba. Analiza skupina impaktiranih zuba ukazuje na statistički značajnu razliku impakcija u maksili i u mandibuli ($\chi^2 = 394,9$, df = 4, p < 0,001). Većina impaktiranih sjekutića i očnjaka nalazi se u maksili (80% svih sjekutića i 95,4% svih očnjaka), dok je 62,1% svih trećih kutnjaka u mandibulli, a 37,9% u maksili. Broj impaktiranih zuba prema čeljustima je podjednak u ispitanika muškog i ženskog spola. U muških ispitanika je taj omjer 54% : 46%, a u ženskih 49% : 51%. Rezultat je statistički značajan (($\chi^2 = 4.17$, df = 1, p = 0.042).

Prema rezultatima uzorka od 1777 impaktiranih zuba, 1310 su treći kutnjaci i od svih impaktiranih zuba oni predstavljaju najbrojniju skupinu. Utvrđeni su na 710 ortopantomograma. Prema rezultatima analize zavisnosti spola i područja 37,9% trećih kutnjaka nalazi se u maksili, a preostalih 62,1% u mandibuli. U skupini muškaraca treći kutnjaci u maksili su brojniji (43,1%) od očekivanih (37,9%), dok je u žena trećih kutnjaka nešto manje (34,4%). Ova je razlika dovoljna da se pojava impaktiranih trećih kutnjaka u maksili, odnosno mandibuli, satatistički značajno razlikuje po spolu (χ^2 = 10,18, df = 1, p = 0,002).

Distribucija kategorija angulacije prema Winteru i prema spolu statistički se značajno razlikuju prema rezultatima χ^2 testa (χ^2 = 17,70, df = 4, p = 0,001). Bitna se razlika odnosi na znatno veću učestalost horizontalne angulacije muških u odnosu na ženske ispitanike, 58,5% odnosno 41,5% u odnosu na očekivani omjer 41,8% : 58,2%. Angulacija prema Winteru ukazuje na statistički značajnu razliku prema rezultatima χ^2 testa (χ^2 = 272,1, df = 4, p < 0,001). Bitna se razlika očituje u znatno većem udjelu mezijalne angulacije u maksili (59,1%) u odnosu na očekivanih 37,9%. Kod distalnih i vertikalnih angulacija (85,0%, odnosno 77,3%) pojavnost je znatno veća od očekivane pojavnosti od 62,1% u mandibuli. Kod horizontalne angulacije znatno je veća učestalost u maksili (80,9%) od očekivane 37,9%. Bukolingvalna kategorija se javlja u postotku od 37,3% i 62,7% u skladu s očekivanim vrijednostima (37,9%: 62,1%). Distribucija klase prema Pell-Gregoryju koja se odnosi na dubinu registrirana je kod 1310 trećih kutnjaka koji se statistički značajno razlikuju po klasama s tim obilježjima. Najmanji je udio klase A s 2,8%, potom slijedi klasa B s 34,9% udjela, te s najvećim udjelom od 62,3% slijedi klasa C. Klasa C javlja se dominantno u maksili u iznosu od 70%, a rezultat je statistički značajan (χ^2 = 96,6, df = 2, p < 0,001). Prema klasifikaciji Pell-Gregoryja nema razlike učestalosti impakcije među spolovima (χ^2 = 2,26, df = 2, p = 0,323). Pell-Gregoryjeva klasifikacija I do III odnosi se samo na impaktirane treće kutnjake u mandibuli gdje je klasa I utvrđena u 31,7%, klasa II u 48% i klasa III u 20,4% ortopantomograma. Postoji statistički značajna razlika u frekvencijama Pell-Gregoryjeve klase prema spolu ispitanika pripadajućih ortopantomograma, kako je vidljivo iz rezultata χ^2 testa hipoteze o nezavisnosti klasa prema spolu ispitanika pripadajućeg ortopantomograma (χ^2 = 10,98, df = 2, p = 0,004). Bitna se razlika odnosi na činjenicu da se klasa III javlja statistički značajno češće u ispitanika muškoga spola (60,2%), nego u ispitanika ženskoga spola (39,8%), što je značajno različito od očekivanog omjera 45,7% : 54,3%. Klase I i II javljaju se u približno očekivanim omjerima (42,7: 57,3% i 41,5% : 58,5%).

Od ukupno 373 impaktirana očnjaka, samo je njih 17 u mandibuli, dok je preostalih 356 (95,4%) u maksili. Nema statističke razlike među spolovima. Za distribuciju angulacije očnjaka, iz statističke analize je razvidno da dominira mezijalna angulacija s udjelom od 72,9%. Kategorija vertikalne angulacije se javlja na 15,3% ortopantomograma, dok kategorije horizontalne angulacije ima nešto manje (10,7%), a distalna se angulacija gotovo uopće ne pojavljuje (1,1%). Distribucija angulacije za impaktirane očnjake u maksili se statistički značajno razlikuje prema spolu ($\chi^2 = 16{,}51$, df = 2, $p < 0{,}001$). Razlika je u vertikalnoj angulaciji koja se javlja u znatno većem broju na ortopantomogramima muških osoba u 59,6% slučajeva, dok je očekivana vrijednost takvih ortopantomograma 36,7%.

Distribucija angulacije pretkutnjaka navedena je deskriptivno, jer se radi o suviše malom broju pretkutnjaka za statističko testiranje. Registrirana je samo na 65 ortopantomograma, što predstavlja 65/1777 = 3,66% impaktiranih zuba. I ovi zubi nisu pogodni za testiranje bilo kakve hipoteze. Vertikalna i mezijalna angulacija je učestalija od distalne i horizontalne angulacije, što nije moguće testirati statističkim metodama rada.

Sjekutići se pojavljuju na samo 26 ortopantomograma, što predstavlja 26/1777 = 1,46% impaktiranih zuba. Distribucija angulacije navedena je deskriptivno.

Patološke promjene vezane uz impaktirane zube u našem istraživanju registrirane su u malom broju slučajeva. Općenito, samo za resorpciju korijena susjednog zuba nađen je značajan broj slučajeva, dok pojavnost ostalih patoloških promjena iznosi oko 5% ili manje. Resorpcija korijena pojavljuje se u 25,2% od ukupno 1777 impakiranih zuba. Od tih, 28,6% resorpcije susjednih zuba odnosi se na lateralne sjekutiće, a 71,4% na druge kutnjake.

Zaključak: U našem istraživanju učestalost impaktiranih zuba u ukupnom broju od 5515 ortopantomograma kosovskih sudionika procjenjuje se na 16, 6% u muškaraca i 18,3% u žena, što čini prevalenciju impaktiranih zuba oko 17,6%. Prevladavanje pojave impakcije u mlađoj dobnoj skupini može biti odraz relativno većeg udjela ispitanika u skupini od 18 do 30 godine, u ukupnom broju naših uzoraka. U odnosu na spol, nije bilo statistički značajne razlike u impakciji zuba između muških i ženskih ispitanika. Broj impaktiranih zuba u maksili i mandibuli u našem istraživanju bio je gotovo isti, 906 od 1777 zahvaćenih zuba bilo je lokalizirano u maksili, (51%), a 871 zub (49%) u mandibuli. Ovo istraživanje pokazalo je da treći kutnjaci imaju najveću prevalenciju impakcija u odnosu na ostale zube (73,7%). Kod impakcije trećih kutnjaka nije bilo značajne korelacije između spola i čeljusti. Najčešća je mezioangularna angulacija (33,8%), a kod klase C (62,3%) zabilježen je najveći udio imapktiranih trećih kutnjaka.

Učestalosti drugih skupina impaktiranih zuba su bile 21% za očnjake, 3,7% za pretkutnjake, 1,4% za sjekutiće, a impaktirani prvi i drugi kutnjaci imali su učestalost od samo 0,2%.

Resorpcija korijena susjednog zuba imala je najveću prevalenciju patologija povezanih s impaktiranim zubima (25,2%). Povećana perikoronarna transparencija impaktiranoga zuba imala je najnižu učestalost patologija od 1,1%, a zapažena je samo u trećim kutnjacima.

Ključne riječi: Impakcija, ortopantomogram, mezijalna angulacija, distalna angulacija.

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List of Abbreviations

Abbreviation	**Term**
PAN	Panoramic radiographs
UDCCK	University Dentistry Clinical Center of Kosovo
CBCT	Computed tomography

1. INTRODUCTION

Impacted tooth has been a widely known condition since prehistoric times. Plato and Hippocrates described impacted wisdom teeth in their texts (1). Word impaction derives from the Latin word *impactus* and it indicates a circumstance where one object is retained by another (2).

An impacted tooth is described in the dental science literature as a pathological condition which occurs when a tooth does not erupt into the dental arch on its appropriate anatomical position within the estimated frame time (3).

1.1 Historical background

A prominent eighteenth century zoologist and anatomist Baron George Cuvier is believed to have said "Show me your teeth and I will tell you who you are". Cuvier's phrase can perfectly relate to human teeth, even though it is believed to be related to Courier's passion to recreate entire animals restored from extinct species, that is, from degraded soft-tissue found in fossilized remnants of their dentitions (4).

The importance of our teeth can be also seen in the study by Smith, suggesting that dental tissues present realistic archives of birth. Apart from describing their progressive growth, Smith also proposed that eruption period of molars, tooth wear, growth disorders, tooth calcification and tooth chemistry may give new insight into the evolution of hominid lifetime history (5). On the other hand, tooth impaction itself has been with human race for thousands of years since the cases of impacted canines were found in an excavated skull dated from 2700 to 2724 BC (6).

1.2 Teeth development

The development of the teeth, formation of the dentition and growth of the craniofacial complex are closely related in the prenatal as well as postnatal development period. Understanding of the growth of teeth and their eruption into the oral cavity is relevant to clinical practice, demography, archaeology, forensics and paleontology (7).

1.3 Eruption

Apart from the teeth development being a complex process of human dentition, the eruption of permanent teeth is a varied and unique development process in the human body that is generally genetically based (8-9).

Not only is tooth eruption a developmental process, but it is also a biological process. As a result, these events are described as a biological product that includes growth, differential growth, apoptosis and cell migration (8). Eruption of tooth is defined as the tooth movement from its development site, intraosseous position in the maxilla and mandible into the alveolar process and into its functional position in the oral cavity (10).

The eruption process is generally divided into three stages: presumptive stage, eruptive stage and post eruptive stage (11). Furthermore, the term refers to the total life span of the tooth, from the start of crown growth until the tooth is lost or the individual passes away. The term active tooth eruption implies the emergence of a crown into the oral cavity.

1.3.1 Pre eruptive stage

This is the initial phase when crown growth begins. If this stage is associated with eruptive movements, it consists of two variations: spatial and eccentric (11). The crown grows in spatial movement while the lowermost of the socket fills in with bone, thus pushing the crown towards the surface. While in eccentric growth, the crown does not grow in proportioned pattern. During this time, the crown expands and it grows in one part more than in another, as a result tooth appears to be moving because the epicenter of the tooth is altering (11).

1.3.2 Eruptive stage

The development of the root marks the beginning of the eruptive stage. Crypt bone is a location where the root grows (11). When development starts, osteoclasts might make the crypt deeper by resorbing bone at the lowermost part to create space for the growth in root length. Meanwhile, as root sustains length developing, the tooth moving towards the oral cavity is initiated. At the same time, the alveolar bone keeps developing; hence it keeps speed with it (8, 11). During this time, a tooth moves more rapidly compared to the developing alveolar bone, which results in tooth impending the surface of the oral epithelium, thus erupting into the oral cavity. This stage continues until the erupting teeth meet the opposing teeth (11).

1.3.3 Post eruptive stage

When erupted teeth come into occlusion with the opposing teeth it is the time when post eruptive stage begins and continues until teeth are lost or death occurs. In the end, the tooth may sustain to erupt if the opposite tooth is missing or lost. This phenomenon is called supraeruption. However, supraeruption is by some authors considered to be part of eruptive stage (11).

1.3.4 Causes of tooth eruption

Bearing in mind the fact that tooth eruption, precisely pathological tooth eruption, has the most important role in clinical and theoretical dentistry, astonishingly there is a lack of literature on this topic. Without any hesitation, this is a result of research method being very complex since experimental studies on animal tissue cannot uncritically be transferred to human conditions. Therefore, for the time being, the eruption process cannot be studied appropriately on a molecular level. In addition, it cannot be studied longitudinally in human tissues since teeth have to be extracted, which is a procedure that splits teeth from the periodontal ligament and the adjacent bone (8).

So far, a clear understanding of causes of the eruption process has not been found. We can read that different authors suggest different theories. Tooth eruption mechanisms are still under debate. There are numerous theories and discussions; however each theory on the eruption mechanism poses a problem in its conception (8, 11).

1.3.4.1 Alveolar bone formation and changes

Alveolar bone alteration in association with tooth growth and eruption are mutually dependent processes. In the areas where the teeth will grow, it will result with alveolar process being grown. However, in the areas where teeth development will not succeed, the alveolar process will be deficient (11). Two very important processes of osteoclastogenesis and osteogenesis are responsible for alveolar bone changes and resorption; these two metabolic processes are linked to the presence of dental follicle (8). Dental follicle is positioned between the alveolar bone and the enamel organ of the unerupted tooth, which makes it an ideal connective tissue to regulate the alveolar bone activity. Therefore, the dental follicle is essential for eruption due to initiated processes of osteoclastogenesis and osteogenesis (8).

1.3.4.2 Root elongation

Some authors suggest that eruption force is related to forces that arise while the root is elongating. The increase in root length, or root elongation, forces the tooth into the oral cavity. There is an association between the tooth eruption force and root extension (12). On the other hand, several studies tend to disapprove this, especially in case when third molars develop their roots to their complete length. However, teeth do not erupt under such circumstances. This shows that root elongation is not vital for tooth eruption, but it is certainly associated with its development (8, 11).

1.3.4.3 Vascular pressure in dental tissues

So far, it has been believed that vascular pressure has been present in pulpal tissue and periodontal ligament. In the textbook "Essentials of Oral Histology and Embryology" Avery stated that: "Of the numerous causes of tooth eruption, the most frequently cited are root growth and pulpal pressure" (12). The pulsating blood pressures are not responsible only for cellular movement improvement. It appears that they directly affect the eruptive part. This theory is challenging since the removal of the entire fluid pressure would impede oxygen and other nourishments from growing, hence the complete eruption of the tooth is unlikely to occur (8, 11).

1.3.4.4 Periodontal ligament

There is a correlation between pulpal and periodontal reactions, which has also been stated as a causal factor in eruption (12-13). Today there has been a lot of speculation about the involvement of the periodontal ligament in tooth eruption. At present, it is believed that periodontal ligament is less involved in tooth eruption compared to findings of the previous research (11). However, periodontal ligament still has a bigger role to play towards the end of tooth eruption compared to the role it plays at the beginning.

Almost certainly all the above mentioned factors are of utmost importance, but they are not necessarily independent of each other.

1.4 Definition of impaction

Over the years, impacted tooth has had various definitions in dental science because additional information on impaction causes became clearer.

In 1954, Mead (14) defined an impacted tooth as a pathological condition when malposition, lack of space or other immediate prevented a tooth to erupt into its position. In 1998, Peterson (15) defined impacted tooth as the one that failed to erupt into the dental arch into an excepted time. Furthermore, Eidelman in 1979 (16), and Hattab and Alhaija 1999 (3) defined impacted tooth as one that does not erupt in the dental arch in the excepted time and into its appropriate position; in fact they stay under the gingival line.

Chu et al. (21) stated that tooth impaction appears when its eruption path is obstructed by an adjacent tooth, soft tissue or bone. According to Sabra and Soliman in 2013 (17) tooth is defined as impacted if scheduled time of tooth eruption is passed.

1.5 Etiologic factor of impaction

A considering number of theories have been proposed to enlighten the etiology of impacted teeth.

Brash (18) pointed to the fact that teeth impactions are a result of evolutionary decrease in jaws development in relation to the skull. He believed that teeth have been decreased in number and dimension, while jaws are decreased at more swift rhythm and this decrease has been reflected on the alveolar part. Brash has also stated that an enduring jaw decrease in humans parallel to their evolution in the long run will ease situation resulting in complete disappearance of a group of teeth, of third molars respectively.

Much sound evidence could be provided in support of the notion that inheritance plays a big role in formation of human face, which has been universally accepted. Similar hereditary predispositions are shared by jaws and teeth. Therefore, large teeth inherited from one parent and small jaws from the other may be a superior possible cause of potential impaction (19).

Furthermore, tooth impaction including problems with maxillofacial growth has long been related to imperfect nutrition (19). Omar (20) stated that prevalence of impacted teeth may vary between races as jaws growth despite being largely influenced by hereditary factors. It may be influenced by change of dietary habits, as today diet has shifted from crude abrasive to a softer food.

Regardless of whether impacted teeth are causing problems due to evolutionary, hereditary or environmental factors, it is believed that impaction influences primarily the mechanism of bone growth. Throughout the growth period of an individual, the alveolar bone is particularly plastic, thus allowing continuous increase in tooth development and movement of the teeth (19).

On the other hand, a considering number of studies reported that local conditions may interfere with normal eruption of teeth and predispose to tooth impaction when they occur throughout the growth period of the permanent teeth (19, 21-22). Early loss of the second deciduous molar before complete eruption of the first permanent molar predisposes to mesialisation of molar and leads to irregular eruption or impaction of the second premolar (19, 22). When premature or delayed resorption of deciduous teeth occurs, the inflammatory circumstances of the alveolar process related to the deciduous teeth accidental trauma of the tooth germ and trauma in the form of fracture and accidental trauma of the tooth germ are additional examples of local conditions leading to impaction. Other conditions that may influence tooth impaction are: supernumerary teeth cysts and calcified odontomas (19).

Therefore, from a review of the current literature, the main causes of teeth impaction can be classified in two main groups. In the first group, the main causes of tooth impaction are the following local factors (21-23):

- Increase in bone deposition
- Early loss of the primary teeth
- Trauma
- Delayed dentition of primary dentition,
- Insufficient arch length and space for tooth eruption.
- Local pathologies

In the second group, main causes can be associated with the following systematic factors:

- Hereditary factors
- Phylogenetic
- Childhood diseases
- Ankylosis of the temporomandibular joint

- Cleft palate
- Syphilis
- Cleidocranial dysostosis

If the above mentioned factors are left untreated, they can lead to impaction of incisors, canines, premolars and third molars.

1.6 Most affected teeth by impaction

According to Hattab and Alahija (3), in entire dental impactions, 98% of cases belong to the third molars, which results with them being the most commonly impacted teeth and their prevalence is on the rise. However, there is always an on-going discussion on the topic whether third molars in maxilla or mandible are more commonly found.

On the other hand, after third molars, impacted canines in maxilla are most frequently impacted teeth followed by canines in mandible and premolars (21-22, 24, 25), whereas incisors are the most rarely reported impacted teeth (26).

1.6.1 Third molar – most affected tooth by impaction

1.6.1.1 Third molar impaction condition

The last tooth to form is third molar and it is the most often to fail to erupt into the oral cavity (27-28). When its proper eruption fails, it results in third molar impaction. Despite the fact that any teeth in maxilla and/or mandible may become impacted, third molar becomes impacted more frequently than any other tooth in modern population with percentage of 98% of all impacted teeth (28-30).

Third molars impaction is routinely diagnosed by a dentist and it has been recorded that around 73% of adults specifically aged 20 years may have at least one impacted third molar, specifically third molar in the mandible (31). The large variety of figures is given in the literature for the occurrence of third molar impaction. Depending on how impaction is defined, the incidence of this condition is said to be between 22.3% and 66.6% (32).

However, if partially erupted third molars are considered impacted, the results of teeth impaction might be up to 96% of the population who may have at least one impacted tooth and this, also, represents a complication that is very commonly observed across populations (28, 33-34).

1.6.1.2 Development and eruption of third molars

Third molars are succession teeth that originate from the dental lamina, a primitive group of ectodermal cells growing from the epithelium of the embryonic jaws into the underlying mesenchyme. A bud of third molars becomes evident at the age of four or five years (35-36). Its mineralization initiates as early as at the age of five years and as late as the age of 14 years, however, the majority of third molars start erupting at the age of eight or nine years (37-39). The crown of the third molar is generally complete between the age 12-15 years and mineralization continues gradually until the root is completely formed and the root apex is closed (35). The time of the third molar emergence into the oral cavity has a wide range of variation, although most often it erupts from age 17 to 21 years, otherwise up to 24 years and this tooth can rarely erupt as late as at the age of 32 years (35, 40-41). The third molar has a highly variable eruption time. However, it is the very last tooth to erupt in all populations (30).

Since other teeth erupt earlier, the space in the maxilla and mandible that accommodates the eruption of third molar is frequently occupied by other permanent teeth and this is one of the causes why the third molar becomes so commonly impacted (30, 42, 43).

1.6.1.3 Etiology of third molar impaction

Since third molar impaction is the most frequent pathology, the causes of impaction of this tooth have been studied much more compared to the rest of teeth impactions. Etiologic factor of third molar impaction has been a controversial subject for many years. Generally, it has been accepted that causes are multifactorial. The most common theories explaining the causes of third molar impaction relay on:

1. Insufficient space between the second molar and the distal osseous part of the jaw (44)
2. Limited or insufficient skeletal growth (43, 45)
3. Increased crown size of impacted teeth compared to normally erupted teeth (45)
4. Late mineralization of third molar in the reduced jaw space may additionally multiple the risk of third molar impaction (46)
5. Dimension of the entire dental arch may influence less third molar impaction compared to local factors such as the amount of the space in the retro molar region (47)

Among all the above mentioned theories raised, insufficient space in the retro molar region has been suggested as the most significant factor associated with third molar impaction with the possibility of impaction directly linked to the amount of space available in that region (15, 28, 44, 48). Despite the fact that the exact amount of space in the retro molar region required for eruption of the third molar has yet remained unknown, the length of this space must exceed the width of this tooth crown (49-50).

Furthermore, sometimes there are cases when a complete dental arch does not have the required space for third molar eruption. For that space to be produced, a natural mesial drift of teeth needs to occur gradually along the course of one’s life producing space at the back of the jaws to accommodate the eruption of the third molar (51). This mesial drift can arise as a result of an intake of an abrasive, non-refined diet which causes circumferential abrasion that reduces the mesiodistal width of teeth. The occurrence of a gradual dental abrasion over time may significantly produce space in the jaws, which in some situations allows a later eruption of this tooth.

Begg (52) reported that a normal physiological mesial drift of the second molar in Australian aborigines is more than 1 cm before the time of third molar eruption. As a result, third molars erupted in a considerably more mesial position within the dental arch. A gradual change to softer diets has been noted in many population groups, consequently leading to a lack of dental abrasion, thus resulting in a lack of production of space in the dental arch. Therefore, it has been assumed that third molar impaction represents a developmental condition typical of modern civilization (28).

However, in cases where space in the jaws is not formed naturally by skeletal growth, the third molar may not find the space for eruption without any previous tooth loss. This leads to the theory that regardless of the occurrence of dental attrition or tooth loss, the space in the retro molar region needs to exist for the third molar to erupt. Consequently, non-coordination between skeletal growth, third molar maturation and time of eruption, has been also associated with the third molar eruption failure (28).

1.6.2 Canine impaction – Most affected impacted teeth

1.6.2.1 Canine impaction condition

Functional and esthetical characteristics related to canines are of enormous significance; therefore the canine tooth is a critical tooth in the dental arch and plays an important role. Nevertheless, the canine often occurs impacted due to its compound development and eruption path (53).

1.6.2.2 Development and eruption of canine

Dewel (54) underestimated the role of the canine tooth. In growth interpretation, there is no tooth more intriguing than the canine tooth, in particular the maxillary canine. This is due to the fact that canines have the most extended time and the deepest zones of development. Also, the canine has the most unscrupulous structure to travel from its origin to complete occlusion. Despite the fact that the initial calcification of canines starts as early as that of central incisors and first molars, it takes canines almost nearly twice as long to complete the entire eruption.

On the other hand, Moyers (55) confirmed that, in particular, maxillary canines have a more challenging and twisted route of eruption compared to every other tooth. The location of the canine at the age of three is up in height in the maxilla, with its crown heading mesially and slightly lingually. It continues to move towards the occlusal plane, progressively rectifying itself, up until it reaches the distal part of the root of the lateral incisor. Later on it seems that the canine diverts in further vertical position and erupts in the oral cavity more often with predisposition for mesial inclination.

Uninterrupted development and eruption of the canine in the oral cavity is essential due to its strategic position at the angle of the arch, as a significant factor to preserve coordination and symmetry of occlusal relationship and defining the outline of the mouth (25). Impacted canines may influence dental/oral health and could cause root resorption of the adjacent tooth. This emphasizes the importance of early detection of impacted canines (25).

1.6.2.3 Etiology of impacted canines

Bishara and Ortho (56) summarized the etiology of canine impaction in two main groups:

Local causes

The majority of causes for impacted canine are local and they can be a result of one factor or as a combination of the following factors:

1. Tooth size - Arch length discrepancies
2. Prolonged retention of the tooth bud
3. Presence of an alveolar cleft
4. Ankylosis
5. Cystic or neoplastic formation
6. Dilacerations of the root
7. Iatrogenic origin and
8. Idiopathic condition with no apparent cause

The causes for impacted canines may be generalized

This group comprises:

1. Endocrine deficiency
2. Febrile disease
3. Abnormal muscle pressure
4. Vitamin D deficiency
5. Radiation

1.7 Prevalence of impacted teeth

A review of the literature on the prevalence of impacted teeth resulted in variability from one study to another (21-23, 57).

Dachi and Howell (23) conducted a study that included 3.599 PANs of patients ranging from the age of 20 years, both male and female. Those PAN's were taken at the Indiana University School of Dentistry and Dental School of the University of Oregon, and they showed that the prevalence of patients with at least one impacted teeth was 16.7 %.

Chu et al. (21) carried out a research on the prevalence of impacted teeth in the Hong Kong Chinese population. The study included 7486 PAN's of patients who attended Primary Care Clinic at the Prince Philip Dental Hospital between September 1997 and 1998, with patient's lowest age of inclusion being 17 years. The authors estimated that age of 17 years is usually observed as time when third molars start to erupt. Both men and female were included, with the research ratio male to female being 1:1.6 (2856:4630). The results of the study showed the prevalence of 28.3% of impacted teeth in population, with impacted third molars having the highest prevalence. The prevalence was followed by impacted canines, premolars and rare cases of impacted maxillary or mandibular incisors.

In clinical and radiographic research that took place in Oral Surgery Clinic, Faculty of Dentistry, at Atatürk University, by Saglam and Tuzum (51) et al. the main focus was to determine prevalence of impacted teeth in Turkish population. A total number of 1000 patients who were referred to the Center underwent an intraoral examination, where 110 patients were diagnosed with impacted teeth after their radiographs were recorded. Inclusion criteria were both male and female, with minimum age 16 years and older. The prevalence of fully impacted teeth was 11%.

The main aim of the study conducted in a Greek population, which included 425 PANs (223 females and 202 males), was to determine the prevalence of impacted teeth. All PANs were taken between October 2008 and June 2009 from patients who visited Clinic of Oral Surgery at the Department of Oral and Maxillofacial Surgery, School of Dentistry, University of Athens, Greece (22). Minimum age for inclusion was 18 years; both male and female patients were included. In this study, a total of 940 impacted teeth were identified. Most important results of this study were data on prevalence of impacted tooth category: highest prevalence of impaction had third molars, followed by canines, premolars, first and second molars, with only one case of impacted incisor (22). Similar to this study, the same percentages of prevalence of impacted teeth were found in previous studies (21, 58).

The prevalence of impacted teeth was studied by Pursafar et al. (59) on 900 PANs of the patients who were referred to Hamadan Dental School in 2009. Inclusion criteria were both males and females; with patients' age of 14-70 years (mean age 42). Minimum age for inclusion criteria was 14 years, as the author clearly stated. The fact that all teeth finish their eruption process, apart from third molars, has been universally accepted. The prevalence of impacted teeth in this study was 18% with impacted third molars in the mandible and maxilla being the most frequent impacted teeth.

The main aim of a retrospective study of 1352 PANs in a subpopulation in Brazil was to determine the prevalence of impacted teeth. This study included PANs taken in 2011 at an oral radiology clinic in Cuiaba. Both male and female patients were included. The age inclusion criterion was 15- year- old patients or those older (60). A total number of 22984 teeth were examined, of these 692 were impacted. The third mandibular molars had the highest prevalence of impacted teeth, followed by impacted third maxillary molars. The second most frequent group of impacted teeth after third molars was a group of maxillary and mandibular canines.

A low prevalence of impacted teeth was observed by the researchers of the same study for premolars, first and second molars and the lowest for incisors. No impacted mandibular incisors were reported (60).

1.7.1 Prevalence of impacted teeth in maxilla and mandible

The distribution of impacted teeth varies between the maxilla and the mandible (21-23).

Dachi et al. (23) reported that the distribution of impacted teeth has a slightly higher prevalence of impaction in the maxilla compared to the mandible. Maxillary third molars had the highest prevalence of 21.9%, followed by mandibular third molars, maxillary canines and maxillary premolars.

In a Hong Kong study, the highest prevalence of impacted teeth was recorded in the mandible, with frequency of 84% (3178) for third molars in the mandible, a value that has not been reported in studies of other ethnicities (21). It was followed by maxillary third molar impaction, maxillary canines, mandibular premolars and only few maxillary premolars. The distribution of other group of impacted teeth had a very low frequency; the lowest prevalence was recorded for first and second molars in the maxilla, followed by impacted mandibular central and lateral incisors. The cases with only five impacted teeth per group were recorded for mandibular canines, also, first and second mandibular molars. Maxillary central and lateral incisors also had the lowest prevalence among impacted teeth (21).

Data on distribution of impacted teeth in a study of Greek population showed that the highest prevalences of impacted teeth were found in the mandible compared to the maxilla ($P<0.001$) (22). Out of 940 impacted teeth, 508 were impacted mandibular third molars, followed by maxillary third molars; maxillary canines and few cases of impacted mandibular canines were reported. Impacted mandibular first premolars were rarely reported, while no impacted maxillary first premolars were found. Impacted mandibular second premolars and impacted maxillary second premolars were not frequent. According to the study distribution of posterior impacted teeth, the lowest prevalence was recorded for impacted mandibular first molars. Additionally, a distribution of anterior impacted teeth with the lowest prevalence of impaction was recorded for impacted maxillary central and lateral and mandibular incisors. Only one case of impacted central incisor has been reported (22).

The pattern of the study about the distribution of impacted teeth between the maxilla and the mandible conducted at Hamadan Dental School (59) was comparable to previous reports (21-22), with impacted third molars having the highest prevalence of the 248 impacted teeth, being followed by maxillary canines and other teeth with their lowest prevalence.

Furthermore, the distribution of 692 impacted teeth in the maxilla and the mandible in a study of subpopulation in Brazil showed that impacted mandibular third molars had the highest prevalence, followed closely by the maxillary third molars, followed by the maxillary and mandibular canines (60). The prevalence of impacted mandibular second molars was higher compared to that of impacted first and second mandibular premolars, which is a different result compared to other studies (21-22) in which the prevalence of the impacted first and second maxillary molars was higher, compared to that of impacted mandibular first and second molars. In this study, no cases of impacted mandibular central and lateral incisors were reported and only one, respectively, and two cases of impacted maxillary central and lateral incisors (60).

1.7.2 Prevalence of impacted teeth in correlation with age

Impacted teeth can be diagnosed at any age. Numerous authors have confirmed by their findings the fact that the highest prevalence of teeth impaction was reported for the age group of 20-30 years (21-23).

In the Hong Kong study by Chu et al. (21) patients were aged between 17 to 89 years (mean 39.6 years). Over 30% of patients who participated in this study were aged 21- 30 years. The authors explained why there was a correlation between that specific age group and its larger percentage of participants: there was a growing awareness about free dental care services offered by Hong Kong government during the period of primary school. In a total number of 2115 patients with at least one impacted tooth, the mean age was 27.9 years. The highest prevalence of tooth impaction was in the 20-29 years age group. Higher percentage of patients with impaction in that age group can be explained by the fact that a relatively high ratio of patients belonged to that age group as mentioned above in the text. On the other hand, the results of this study revealed that the prevalence of impaction reduced with age rise.

The findings of Gisakis et al. (22) showed that the majority of patients with at least one impacted teeth belonged to the age group up to 30 years. As age raised the prevalence of impacted teeth progressively decreased until the age of 50 years. The prevalence of impaction remained stable after the age of 50 years. This impaction prevalence was comparable to the results obtained by Ahlqwits and Grondahl (58). They found that underscored impaction prevalence steadied with a constant incidence at the age of 50 years. Age inclusion criteria of a study by Pursafar et al. (59) was 14-70 years (42 mean), which is similar to Unwerawattana (61) study. Thirty per cent of patients included in these studies were aged 22 - 30 years.

Compared to previous studies in which only specific age groups were examined, in the Hammadan School Study the patient sample was taken across a range (59). Furthermore, the findings in a Brazilian subpopulation showed that absolutely the highest incidence of impacted teeth was found in patients aged 20 - 29 years (60). As the results of the study show, the increase of age over 30 years was followed by a drastic decrease in the prevalence of impacted teeth. This finding is similar to findings of previous studies (21-22, 59). Patients in the age group 70 - 79 years had the lowest incidence of impacted teeth; this finding also correlates with previous reports (9, 21-22, 62-63).

1.7.3 Prevalence of impacted teeth in correlation with sex

Reports on the prevalence of impacted teeth related to sex vary. Females dominate in a number of studies, whereas males dominate in other studies. The results of some studies have shown that there are no differences according to sex regarding the prevalence of impacted teeth (21-23, 59).

Dachi et al. (23) claimed that statistically no sex differences were reported about the impaction of third molars, however, it was reported that only impacted maxillary canines had more frequent incidence in females compared to their male counterparts.

Chu et al. (21) research, in which both genders were included, with study groups male to female ratio being 1:1.6 (2856:4630), resulted in a slight prevalence of impaction in female patients.

The results of a study in a Greek population showed that from all examined patients, 223 were females and 202 were males and no statistically significant differences were found (22). However, compared to a study by Haidar and Shalhoub (64), the results revealed higher prevalence of impaction in males compared to that in females, especially the incidence of third molar impaction.

In a Brazilian subpopulation study, the majority of assessed teeth belonged to female patients (14178:8806), a phenomenon that was described by several authors (60, 62, 65-66). However despite the above mentioned fact, according to Brazilian study results, the gender of patients did not seem to influence significantly the mean number of impacted teeth (60). In a similar way to all above mentioned studies, no statistically significant differences were found between two genders regarding the frequency of impacted teeth as reported by Kramer and Williams (67), and by Brown et al. (68).

On the other hand, male to female ratio of 900 patients was 5.1:3.9 in Hamadan Dental School study. The results of the study concerning sex related impaction showed that a statistically significant difference was found (59).

1.8 Prevalence of teeth most affected by impaction

1.8.1 Prevalence of impacted third molars and their classification

A review of selected dental literature shows that in human dentition impacted third molars have the highest prevalence of impacted teeth and the incidence varies widely from one population to another with a range from 17% to 94.8%, also with a significant variation in the distribution of impacted third molars between two jaws and sexes (64-65, 67, 69-70).

In Dashi et al. (23) study, the prevalence of impacted third molars was 39.4%. This result showed that statistically significant difference was not found regarding the incidence of impacted third molars between the maxilla and the mandible, with no sex differences marked in the prevalence of third molars impaction.

The prevalence of impacted teeth in Saudi community was discussed in a study that consisted of 1000 PANs taken from patients attending the College Dentistry in Riyadh beginning in 1981 until 1983. The study included both male and female patients with age range from 20-40 years, with a mean age of 24 years (64). The result of the study showed that out of 3,681 wisdom teeth identified in the PANs, 1173 were impacted. In this study, a statistically significant difference was not found in the incidence of impacted third molars between the maxilla and the mandible. The study showed that there were no significant differences in the incidence of impacted third molars between males and females (64).

Hattab et al. (70) studied PANs of 232 Jordanian students, males (108) and females (124) with mean age of 20.4 years. Data calculation showed that out of a total number of 688 teeth, 194 were impacted. The prevalence of impacted third molars in the maxilla was higher compared to that of the mandible and the percentage of impaction in male patients was slightly higher compared to female patients.

Nevertheless, the literature review implies that impacted third molars have the highest prevalence of distribution in the mandible compared to the maxilla. The results of Chu et al. (21) showed that in a total number of 3853 impacted teeth, 82.5% of them were impacted third molars occurred in the mandible, compared to only 15.6% of them in the maxilla. In a retrospective study by Quek et al. (65) in a Singapore Chinese population, one thousand PANs of patients aged 20-40 years were assessed. In 1000 PANs, 686 of them had at least one impacted teeth, where the incidence of impacted third molars was three times higher in the mandible than in the maxilla. In this study, significantly larger number of females had at least one impacted third molar compared to males (65). Furthermore, similar findings to Quek et al. (65) retrospective study were found in a Southeast Iran study, where up to 2300 PANs of patients who were referred to the radiology clinic from 2007 to 2011 were assessed. Both male and female patients with their sex ratio 1:1.7 and age range 19 to 55 years (mean age + - SD=26.2 + 05.8) were included (62). Data showed that in the 1020 PANs, 585 cases were reported to have at least one impacted third molar, with the significant difference between the mandible and the maxilla. Tooth impaction occurred 1.9 times more likely in the mandible compared to the maxilla. At the same time, female patients had higher prevalence of impacted third molars compared to males (62).

A radiographic study of 1100 PANs of patients who were referred to Maxillofacial Department in People's Hospital in Bhopal India between 2011 and 2012 were evaluated retrospectively. In this study, 730 male and 370 female patients were included. They were aged between 20 and 35 years. In this study, 50.20% of impacted third molars were impacted, where distribution of impactions in the mandible had statistically higher prevalence compared to that in the maxilla (69). A similar study took place in Ordu University Faculty of Dentistry where samples of 1006 patients, both male and female, between the ages 19 and 26 years, who were referred to the department of Oral and Maxillofacial between 2010 and 2015 were evaluated (71). The study results confirmed a total number of 1518 impacted third molars, with no significant differences in gender. Assessing distribution of impacted third molars between the maxilla and the mandible, it was clearly shown that the incidence of impacted third molars in the maxilla was lower compared to that in the mandible, with their possibility of occurring in the mandible 1.33 times more often (71).

The current dental literature on tooth impaction clearly implies that impacted third molars have the highest prevalence of all impacted teeth and are a frequent health concern because of their association with several pathologies and other significant clinical conditions such as caries and tooth resorption of the adjacent tooth. Development of cystic lesions and tumors is also related to third molar impaction, although the prevalence is quite low (2.77%) (72-73). Due to the above mentioned pathologies caused by impacted teeth, respectively impacted third molars, extraction is one of the most common treatment procedures (72-75).

Classification of the impacted third molars, based on evaluation of their angulation, level of impaction and relationship with the anterior ramus of the mandible, is of pivotal importance because there is specific surgical challenge with removal of third molars. This classification helps clinicians estimate the difficulty of the extraction of impacted third molars, thus avoiding possible complications. Most reliable systems of classification in use are those by Winter and Pell-Gregory who use the relationship between the longitudinal axis of impacted third molar, adjacent tooth, the occlusal surface of the adjacent tooth, and the ascending ramus of the mandible (76-77).

1.8.1.1 Prevalence of impacted third molars angulation

The literature suggests that mesioangular impaction has the highest prevalence of angulation of impacted third molars (78-79). A study by Khan et al. (78) included a total sample of 286 patients and mesioangular angulation was most common impaction. There is a disagreement among researchers on whether impacted third molars in the maxilla are more often in mesial or vertical angulations. Some authors recommend that impacted third molars in vertical angulation are more common in the maxilla (62, 65, 79). Kruger et al. (80) reported that mesioangular impaction had the highest prevalence in the maxilla.

Quek et al. (65) and Hashemipour et al. (62) reported that mesioangular impaction of third molar in the mandible was the most frequent angulation. A predominance of mesial angulated impacted third molars towards the adjacent second molar was also reported in a study by Syed et al. (79) with occurrence of 50.8% in patients.

Nevertheless, there are studies that report vertical impaction to be a common type of impacted third molar in the mandible. The studies conducted by Pillai et al. (69) and Ayranci et al. (71) reported the prevalence of vertical impaction in the maxilla compared to mesioangular impaction.

A study group from Queen's University - Belfast Study Group, as cited by Ishwar Kumar (81), has clarified possible causes of higher prevalence of mesioangular impaction. They stated that mesioangular impaction occurs as a result of separated root growth between the mesial and distal root. Since it depends on the root development, the root remains inclined mesially or rotates vertically. If mesial part of the root is less developed, the mesioangular impaction will occur.

1.8.1.2 Prevalence of level of impacted third molar

Using the Pell Gregory classification for the study of the most frequent level of impacted third molars in the maxilla, Quek et al. (65) stated that class B has the highest prevalence in both male and female patients. Class A showed the highest prevalence of impaction in the study by Hashemipour (62). The depth of impacted third molars in maxillary molars may vary in different groups as a result of hereditary factors, a reduced dental health care, dietary habits and less functional activity.

A number of authors have also used Pell-Gregory classification to determine the level of impacted third molar in the mandible. The IIA class was found to have the highest prevalence in the Obiechina et al. study (82), which was similar to findings of Jaffar and Tin (83), Khan et al. (78) and Hashemipour et al. (62) studies. Blondeau and Daniel (84), and also Almendros et al. (85) reported that class IIB had the most frequent level of impaction for impacted mandibular third mandibular molars in their studies.

Khan et al. (78) elaborated variations of the level of impacted third molar in the mandible. They believed that these levels vary due to different population groups and their differences in their diets: fibrous food stimulates jaw growth, while circumferential attrition of teeth provides space for eruption of third molars. According to the same author, hereditary and racial differences should also be taken into the consideration for the variation in the level of impaction between different populations.

1.8.2 Prevalence of impacted canines

Several epidemiological studies have shown that the prevalence of impacted canines varies with its range between 1% and 5% and also they vary in their distribution between the maxilla and the mandible (25, 53, 86).

Dachi et al. (23) reported a general prevalence of impacted canine in their study at 1.3%, while study results in Turkish subpopulation by Aydin et al. (87) in a sample of 4500 examined patients, with age range 11 to 81 years, reported the prevalence of 3.73% of impacted canines. Ericson and Kurol (88) reported the incidence of impacted canine in Swedish children at the age between 8-12 years. The prevalence was 2.05%. A study by Zahrani (89) in a sample of 4898 Saudi patients with the minimum age inclusion criteria of 13 years and older, reported a prevalence of impacted canines amounting to 3.6%.

The results of a study in a Hong Kong Chinese population, in a total number of 3853 impacted teeth, showed that only 35 impacted canines were detected (21). An incidence of 5.3% in a Greek population was reported in a study by Gisakis et al. (22). The results of a study in Brazil subpopulation showed that in a total number of 356 impacted teeth, only 20 impacted canines were found (60).

1.8.2.1 Impacted canines in maxilla and mandible

The majority of studies have confirmed the fact that impacted maxillary canines are the second most often impacted teeth in dental arch after impacted third molars with prevalence ranging from 0.8 to 2.8% (89-90), whereas canines are the third most commonly impacted mandibular teeth after mandibular premolars (21-25).

The overall prevalence of impacted maxillary canines in Dachi et al. (23) study was 0.92%, which was a higher prevalence compared to that in the mandible with 0.38%. The prevalence of impacted maxillary canines, reported by Ericson and Kurol (88), was significantly higher compared to that in the mandible. A similar result of predominance of impacted maxillary canines was reported by Aydin et al. (87). One of the highest incidences of impacted maxillary canines was reported by Rozsa et al. (91) in a study that was conducted in 1858 PANs of children and adults visiting Department of Pediatric Dentistry and Orthodontics in Budapest.

In a Hong Kong Chinese population, the number of impacted maxillary canines was 30, whereas the number of impacted mandibular canines was 5, in a total number of 3853 impacted teeth. Similarly, Ioannis G. Gisakis reported an absolutely higher incidence of maxillary canines impaction compared to that of mandibular canines (21-22).

Data of a study from Hamadan Dental School showed that in 248 impacted teeth, 18% of impacted teeth were maxillary canines, whereas in a total number of 356 impacted teeth in a Brazilian subpopulation, a total of 14 teeth were detected in the maxilla and 6 in the mandible (59-60).

1.8.2.2 Gender differences in canine impaction

The majority of studies reported higher incidence of impacted canines in females compared to males. The ratio is 3:1 in favor of females (21-22, 60).

1.9 Pathologies associated with impacted teeth

Apart from the variation of prevalence of impacted teeth in human dentition and its constant rise, it should be understood that their extraction is a regular procedure, specifically for impacted third molars due to several pathologies that are associated with their impaction. In consequence, their impaction is a common health concern (15, 92-93).

Pathologies associated with impacted teeth, particularly with impacted third molars have been supported by strong evidence in the dental literature by several authors (21, 74, 92, 94). Knowing their pathological prevalence is of a pivotal importance since this piece of information can be used to justify the preventive surgical extraction of these teeth.

Pathologies that can occur most often as a result of impacted teeth, particularly those related to impacted third molars are:

1. Caries of impacted teeth or adjacent teeth: A study in 2014 by Nazir et al. (95) found that caries prevalence was 38% of all pathologies associated with impacted third molars.
2. Periodontal disease: Study results of Hong Kong Chinese populations showed that periodontal bone loss of more than 5 mm on the distal surface of the second molar that was adjacent to impacted third molar, was the most common pathology, with the highest prevalence of the pathology located in the mandible. Similar results were reported in a study on impacted teeth in a Greek population (21-22).

3. Root resorption of the adjacent teeth: Asymptomatic destruction of regular anatomical structures to adjacent teeth can appear as a result of impacted teeth, for example, a root resorption on a distal surface of the second molar. This tooth resorption caused by impacted third molars or impacted canines is observed with different prevalence by different authors (21-22, 95).
4. Cysts and other conditions: Conditions such as: cystic processes, hyperplastic dental follicle, supernumerary teeth and tumors associated with impacted third molars occur with a very low prevalence (21-22).

Study results in Hong Kong Chinese population showed that periodontal bone loss of more than 5 mm on the distal surface of the second molar that was adjacent to impacted third molar, was the most common pathology, with the highest prevalence of pathology located in the mandible with a frequency of 9%, and in the maxilla only 13 of 600 teeth. This pathology was closely followed by caries of the impacted and/or adjacent teeth, with frequent location on the distal surface of adjacent second molar in the mandible. Other pathologies such as root resorption and increase in the periodontal space of the dental follicle of more than 4mm around the impacted teeth were uncommon (21).

Data from Greek a population study showed that a total number of 777 impacted teeth were associated with some pathology. Periodontal bone loss of the adjacent tooth of more than 5 mm below the cementoenamel junction had the highest prevalence of pathology in 242 cases, root resorption of the adjacent tooth was reported in 183 cases, an increase in the pericoronal space of more than 4mm around the impacted teeth and dental caries of the impacted and /or adjacent teeth was recorded as pathology with the lowest prevalence (22).

Furthermore, the results of a retrospective study of 359 PANs taken from the patients who visited College of Dentistry, Taibah University in Saudi Arabia, in which only male patients were included with an age range between 20-40 years, showed that pathology of loss of lamina dura of adjacent tooth had the highest prevalence, followed by caries of impacted or adjacent tooth. Additionally, an increase in follicular space around the impacted teeth had the lowest prevalence. (96).

Bearing in mind the fact that impacted third molars have the highest incidence of impaction in human dentition, it is not surprising that numerous scientists have focused on the prevalence of pathologies associated with impacted third molars.

Currently, not enough data are being collected on the prevalence of pathologies associated with non-impacted third molars. In a retrospective study by Gündüz et al. (94) that was carried out in 12,129 patients who visited Department of Oral Diagnosis and Radiology, between January 2003 and December 2007, the main aim was to determine the prevalence and pathologies associated with non – third molar impaction in Turkish oral patients. The minimum inclusion age was 14 years and impacted third molars were not included. The study results showed that out of 1356 impacted teeth, cystic changes were most commonly found pathology (5.6%), and impacted canine teeth had the highest prevalence, followed by premolars and molars. Root resorption of adjacent tooth was a rare pathology.

1.10 Use of imaging techniques to diagnose impacted tooth assessment

Panoramic radiographs and/or specialized imaging techniques are used to diagnose impacted teeth. All of the techniques assist to localize position of impacted teeth, their relation to surrounding anatomical structures and adjacent teeth (21-23, 64, 96).

1.10.1 Use of panoramic radiographs in assessing/diagnosing impacted tooth

PAN is a two-dimensional standard radiograph that is commonly used to diagnose impacted teeth (96).

PANs are most commonly used in dental practices due to their advantages: they provide more coverage for periodontal bone defects, periapical lesions, and pathological jaw lesions because there is a wide view of the entire oral cavity in a single image projection, including teeth in the maxilla and the mandible as well as their surrounding tissues. In addition, they are used to examine trauma, to assess impacted teeth, their eruption pattern, growth and development, and, also, to detect lesions and diseases. Besides, there is a minimal radiation exposure, low cost and patients declare no discomfort (21-22, 96).

2. AIM AND HYPOTHESIS

2.1 Identifying gaps in knowledge

- Bearing in mind the fact that the prevalence of impacted teeth varies considerably among studies and that a report about such prevalence misses entirely for population of Kosovo, a study about its prevalence in Kosovar population would help create a clear picture for Kosovo, thus determining globally how often teeth become impacted.
- There is a lack of data on the prevalence of pathologies associated with impacted teeth in a Kosovar population. Evaluating the prevalence of pathologies associated with impacted teeth in a certain population contributes to making a comparison pattern in different regions and populations worldwide.

Therefore, the main aims of this research were as follows:

2.2 Aim

1. To determine the prevalence of impacted teeth in a Kosovar population.
2. To determine the prevalence of pathologies associated with impactions in a Kosovar population.
3. To determine the commonly found impacted teeth in a Kosovar population.
4. Pattern of impacted third molar and its factor (age, gender, angulations, type and depth impaction.

The hypotheses of this research were:

2.3 Null hypothesis

1. There is no difference in the prevalence of impacted teeth between the population of Kosovo and populations from other parts of the world.
2. There is no difference in the prevalence of pathologic changes associated with impacted teeth between a population of Kosovo and populations in other parts of the world.

2.3.1 Working hypothesis

1. There is a varying frequency of impacted teeth groups among Kosovar population due to age.
2. The type of impacted third molars is different with respect to Winter’s classification and Pell and Gregory’s classification and age.

3. MATERIALS AND METHODS

3.1 Study Area and Population

This study was conducted in the University Dentistry Clinical Center of Kosovo. This center is a leading institution in health, teaching and research for dentistry in Kosovo. Its main aim is to incorporate three of the above mentioned activities in order to improve the oral health of the Kosovar population, which at the time of data collecting had a population of 1.9 million (97).

UDCCK is located in Prishtina. It comprises 8 departments including Oral Surgery and Radiology. Patients who visit the UDCCK institute come from all around the country for different dental procedures and the entire population of Kosovo has an easy access to Center.

3.2 Study design

This research is a cross-sectional study of PANs that were selected randomly at the UDCCK during the period of time 2011 to 2015.

3.3 Samples and their demographic representation

3.3.1 Total sample of PANs

In this research a total number of 5155 PANs were studied, which were derived from the UDCCK database. The sample included patients aged 14 - 78 years. Age distribution of participants' PANs is shown in Figure 1. As it can be clearly seen, from the included participants, the group up to 25 years of age was predominant in our research.

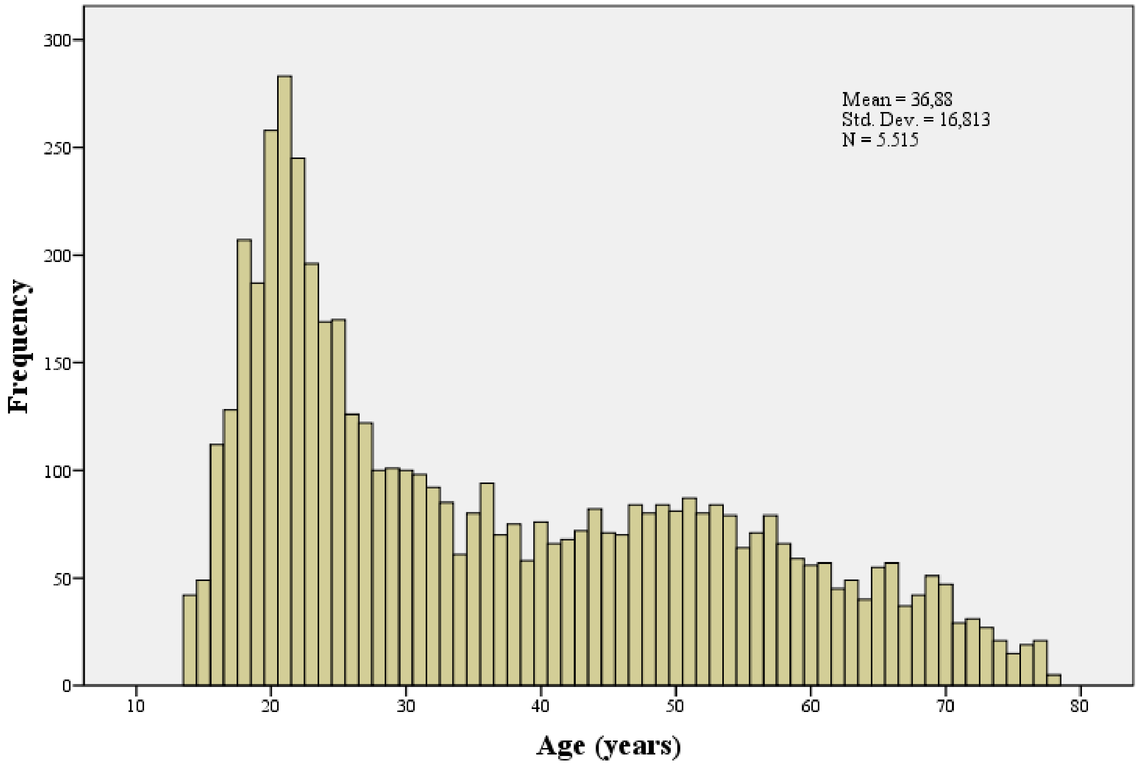

Figure 1 Age distribution of total PANs (N= 5515)

Distributions of age in a total sample of PANs and specifically separately for men and female are shown in Figure 2. It appears that predominance of young participants is especially pronounced in the group age of young women. Statistical analysis of the relationship between these two groups was performed with χ^2 test, while results are presented in Table 1 (χ^2 = 104.3, df = 6, p < 0.001). The difference is statistically significant and can be seen in age groups aged 20- 30 years. However, the participation of younger females is represented by more females than expected (57.1%) in the two youngest age groups, while the incidence is higher than expected in men (42.9%) in the two eldest groups. Middle age groups are similar to the total, which is similar to the expected values.

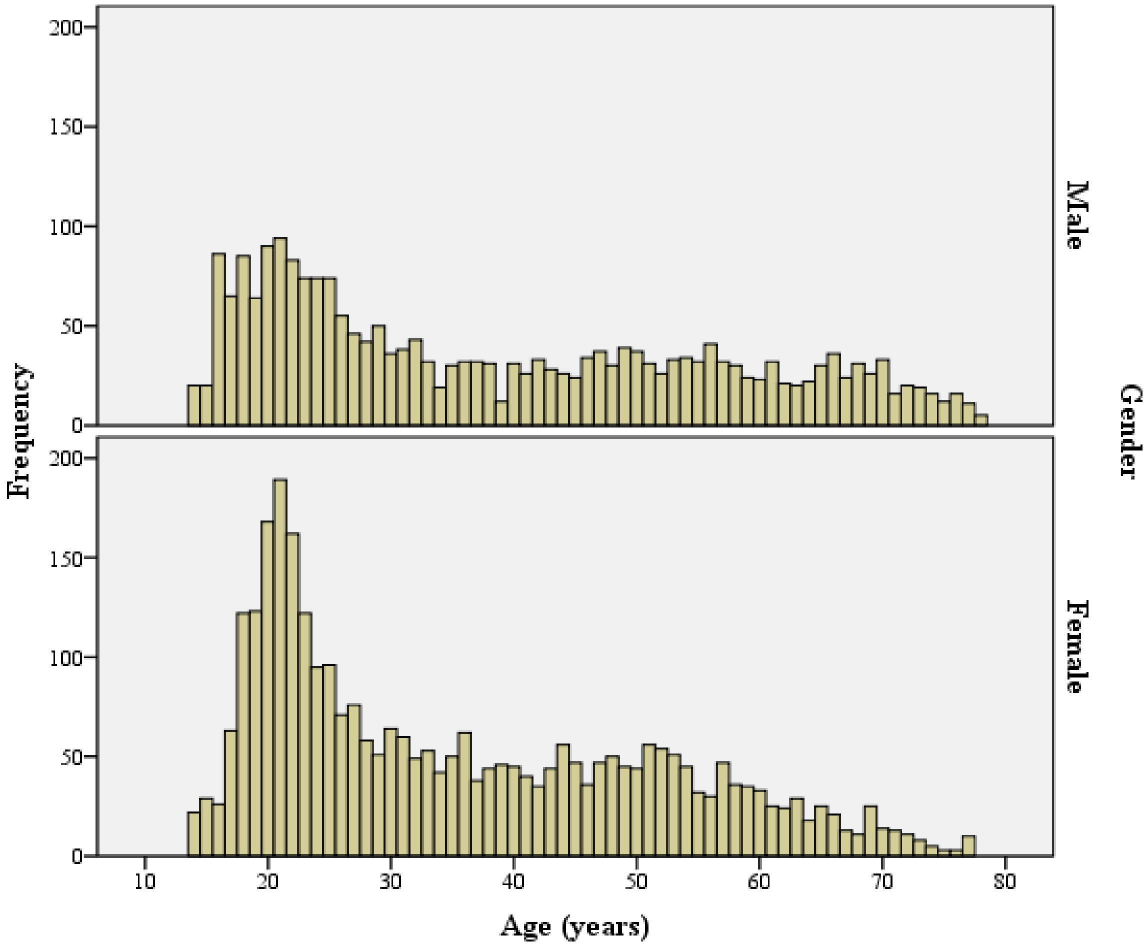

Figure 2 Age distribution of total PANs according to sex (N=5515)

Table 1 Age distribution of total sample of PANs according to sex of participants

Age groups		Sex		Total
		Male	Female	
14-20	n [a]	430	553	983
	hp [b]	43.7%	56.3%	100.0%
	vp [c]	18.2%	17.6%	17.8%
21-30	n	628	984	1612
	hp	39.0%	61.0%	100.0%
	vp	26.5%	31.3%	29.2%
31-40	n	300	489	789
	hp	38.0%	62.0%	100.0%
	vp	12.7%	15.5%	14.3%
41-50	n	314	444	758
	hp	41.4%	58.6%	100.0%
	vp	13.3%	14.1%	13.7%
51-60	n	306	419	725
	hp	42.2%	57.8%	100.0%
	vp	12.9%	13.3%	13.1%
61-70	n	275	205	480
	hp	57.3%	42.7%	100.0%
	vp	11.6%	6.5%	8.7%
71-78	n	115	53	168
	hp	68.5%	31.5%	100.0%
	vp	4.9%	1.7%	3.0%
Total	n	2368	3147	5515
	hp	42.9%	57.1%	100.0%
χ^2 test [d]		$\chi^2 = 104.3$	df = 6	$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 72.1.

3.4 Methods

3.4.1 Data collecting

All PANs were taken as a standard procedure for patients admitted to the UDCCK. The PANs were retrieved as digitalized images from the UDCCK database. Images from the digital PAN machine were exported to JPEG format the SIDEX next generation imaging software, version 2.4® integrated with the I-Max Touch Line: 220-240V-7A 50/60Hz max exposure time: 15s, produced by Owandy (OWANDY 6, alle Kepler 774420 Champs-sur-Marne-France) ®.

Subsequently, digital images were analyzed with Corel Draw (Graphic Suite X7, United States). During analysis, 'Magnify' and 'Ruler' tools were used (Figure 3|). Patients' personal data were collected only based on their date of birth, date of radiography examination and gender. During the PANs examination, a tooth was considered impacted in case it did not have functional occlusion, the eruption path was obstructed by an adjacent tooth, and bone or soft tissue and their roots were entirely developed. When an impacted tooth was identified, the eruption status of the patient's other teeth was also assessed.

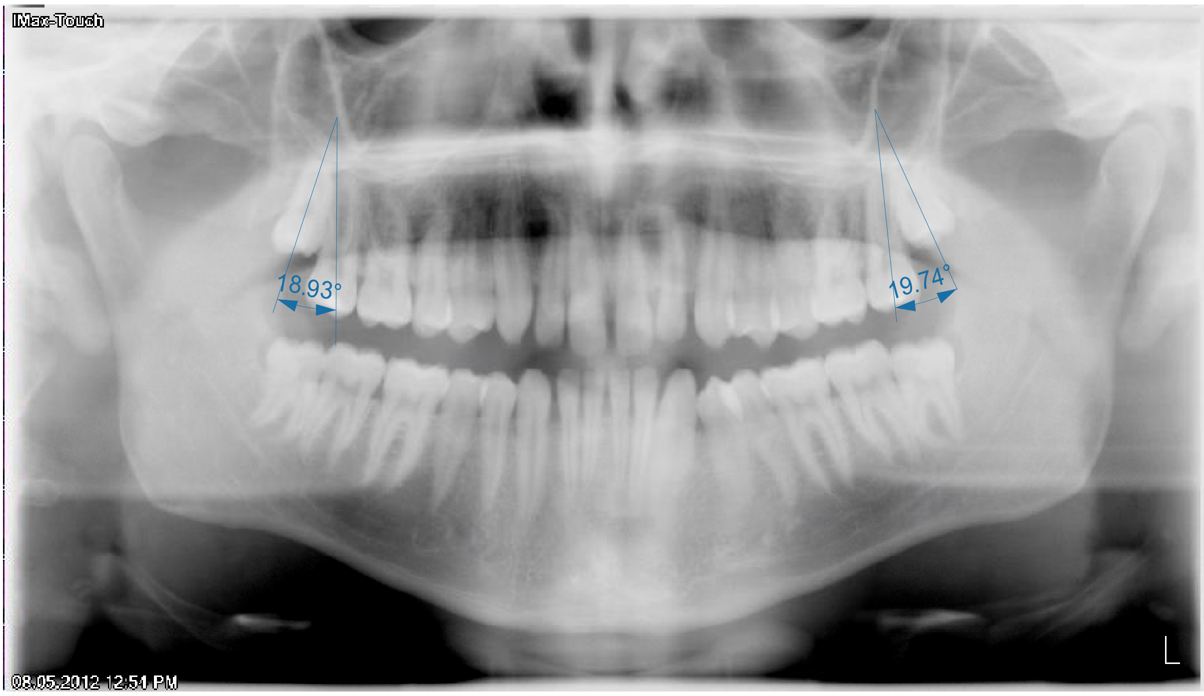

Figure 3. Measurements with Corel Draw in PAN

3.4.1.1 Angulation of impacted third molars

The angulations of impacted third molars were determined based on Winter's classification, which is dependent on the angle formed between the longitudinal axis of the second molar and third impacted molar (76). Winter's classification was used for impacted third molars in maxilla and mandible (Figure 4).

Angular position of the impacted third molars was determined from a tracing of digital images. A line was drown through longitudinal axis of second molar and impacted third molar, these lines represent the long axes of the teeth. The angle between the long axes gave a vertical, mesial, horizontal, distal angulation, buccolingual or other orientation. The angulations on the digital images were analyzed with Corel DRAW (Graphics Suite X7, Unites States).

The calculated angles between the cross longitudinal axes of the second and third molars were:

1. The vertical impaction (10° to -10°)
2. Mesio angular impaction (11° to 79°)
3. Horizontal impaction (80° to 100°)
4. Disto angular impaction (-11° to -79°)
5. Buccolingual impaction (tooth oriented in a buccolingual direction with crown overlapping the roots)
6. Others (111° to -80°)

Subsequently, data were entered into spread sheets peculiarly designed for the purpose of this research (Appendix).

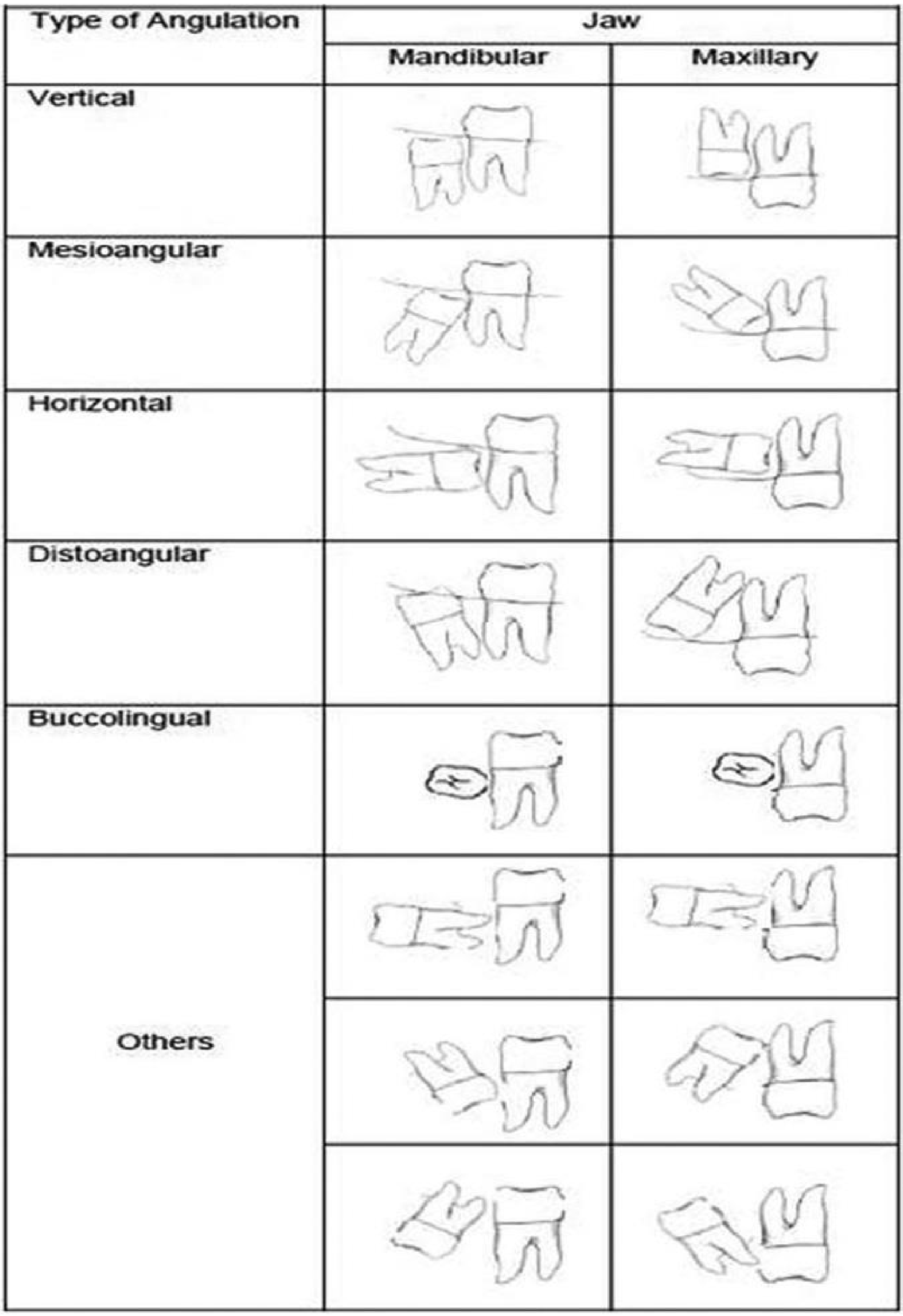

Figure 4 Winter's classification adopted from Hashemipour et al. (62)

3.4.1.2 Level of impaction for impacted third molars

The level of impacted third molars was recorded using the Pell and Gregory's classification while assessing digital panoramic radiographs, where the depth of impacted third molars was determined in relation to the occlusal plane of impacted third molars and second molar (see Figure 5) (77):

Class A – The occlusal plane of impacted third molar was at the same level as the occlusal plane of the second molar

Class B- The occlusal plane of the impacted third molar was between the occlusal plane and the cervical line of the second molar.

Class C – The impacted third molar was below the cervical line of the second molar

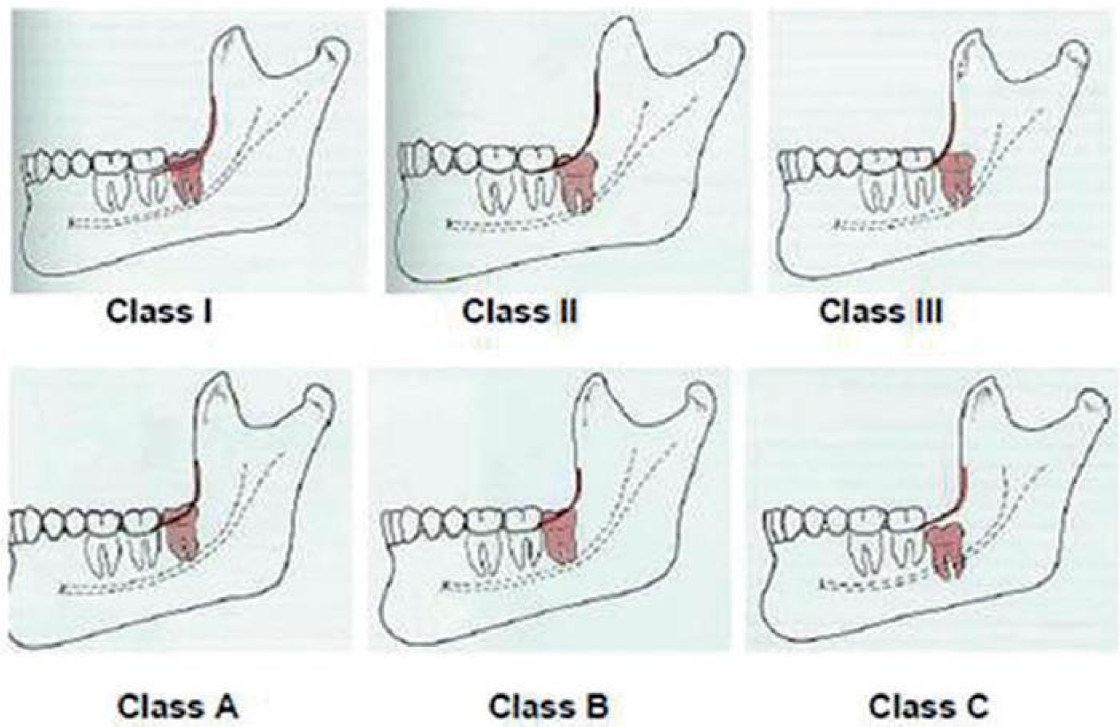

Figure 5 Pell-Gregory classification adopted from Hashemipour et al. (62)

3.4.1.3 Relation to the ramus of mandible for impacted third molars

This Pell Gregory classification system was only reliable for impacted mandibular third molars, which was related to the position of the third molar to the ascending mandibular ramus and the second molar, see Figure 5 (77):

Class I - Occurs when there is sufficient space between the ramus and the distal part of the second molar, for the accommodation of the mesiodistal diameter of the third molar
Class II - Occlusal half of the crown is covered by the anterior border of the ramus
Class III - Entire or most of the third molar crown is located on the anterior border of the ramus of the mandible.

3.4.1.4 Angulation of other impacted teeth

Angulations of other impacted teeth (canines, premolars and incisors) were assessed according to Winter's classification by angles created between long axes of impacted teeth and adjacent teeth. Angels were classified as: mesioangular, disto-angular, vertical or horizontal (76).

3.4.1.5 Pathologies associated with impacted teeth

The following radiographic lesions were assessed on the PANs when impacted teeth were identified (21-22):

- Caries of the impacted and /or adjacent tooth;
- Periodontal bone loss of the adjacent tooth of more than 5mm below the cementoenamel junction
- Root resorption of the adjacent tooth; and
- An increased pericoronal gap of the dental follicle of more than 4 mm around the impacted teeth (Table 2).

Table 2 Criteria for diagnosing lesions around impacted teeth in PANs

Diagnosis	**Criteria**
Caries	Radiographically clear carious lesion in the impacted teeth or/and in the adjacent teeth.
Periodontal bone loss	Radiolucency of the periodontal bone loss on the distal aspect of the second maxillary and mandibular molar was measured from the cementoenamel junction to the marginal bone level.
Root Resorption	A clear loss of substance in the root of adjacent tooth due to direct contact between it and impacted tooth.
Increased pericoronal gap	Completely radiolucent area encompassing the crown of the fully impacted teeth, respectively third molars

When more than one lesion was identified for particular impacted teeth, each lesion was recorded individually for the same case.

3.4.2 Selection Criteria

PANs that were included in the study were based on the inclusion and exclusion criteria described below.

3.4.2.1 Inclusion Criteria

The inclusion criteria of this study were as follows:

- Age: Patients aged from 14 years and older were studied for impacted teeth. However, PANs of patients aged 14-18 years were studied for all impacted teeth, apart from impacted third molars, since the eruption process is completed at age 14 for all teeth apart from third molars. Third molar impactions were studied only for PANs of participants within age group older than 18 years because the accepted view is that third molars normally start to erupt by that age.
- Sex: Both males and females were included
- Types of impaction: Patients with all forms of impactions in both jaws were included

3.4.2.2 Exclusion criteria

The exclusion criteria of this study were as follows:

- Age: Patients aged younger than 14 years were not included.
- Absence of anomalies or syndromes: Patients with craniofacial anomalies or syndromes such as: Down Syndrome, Claudio Cranial Dysostosis and other.
- Quality: PANs of poor quality were not analyzed.
- Tooth Formation: Teeth that did not erupt, despite being on there eruption time, and showing uncompleted root formation.

3.4.3 Ethical concern

The UDCCK consent forms were signed by participants prior to any study assessments being performed. They were informed that their dental records and radiographs could be used for research and educational purposes without the possibility of jeopardizing their confidentiality.

The protocol and guiding principle for this study has been subsequently reviewed, approved by the UDCCK tutorial session by Ministry of Health of the Republic of Kosovo and by Senate of University of Zagreb (Class: 643-03/18-07/34 Reference Number: 380-130/042-18-4 Zagreb, 13 November 2018) School of Dental Medicine Ethic Committee.

3.4.4 The agreement of the researcher

The PhD candidate examined all PANs and determined the number and type of impacted teeth, as well as the presence of associated pathologies, to eliminate interexaminer errors. The validity of the PAN readings was tested for 99 impacted teeth observed on 50 randomly selected PANs using Kappa statistics.

Two weeks after the first assessment by the researcher, the assessment was repeated by the second supervisor of the researcher. All PANs were examined using a blind approach, without the possibility of evaluating age and sex. As it can be clearly seen in Table 3, the examiner used Cohen's kappa coefficient and the levels of agreement are satisfactory for all variables. The kappa mean value of 0.756 is substantial.

Table 3 Cohen's kappa coefficient is used to measure inter-rater reliability (and also Intra-rater reliability) for key variables

Variables	Kappa coefficient		n	p value
Caries of impacted and/or adjacent teeth	0.491	moderate	91	< 0.001
Periodontal bone loss of adjacent tooth of more than 5 mm	0.871	almost perfect	99	< 0.001
Root resorption of adjacent tooth	0.814	almost perfect	99	< 0.001
Increased pericoronal gap	0.657	substantial	99	< 0.001
Pell-Gregory classes	0.979	almost perfect	99	< 0.001
Pell-Gregory depth classes	0.553	moderate	99	< 0.001
Winter angulation	0.924	almost perfect	99	< 0.001
Mean value of Kappa coefficients	0.756	substantial		

According to Landis and Koch, the strength of the kappa coefficients for 0.01-0.20 is slight; 0.21-0.40 is fair; 0.41-0.60 is moderate; 0.61-0.80 is substantial; 0.81-1.00 almost perfect (Table 4) (98).

Table 4 Kappa Coefficients

Value of Kappa coefficients	Level of Agreement
0.01 – 0.20	slight
0.21 - 40.0	fair
0.41 – 0.60	moderate
0.61 – 0.80	substantial
0.80 – 1.00	almost perfect

3.4.5 Statistical Analysis

Data analyzing refers to the original sample of PANs with impacted teeth as entities. Of course, the PANs appear in a sample multiple times, depending on the number of impacted teeth. Due to that sample PAN has been created as an entity with the number of affected teeth and their associated data. When PAN was performed, apart from age, all other variables were of the lowest measurement level, nominal, which can be considered as scale, in other words, variables the categories of which create some groups, such as age groups. Constrained by these facts, the variables of this study are shown in frequencies and relative frequencies (%) in tables and in some cases graphically. The set hypothesis of the research is verified by a series of working hypotheses on the independence of couple of variables, for example the independence of root resorption of the adjacent teeth of third molars. Statistical test is a $\chi 2$ test and is presented with the contingency table. In the cases of analyzing the number of impacted teeth in PAN by age groups, Kruskal-Wallis test has been used, verified with Robust Tests of Equality of Means, specifically with Welch Two Sampe t-test. For the statistical decision making, the value of usual level of 0.05 and 5% was used.

The data analysis was performed using the STATISTICA version 10 software package (StatSoft, Inc. (2011) STATISTICA (data analysis software system), version 10. www.statsoft.com.).

4.RESULTS

4.1 Distribution of PANs with impacted teeth

The results of distribution of total PANs according to age, and in particular PANs with and without impacted teeth, are presented. It is clearly evident that the number of younger participants is predominantly larger, as mentioned above in the text. Statistical analysis of these two groups was made using the χ^2 test, while the results are presented in Table 5 ($\chi^2 = 301.64$, df = 6, $p < 0.001$). Younger age groups have a statistically significant higher percentage of impacted teeth compared to older age groups.

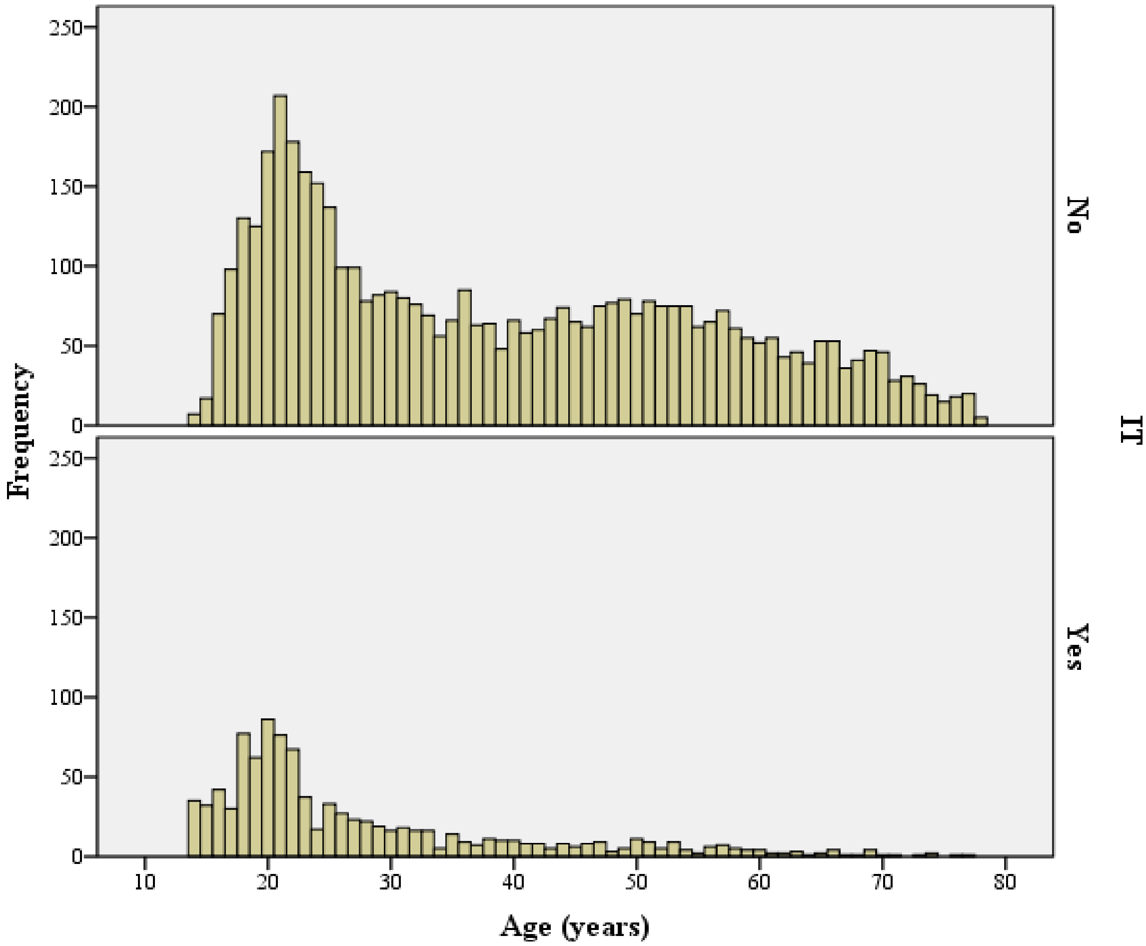

Figure 6 Distribution of age groups of total PANs present with impacted teeth (N= 5515)

Table 5 Distribution of age groups in total PANs per impacted tooth of participants

Age groups (years)		IT		Total
		No	Yes	
14-20	n [a]	619	364	983
	hp [b]	63.0%	37.0%	100.0%
	vp [c]	13.6%	37.5%	17.8%
21-30	n	1275	337	1612
	hp	79.1%	20.9%	100.0%
	vp	28.1%	34.7%	29.2%
31-40	n	673	116	789
	hp	85.3%	14.7%	100.0%
	vp	14.8%	12.0%	14.3%
41-50	n	687	71	758
	hp	90.6%	9.4%	100.0%
	vp	15.1%	7.3%	13.7%
51-60	n	670	55	725
	hp	92.4%	7.6%	100.0%
	vp	14.7%	5.7%	13.1%
61-70	n	459	21	480
	hp	95.6%	4.4%	100.0%
	vp	10.1%	2.2%	8.7%
71-78	n	162	6	168
	hp	96.4%	3.6%	100.0%
	vp	3.6%	0.6%	3.0%
Total	n	4545	970	5515
	hp	82.4%	17.6%	100.0%
χ^2 test [d]		$\chi^2 = 439.1$	df = 6	$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 29.5.

Statistical analysis of the prevalence of impacted teeth in a total number of sample according to sex was performed with χ^2 test, while the results are presented in Table 6 ($\chi^2 = 2.82$, df = 1, p = 0.100). It is noticeable that the occurrence of impacted teeth is not sex specific, as there is no significant statistical difference according to sex. Table 6 provides an analysis of prevalence of impacted teeth in PANs, which is 16.6% in male participants, and slightly higher, 18.3%, in female participants. As a result, in our study, a sample prevalence of impacted teeth in a Kosovo population showed the value of 17.6% in PANs.

Table 6 Distribution of impacted teeth in PAN samples according to sex of participants

IT		Sex		Total
		Male	Female	
No	n [a]	1975	2570	4545
	hp [b]	43,5%	56,5%	100,0%
	vp [c]	83,4%	81,7%	82,4%
Yes	n	393	577	970
	hp	40,5%	59,5%	100,0%
	vp	16,6%	18,3%	17,6%
Total	n	2368	3147	5515
	hp	42,9%	57,1%	100,0%
χ^2 test [d]		$\chi^2 = 2.82$	df = 1	p = 0.100

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (0%) have expected count less than 5. The minimum expected count is 416.5.

4.2 Total sample of PANs with impacted teeth

While analyzing study samples, a total number of 1777 impacted teeth have been found in 970 PANs and 1310 of impacted third molars have been found in 710 PANs.

The distributions of age groups according to sex of participants' PANs with impacted teeth are presented in Table 7. As the results of χ^2 test show (chi-square test) ($\chi^2 = 23.39$, df = 5, $p < 0.001$), there is a statistically significant difference according to sex. In younger age groups, a larger number of PANs with impacted teeth occurred in females compared to males, while in older age groups a larger number of impacted teeth occurred in males. This difference is proven by mean age of male (n = 393, M = 29.3, SD = 14.56) and female (n = 577, M = 26.3, SD = 11.19) participants, which was on average three years. According to t- test for independent samples, this difference is statistically significant ($t = 3.65$, df = 968, $p < 0.001$).

Table 7 Distribution of age groups according to sex of PANs with impacted teeth

Age groups (years)		Sex		Total
		Male	Female	
14-20	n [a]	147	217	364
	hp [b]	40.4%	59.6%	100.0%
	vp [c]	37.4%	37.6%	37.5%
21-30	n	114	223	337
	hp	33.8%	66.2%	100.0%
	vp	29.0%	38.6%	34.7%
31-40	n	50	66	116
	hp	43.1%	56.9%	100.0%
	vp	12.7%	11.4%	12.0%
41-50	n	36	35	71
	hp	50.7%	49.3%	100.0%
	vp	9.2%	6.1%	7.3%
51-60	n	26	29	55
	hp	47.3%	52.7%	100.0%
	vp	6.6%	5.0%	5.7%
61-78	n	20	7	27
	hp	74.1%	25.9%	100.0%
	vp	5.1%	1.2%	2.8%
Total	n	393	577	970
	hp	40.5%	59.5%	100.0%
χ^2 test [d]		$\chi^2 = 23.39$	df = 5	$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.94.

Out of a total number of 970 PANs, 710 PANs had at least one of the most commonly impacted tooth- third molar. Table 8 shows the distribution of age groups of 710 PANs with impacted third molars by sex. There is a statistically significantly difference by sex according to the $\chi 2$ test result ($\chi^2 = 27.42$, df = 5, $p < 0.001$). More specifically, there were higher proportions of female participants in the age group of 30, and there were higher proportions of male participants in the older age groups. This is also similar to the total number of 970 PANs. Furthermore, this is indicated also by the difference in the average age of men (n = 296, M = 32.1, SD = 14.60) and women (n = 414, M = 27.3, SD = 10.86), on average it is almost 5 years, which is higher difference than in the total sample of PANs with impacted teeth. According to independent sample t-test, this difference is statistically significant (t = 5.03, df = 708, p <0.001).

Table 8 Distribution of age groups by sex of PANs with impacted third molars

Age groups (years)		Sex		Total
		Male	Female	
18-20	n [a]	73	122	195
	hp [b]	37.4%	62.6%	100.0%
	vp [c]	24.7%	29.5%	27.5%
21-30	n	106	194	300
	hp	35.3%	64.7%	100.0%
	vp	35.8%	46.9%	42.3%
31-40	n	43	48	91
	hp	47.3%	52.7%	100.0%
	vp	14.5%	11.6%	12.8%
41-50	n	33	23	56
	hp	58.9%	41.1%	100.0%
	vp	11.1%	5.6%	7.9%
51-60	n	23	21	44
	hp	52.3%	47.7%	100.0%
	vp	7.8%	5.1%	6.2%
61-78	n	18	6	24
	hp	75.0%	25.0%	100.0%
	vp	6.1%	1.4%	3.4%
Total	n	296	414	710
	hp	41.7%	58.3%	100.0%
χ^2 test [d]		$\chi^2 = 27.42$	df = 5	$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.01.

4.3 Results of analysis of impacted teeth per PANs

4.3.1 Prevalence of impacted teeth per PANs

The distribution of impacted teeth in 970 PANs that were identified with impaction are shown in Figure 7. Noticeably half of PANs (51%) have only one impacted tooth, 30% two, 10% three and 6% of PANs have four impacted teeth. Only 3% of PANs have five to eight impacted teeth, consequently, it is suggested that those PANs can be treated as one category, as shown in Figure 8.

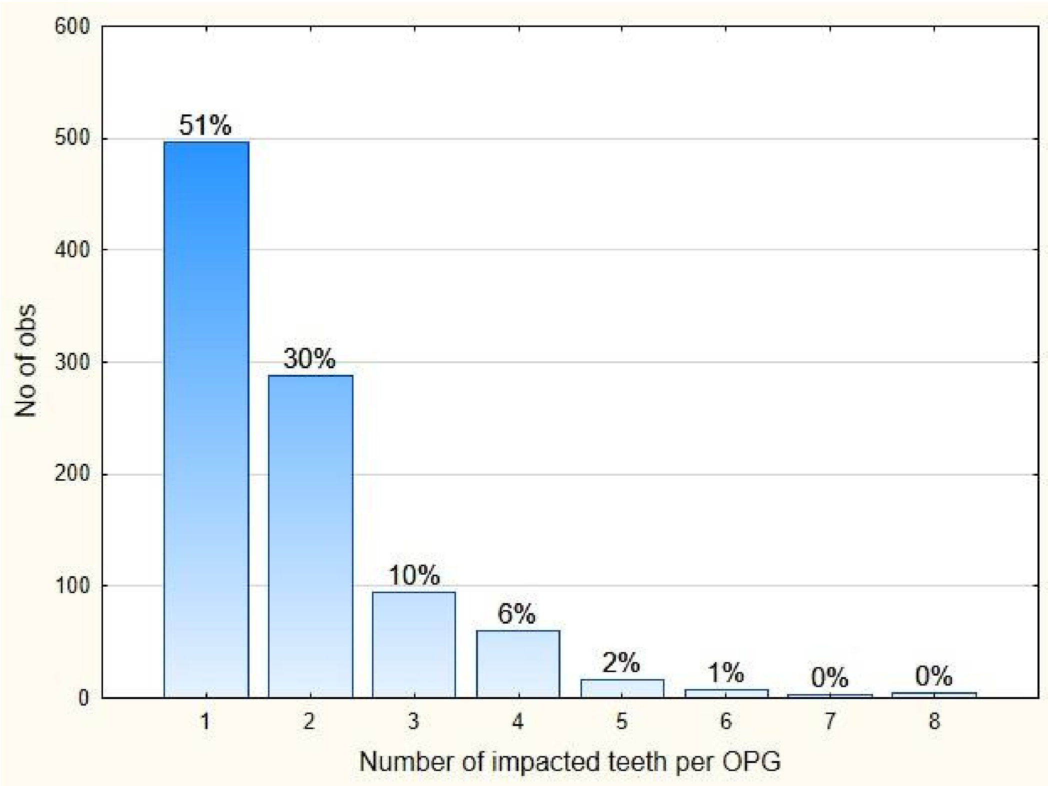

Figure 7 Distribution of number of impacted teeth per PANs (N=970)

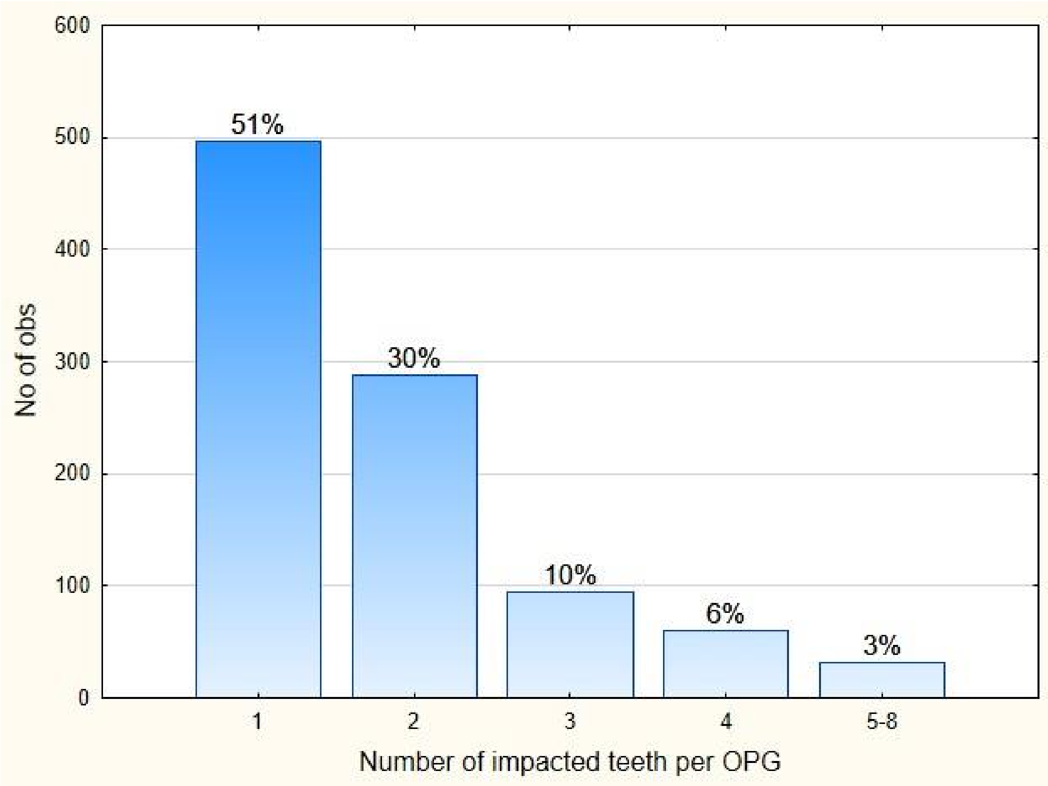

Figure 8 Distribution of impacted teeth per PANs (N=970)

Distributions of impacted teeth in PANs are same for both sexes, as the results of the corresponding χ2 test show (χ^2 = 3.74, df = 4, p = 0.442), which are presented in Table 9, accompanied with the corresponding contingent table. This means that number of impacted teeth per PAN is similar to their sex ratio, which is approximately 4: 6. This can be clearly seen in Figure 9.

Table 9 Distribution of impacted teeth per PAN according to sex

Number of teeth		Sex		Total
		Male	Female	
1	n [a]	197	299	496
	hp [b]	39.7%	60.3%	100.0%
	vp [c]	50.1%	51.8%	51.1%
2	n	128	160	288
	hp	44.4%	55.6%	100.0%
	vp	32.6%	27.7%	29.7%
3	n	34	61	95
	hp	35.8%	64.2%	100.0%
	vp	8.7%	10.6%	9.8%
4	n	24	36	60
	hp	40.0%	60.0%	100.0%
	vp	6.1%	6.2%	6.2%
5-8	n	10	21	31
	hp	32.3%	67.7%	100.0%
	vp	2.5%	3.6%	3.2%
Total	n	393	577	970
	hp	40.5%	59.5%	100.0%
χ^2 test [d]		$\chi^2 = 3.74$	df = 4	p = 0.442

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.6.

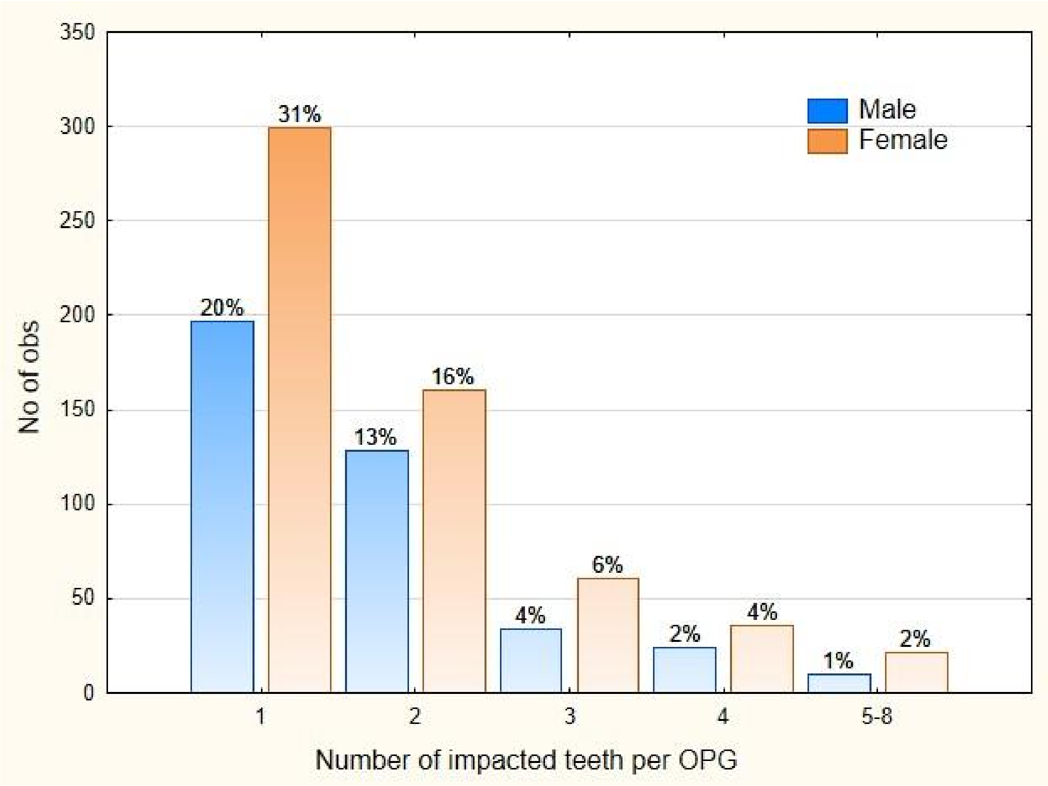

Figure 9 Distribution of impacted teeth per PANs according to sex (N=970)

The distribution of the number of impacted teeth per PAN according to age group is illustrated in Figure 10 and 11. Evidently the number of impacted teeth decreases with age, for all cases of impacted teeth from 1 to 8, respectively from 1 to 5-8.

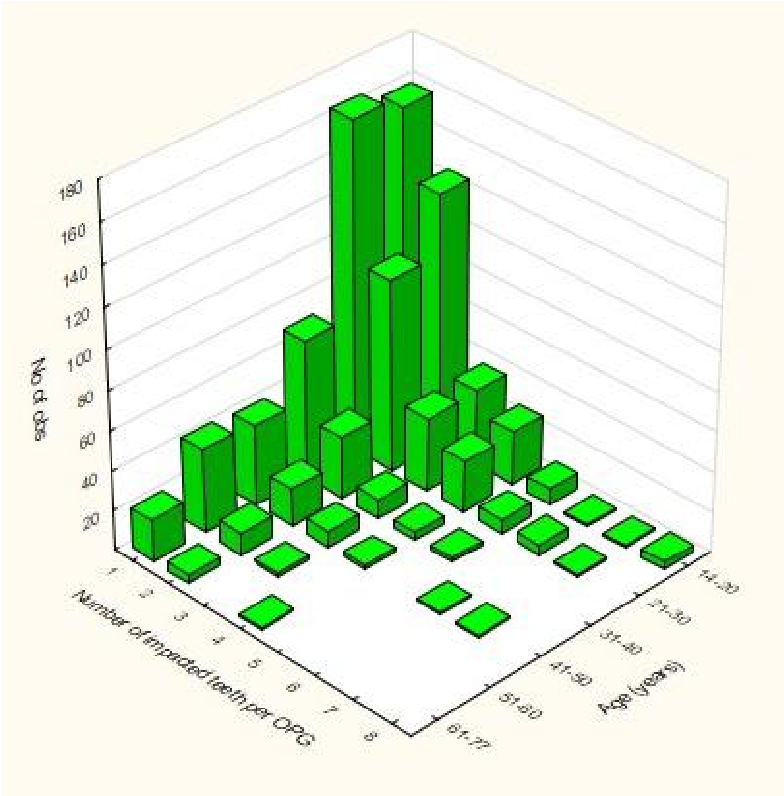

Figure 10 Distribution of impacted teeth per PANs and according to age groups (N=970)

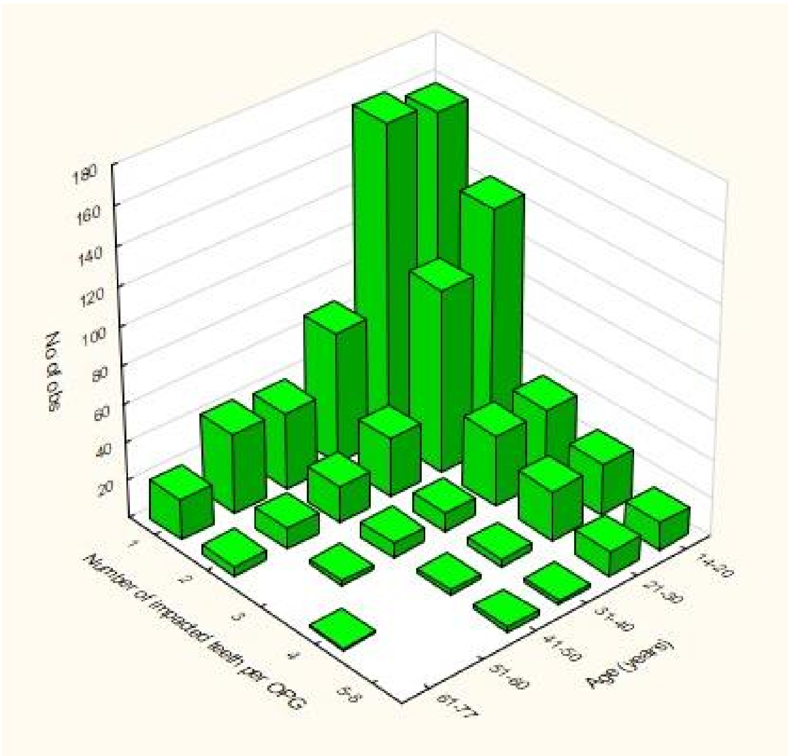

Figure 11 Distribution of impacted teeth per PANs and according to age groups (N=970)

Distributions of number of impacted teeth per PANs according to age groups are shown in Table 10. Since there were significant amounts of low-frequency cells, the $\chi2$ test was not applicable. However, the fact is that a considering number of PANs with one impacted tooth was significantly larger in age groups over 30 years with share of 51.1% of PANs in the total sample of 970 PANs.

Table 10 Distribution of impacted teeth per PANs according to age groups

Age group (years)		Number of impacted teeth per PAN					Total
		1	2	3	4	5-8	
14-20	n [a]	159	126	38	27	14	364
	hp [b]	43.7%	34.6%	10.4%	7.4%	3.8%	100.0%
	vp [c]	32.1%	43.8%	40.0%	45.0%	45.2%	37.5%
21-30	n	165	96	37	26	13	337
	hp	49.0%	28.5%	11.0%	7.7%	3.9%	100.0%
	vp	33.3%	33.3%	38.9%	43.3%	41.9%	34.7%
31-40	n	69	31	10	4	2	116
	hp	59.5%	26.7%	8.6%	3.4%	1.7%	100.0%
	vp	13.9%	10.8%	10.5%	6.7%	6.5%	12.0%
41-50	n	40	19	8	2	2	71
	hp	56.3%	26.8%	11.3%	2.8%	2.8%	100.0%
	vp	8.1%	6.6%	8.4%	3.3%	6.5%	7.3%
51-60	n	42	11	2	0	0	55
	hp	76.4%	20.0%	3.6%	0.0%	0.0%	100.0%
	vp	8.5%	3.8%	2.1%	0.0%	0.0%	5.7%
61-78	n	21	5	0	1	0	27
	hp	77.8%	18.5%	0.0%	3.7%	0.0%	100.0%
	vp	4.2%	1.7%	0.0%	1.7%	0.0%	2.8%
Total	n	496	288	95	60	31	970
	hp	51.1%	29.7%	9.8%	6.2%	3.2%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent

The average numbers of impacted teeth per PAN, in particular according to age groups and their corresponding descriptive parameters, are listed in Table 11. In the previous test, the observed statistically significant difference in the frequency of impacted teeth per PANs by age groups (Table 4x), is also evident for the average number of impacted teeth per PANs. Therefore, as the results in Table 5x show, the age groups up to 30 years had an average of about two impacted teeth per PANs (preciously 1.97 and 1.91), and in the last two age groups it is between 1.27 and 1.30. There is a significant difference according to Robust Tests of Equality of Means (Welch statistic = 14.87, df1 = 5, df2 = 173.69, p <0.001).

Table 11 Average number of impacted teeth per PAN according to age groups

Age group (years)	N	Mean	Std. Dev.	Std. Error	95% CI for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
14-20	364	1.97	1.244	0.065	1.84	2.10	1	8
21-30	337	1.91	1.184	0.065	1.78	2.04	1	7
31-40	116	1.61	0.911	0.085	1.44	1.78	1	5
41-50	71	1.73	1.146	0.136	1.46	2.00	1	7
51-60	55	1.27	0.525	0.071	1.13	1.41	1	3
61-78	27	1.30	0.669	0.129	1.03	1.56	1	4
Total	970	1.83	1.153	0.037	1.76	1.90	1	8

The average value of impacted teeth for 970 PANs was not statistically significant, as the results of the t-test for independent samples presented in Table 12 show. Men have on average 1.80 impacted teeth and women almost the same, 1.85 ($t = -0.735$, $df = 968$, $p = 0.462$).

Table 12 Average number of PANs with impacted teeth by sex – results of t-test for independent samples

Gender	N	Mean	Std. Dev.	Std. Error	95% CI for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
Male	393	1.80	1.070	.054	1.69	1.91	1	8
Female	577	1.85	1.206	.050	1.76	1.95	1	8
Total	970	1.83	1.153	.037	1.76	1.90	1	8

The average value of the impacted teeth for 970 PANs is not statistically significantly different from the area, as the results of the t-test for the dependent samples show in Table 13. In the maxilla, the maximum is on average 0.93 and 0.90 of the impacted teeth in the mandible ($t = 10.11$, $df = 969$, $p < 0.001$).

Table 13 Average number of impacted tooth in PANs by jaws – results of the analyses of dependent t-test

Area	N	Mean	Std. Dev.	Std. Error
Maxilla	970	0.93	0.853	0.027
Mandible	970	0.90	0.797	0.026

4.3.2. Prevalence of impacted third molars per PANs

The distribution of impacted third molars per PAN is equal for both sexes, as the results of the corresponding $\chi2$ test show ($\chi2 = 1.79$, $df = 3$, $p = 0.616$), which are presented in Table 14, together with the corresponding contingent table. This means that the number of impacted third molars per PAN is similar to their sex ratio, which is approximately 4: 6.

Table 14 Distribution of number of impacted third molars per PANs according to sex

Number of third molars		Sex		Total
		Male	Female	
1	n [a]	155	202	357
	hp [b]	43.4%	56.6%	100.0%
	vp [c]	52.4%	48.8%	50.3%
2	n	91	138	229
	hp	39.7%	60.3%	100.0%
	vp	30.7%	33.3%	32.3%
3	n	32	41	73
	hp	43.8%	56.2%	100.0%
	vp	10.8%	9.9%	10.3%
4	n	18	33	51
	hp	35.3%	64.7%	100.0%
	vp	6.1%	8.0%	7.2%
Total	n	296	414	710
	hp	41.7%	58.3%	100.0%
χ^2 test [d]		χ^2 = 1.79	df = 4	p = 0.616

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.6.

The distribution of the number of impacted third molars per PAN by age groups is shown in Table 15. Because of the large number of low-frequency cells, the $\chi2$ test is not feasible. However, the fact that the proportion of PAN with one impacted third molar is significantly higher in age groups over 30 years, 50.3% of the PANs share one impacted third molar in the total sample of 710 PANs.

Table 15 Distribution of number of impacted third molars per PAN according to age groups

Age group (years)		Number of impacted third molars per PAN				Total
		1	2	3	4	
18-20	n [a]	68	80	25	22	195
	hp [b]	34.9%	41.0%	12.8%	11.3%	100.0%
	vp [c]	19.0%	34.9%	34.2%	43.1%	27.5%
21-30	n	143	98	35	24	300
	hp	47.7%	32.7%	11.7%	8.0%	100.0%
	vp	40.1%	42.8%	47.9%	47.1%	42.3%
31-40	n	55	24	9	3	91
	hp	60.4%	26.4%	9.9%	3.3%	100.0%
	vp	15.4%	10.5%	12.3%	5.9%	12.8%
41-50	n	35	18	2	1	56
	hp	62.5%	32.1%	3.6%	1.8%	100.0%
	vp	9.8%	7.9%	2.7%	2.0%	7.9%
51-60	n	36	6	2	0	44
	hp	81.8%	13.6%	4.5%	.0%	100.0%
	vp	10.1%	2.6%	2.7%	.0%	6.2%
61-78	n	20	3	0	1	24
	hp	83.3%	12.5%	.0%	4.2%	100.0%
	vp	5.6%	1.3%	.0%	2.0%	3.4%
Total	n	357	229	73	51	710
	hp	50.3%	32.3%	10.3%	7.2%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent

The average numbers of impacted third molars per PAN, in particular by age groups and their corresponding descriptor parameters, are presented in Table 16. The observed statistically significant difference in the frequencies of the number of impacted third molars by PANs per age groups in the previous test (Table 4xy), is also observed in the average number of impacted third molars per PAN. Specifically, as the results in Table 16 show, in the age groups of 30 years on average, approximately two impacted third molars per PAN (more precisely 2.01 and 1.80) were found, and in the last two age groups 1.23 and 1.25. The significant difference is confirmed by Robust Tests of Equality of Means (Welch statistic = 15.27, df1 = 5, df2 = 140, p <0.001).

Table 16 Average number of impacted third molars in PANs by age groups

Age group (years)	N	Mean	Std. Dev.	Std. Error	95% CI for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
18-20	195	2.01	0.966	0.069	1.87	2.14	1	4
21-30	300	1.85	0.936	0.054	1.69	1.91	1	4
31-40	91	1.58	0.806	0.084	1.39	1.73	1	4
41-50	56	1.54	0.658	0.088	1.27	1.62	1	4
51-60	44	1.23	0.522	0.079	1.07	1.39	1	3
61-78	24	1.25	0.676	0.138	0.96	1.54	1	4
Total	710	1.80	0.910	0.034	1.68	1.81	1	4

The average value of impacted third molars for 710 PANs that have impacted molars according to sex is not statistically significant as shown by the t-test results for independent samples and as indicated in Table 17. Males have on average 1.83 impacted third molars and women almost the same, 1.85 (t = -0.930, df = 708, p = 0.353).

Table 17 Average number of impacted third molars in PANs according to sex-results of t-test for independent samples

Gender	N	Mean	Std. Dev.	Std. Error	95% CI for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
Male	296	1.76	0.890	0.052	1.60	1.81	1	4
Female	414	1.84	0.925	0.045	1.68	1.86	1	4
Total	710	1.80	0.910	0.034	1.68	1.81	1	4

There are statistically significant differences in the average values of impacted third molars for 710 PANs according to jaws, as the results of t- test for dependent samples show. They are listed in Table 18. In the maxilla, on the average, this occurs in 0.69 and in mandible in 1.14 of the impacted third molars ($t = 10.15$, $df = 709$, $p < 0.001$).

Table 18 Average number of impacted third molars per PANs according to jaw
- the result of the analysis of the dependent samples test

Area	N	Mean	Std. Dev.	Std. Error
Maxilla	710	0.68	0.809	0.030
Mandible	710	1.12	0.781	0.029

4.4 Results of impacted teeth analysis

4.4.1 Prevalence of impacted teeth

The distributions of 1777 impacted teeth in 970 PANs by type and sex, to which PAN belongs, are listed in Table 19. As table clearly shows, the highest percentage of impacted teeth are third molars (73.7%) and canines with a prevalence of 21.0%. Other groups of impacted teeth appear in a total of 5.3% of remaining impacted teeth. Furthermore, Table 19 clearly shows that impacted third molars as the largest group of impacted teeth, statistically they show no sex difference for impaction (74.6%: 73.1%).

Table 19 Distribution of impacted teeth according to sex

Teeth		Sex		Total
		Male	Female	
Incisors	n [a]	14	11	25
	hp [b]	56.0%	44.0%	100.0%
	vp [c]	2.0%	1.0%	1.4%
Canines	n	137	236	373
	hp	36.7%	63.3%	100.0%
	vp	19.4%	22.0%	21.0%
Premolars	n	27	38	65
	hp	41.5%	58.5%	100.0%
	vp	3.8%	3.5%	3.7%
First and second molars	n	1	3	4
	hp	25.0%	75.0%	100.0%
	vp	0.1%	0.3%	0.2%
Third molars	n	527	783	1310
	hp	40.2%	59.8%	100.0%
	vp	74.6%	73.1%	73.7%
Total	n	706	1071	1777
	hp	39.7%	60.3%	100.0%
χ^2 test		$\chi^2 = 4.75$	df = 4	p = 0.313

[a] number of cases, [b] horizontal percent, [c] vertical percent, 2 cells (20.0%) have expected count less than 5. The minimum expected count is 1.59.

The analyses of impacted teeth according to side of the jaws are shown in Table 20. There are no statistically significant differences in the distribution of impacted teeth according to the side of the jaws ($\chi 2 = 4.17$, df = 4, p = 0.383).

Table 20 Distribution of impacted teeth according to the side of jaws

Teeth		Side		Total
		Right	Left	
Incisors	n [a]	13	12	25
	hp [b]	52.0%	48.0%	100.0%
	vp [c]	1.5%	1.3%	1.4%
Canines	n	186	187	373
	hp	49.9%	50.1%	100.0%
	vp	22.0%	20.0%	21.0%
Premolars	n	37	28	65
	hp	56.9%	43.1%	100.0%
	vp	4.4%	3.0%	3.7%
First and second molars	n	2	2	4
	hp	50.0%	50.0%	100.0%
	vp	0.2%	0.2%	0.2%
Third molars	n	606	704	1310
	hp	46.3%	53.7%	100.0%
	vp	71.8%	75.5%	73.7%
Total	n	844	933	1777
	hp	47.5%	52.5%	100.0%
χ^2 test [d]		$\chi^2 = 4.17$	df = 4	p = 0.383

[a] number of cases, [b] horizontal percent, [c] vertical percent, 2 cells (20.0%) have expected count less than 5. The minimum expected count is 1.90.

Table 21 shows the analyses of impacted teeth by the maxilla and the mandible. There is a statistically significant difference in the distribution of impacted teeth between the maxilla and the mandible ($\chi2 = 394.9$, df = 4, $p <0.001$). Most of impacted incisors and canines are found in the maxilla (80.0% of all incisors and 95.4% of all canines). The majority of impacted third molars are found in the mandible 62.1% and 37.9% in the maxilla.

Table 21 Distribution of impacted teeth according to jaws

Teeth		Jaw		Total
		Maxilla	Mandible	
Incisors	n [a]	20	5	25
	hp [b]	80.0%	20.0%	100.0%
	vp [c]	2.2%	0.6%	1.4%
Canines	n	356	17	373
	hp	95.4%	4.6%	100.0%
	vp	39.3%	2.0%	21.0%
Premolars	n	31	34	65
	hp	47.7%	52.3%	100.0%
	vp	3.4%	3.9%	3.7%
First and second molars	n	3	1	4
	hp	75.0%	25.0%	100.0%
	vp	0.3%	0.1%	0.2%
Third molars	n	496	814	1310
	hp	37.9%	62.1%	100.0%
	vp	54.7%	93.5%	73.7%
Total	n	906	871	1777
	hp	51.0%	49.0%	100.0%
χ^2 test		$\chi^2 = 394.9$	df = 4	$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, 2 cells (20.0%) have expected count less than 5. The minimum expected count is 1.24.

An equal number of impacted teeth is found in the maxilla (51%) and (49%) in the mandible. In males, this ratio is 54%: 46%, and in females it is 49%: 51%. This means that impacted teeth equally occur in the maxilla and the mandible, in both males and females (Table 22). This result is statistically significant (($\chi 2$ = 4.17, df = 1, p = 0.042)

Table 22 Distribution of impacted teeth according to sex and jaws

Sex		Jaw		Total
		Maxilla	Mandible	
Male	n [a]	381	325	706
	hp [b]	54.0%	46.0%	100.0%
	vp [c]	42.1%	37.3%	39.7%
Female	n	525	546	1071
	hp	49.0%	51.0%	100.0%
	vp	57.9%	62.7%	60.3%
Total	n	906	871	1777
	hp	51.0%	49.0%	100.0%
χ^2 test [d]		χ^2 = 4.17	df = 1	p = 0.042

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (.0%) have expected count less than 5. The minimum expected count is 346.05.

The occurrence of impacted teeth on the sides of the jaw is not statistically significantly different ($\chi 2$ = 1.52, df = 1, p = 0.225) and is equal to the gender of the participants PANs. In a total number of 1777 impacted teeth, 844 (47.5%) occur on the right and 933 (52.3%) on the left side of the jaws. This ratio right /left is very similar in the group of males and females (Table 23).

Table 23 Distribution of impacted teeth according to sides of the jaws and sex

Sex		Side		Total
		Right	Left	
Male	n [a]	348	358	706
	hp [b]	49.3%	50.7%	100.0%
	vp [c]	41.2%	38.4%	39.7%
Female	n	496	575	1071
	hp	46.3%	53.7%	100.0%
	vp	58.8%	61.6%	60.3%
Total	n	844	933	1777
	hp	47.5%	52.5%	100.0%
χ^2 test [d]		$\chi^2 = 1.52$	df = 1	p = 0.225

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (.0%) have expected count less than 5. The minimum expected count is 335, 32.

4.4.2 Prevalence of impacted third molars

According to the results shown in Table 19, it is evident that in the sample of 1777 impacted teeth, 1310 are impacted third molars and they are the most numerous impacted teeth. The impacted third molars are found in 710 PANs, which are shown and analyzed in section 4.4.2.

According to the analysis of dependence of sex and jaws, 37.9% of impacted third molars are in the maxilla and the remaining 62.1% are located in the mandible. In the male group, third molars ratio in the maxilla was higher (43.1%) of the expected 37.9%, while in the female group it was slightly lower (34.4%), (Table 24). These differences are sufficient to show that according to sex of participants PANs, the impacted third molars in the maxilla and those in the mandible occur in a significantly different prevalence ($\chi 2 = 10.18$, df = 1, p = 0.002).

Table 24 Distribution of impacted third molars according to sex and jaws

Gender		Jaw		Total
		Maxilla	Mandible	
Male	n [a]	227	300	527
	hp [b]	43.1%	56.9%	100.0%
	vp [c]	45.8%	36.9%	40.2%
Female	n	269	514	783
	hp	34.4%	65.6%	100.0%
	vp	54.2%	63.1%	59.8%
Total	n	496	814	1310
	hp	37.9%	62.1%	100.0%
χ^2 test [d]		$\chi^2 = 10.18$	df = 1	p = 0.002

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (.0%) have expected count less than 5. The minimum expected count is 199.54

The results of the analysis of sex and jaws ratio are similar to the previous analysis (Table 24). This table shows that there is a higher frequency of impacted third molars in the maxilla in males (49.5%) and lower in females (44.1%) than the expected 46.3%. However, the result is not statistically significant ($\chi2 = 3.78$, df = 1, p = 0.055) (Table 25).

Table 25 Distribution of impacted third molars according to sex and side of jaws

Sex		Side		Total
		Right	Left	
Male	n [a]	261	266	527
	hp [b]	49.5%	50.5%	100.0%
	vp [c]	43.1%	37.8%	40.2%
Female	n	345	438	783
	hp	44.1%	55.9%	100.0%
	vp	56.9%	62.2%	59.8%
Total	n	606	704	1310
	hp	46.3%	53.7%	100.0%
χ^2 test [d]		$\chi^2 = 3.78$	df = 1	p = 0.055

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (.0%) have expected count less than 5. The minimum expected count is 243.8.

4.4.3 Prevalence of impacted canines

Of the 373 impacted canines, only 17 were located in the mandible and the remaining 356 (95.4%) were found in the maxilla Table 26. There is no statistical difference between sexes.

Table 26 Distribution of impacted canines according to sex and jaws

Sex		Jaw		Total
		Maxilla	Mandible	
Male	n [a]	128	9	137
	hp [b]	93.4%	6.6%	100.0%
	vp [c]	36.0%	52.9%	36.7%
Female	n	228	8	236
	hp	96.6%	3.4%	100.0%
	vp	64.0%	47.1%	63.3%
Total	n	356	17	373
	hp	95.4%	4.6%	100.0%
χ^2 test [d]		$\chi^2 = 2.017$	df = 1	p = 0.198

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (.0%) have expected count less than 5. The minimum expected count is 346.05.

The prevalence of impacted canines according to the side of the jaws (Table 27) is almost equal for both sides 50% (49.9%: 50.1%).

Table 27 Distribution of impacted canines according to sides and sex

Sex		Side		Total
		Right	Left	
Male	n [a]	64	73	137
	hp [b]	46.7%	53.3%	100.0%
	vp [c]	34.4%	39.0%	36.7%
Female	n	122	114	236
	hp	51.7%	48.3%	100.0%
	vp	65.6%	61.0%	63.3%
Total	n	186	187	373
	hp	49.9%	50.1%	100.0%
χ^2 test [d]		$\chi^2 = 0.860$	df = 1	p = 0.391

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] Fisher's Exact Test, 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.24.

4.5 Impacted third molars – Winter classification

Distribution of angulation patterns using Winter's classification according to the sex of the participants' PANs is statistically significantly different by the $\chi2$ test ($\chi2 = 17.70$, df = 4, p = 0.001) (Table 28). As the obtained results show, there is a significant difference in the incidence of horizontal angulation in male participants' PANs, compared to female participants' PANs: 58.5% and 41.5%, compared to the expected ratio of 41.8%: 58.2%.

Table 28 Distribution of Winter angulation of impacted third molars according to sex

Winter angulation		Sex		Total
		Male	Female	
Mesial	n [a]	157	286	443
	hp [b]	35.4%	64.6%	100.0%
	vp [c]	29.8%	36.5%	33.8%
Distal	n	140	213	353
	hp	39.7%	60.3%	100.0%
	vp	26.6%	27.2%	26.9%
Vertical	n	147	206	353
	hp	41.6%	58.4%	100.0%
	vp	27.9%	26.3%	26.9%
Horizontal	n	55	39	94
	hp	58.5%	41.5%	100.0%
	vp	10.4%	5.0%	7.2%
Buccolingual	n	28	39	67
	hp	41.8%	58.2%	100.0%
	vp	5.3%	5.0%	5.1%
Total	n	527	783	1310
	hp	40.2%	59.8%	100.0%
χ^2 test		$\chi^2 = 17.70$	df = 4	p = 0.001

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 27.0.

The distribution of Winter's angulations according to the jaws is statistically significantly different, as the results of the χ2 test show ($\chi2 = 272.1$, df = 4, $p < 0.001$) (Table 29). The major difference is found for the mesial angulation in the maxilla with its prevalence of 59.1%, compared to the expected value of 37.9%. Furthermore, horizontal angulation is significantly higher in the maxilla, 80.9%, compared to the expected value of 37.9%. The prevalence of distal and vertical angulation is 85.0% in the mandible, and 77.3% respectively, which is a considerably higher value compared to the expected value of 62.1%. The prevalence of buccolingual angulation occurs in 37.3% and 62.7% respectfully, which is in line with the expected values of 37.9%: 62.1%.

Table 29 Distribution of Winter's angulation for impacted third molars according to jaws

Winter angulation		Jaw		Total
		Maxilla	Mandible	
Mesial	n [a]	262	181	443
	hp [b]	59.1%	40.9%	100.0%
	vp [c]	52.8%	22.2%	33.8%
Distal	n	53	300	353
	hp	15.0%	85.0%	100.0%
	vp	10.7%	36.9%	26.9%
Vertical	n	80	273	353
	hp	22.7%	77.3%	100.0%
	vp	16.1%	33.5%	26.9%
Horizontal	n	76	18	94
	hp	80.9%	19.1%	100.0%
	vp	15.3%	2.2%	7.2%
Bucco-linqual	n	25	42	67
	hp	37.3%	62.7%	100.0%
	vp	5.0%	5.2%	5.1%
Total	n	496	814	1310
	hp	37.9%	62.1%	100.0%
χ^2 test		$\chi^2 = 272.1$	df = 4	$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 27.0.

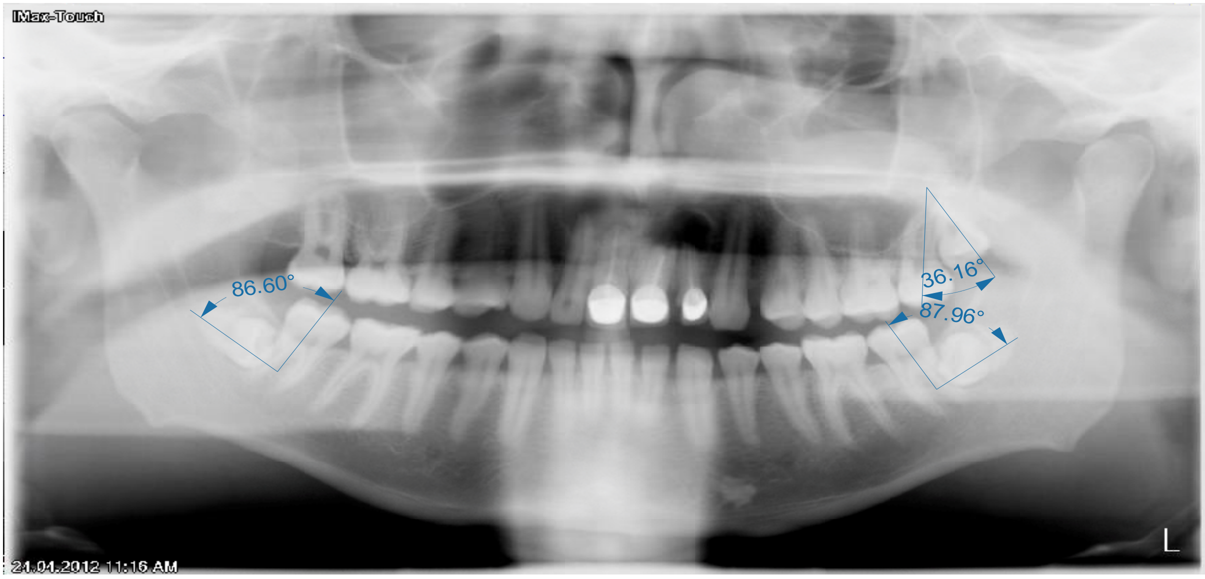

Figure 12 PAN of a female participant aged 25.75 years – impacted third molar in the maxilla and mandible in vertical and horizontal angulation

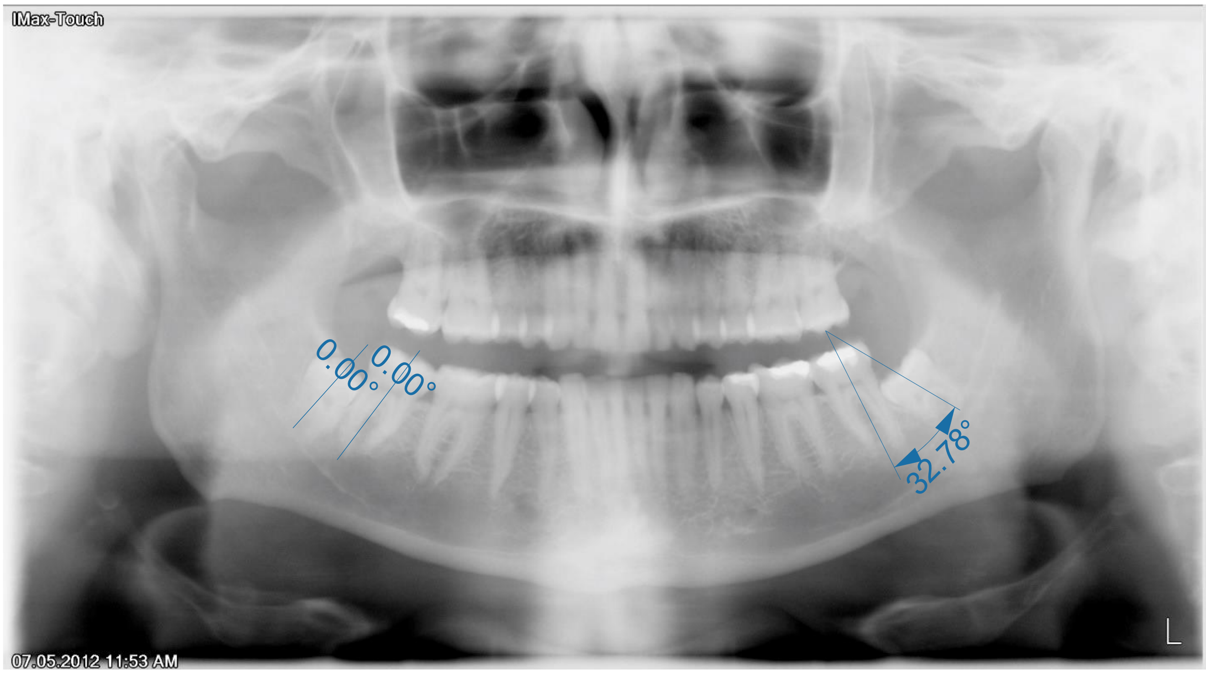

Figure 13 PAN of a male participant aged 21years - impacted third molars in the mandible mesial angulation left side level C class I and right side level B class II

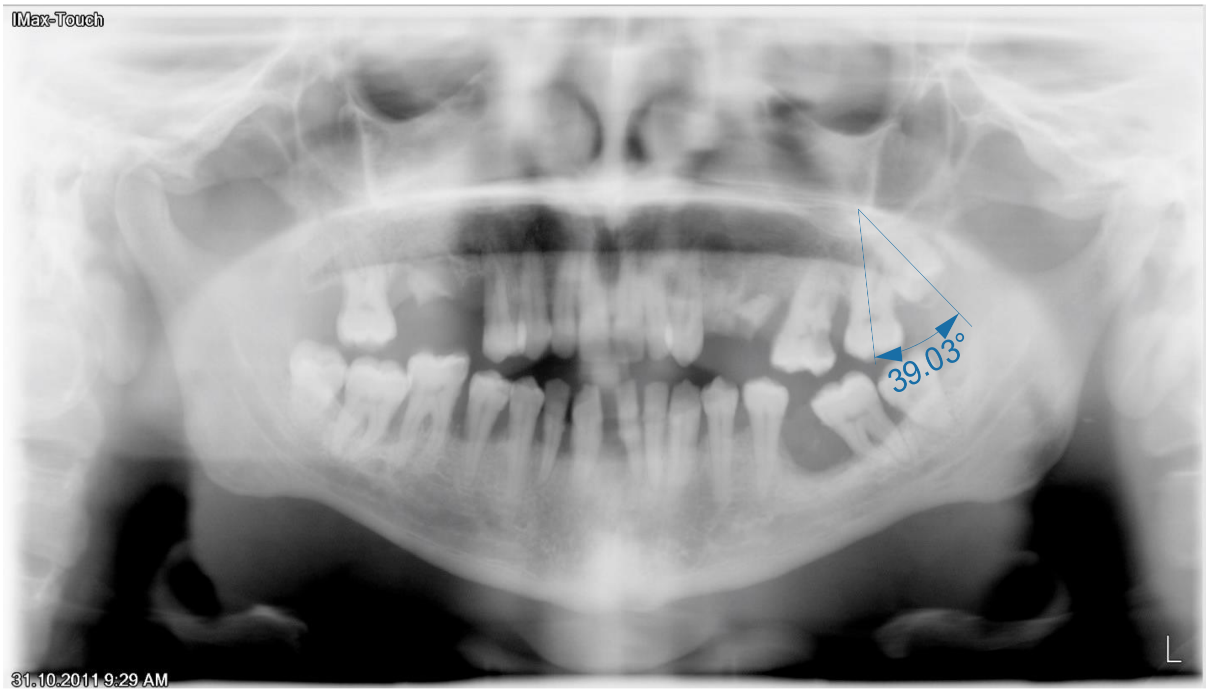

Figure 14 PAN of a female participant aged 40 years - impacted third molar in the maxilla left side distal angulation

4.6 Impacted third molars – Pell Gregory classification

The distribution of Pell-Gregory depth was registered in 1310 impacted third molars. Statistically significant differences were found among the classes of this classification.

The results of the analysis of sex differences in the frequency of Pell-Gregory classes, were obtained by the $\chi2$ test, as shown in Table 30, which clearly indicates that there is no sex differences in the frequency of Pell-Gregory classes ($\chi2$ = 2.26, df = 2, p = 0.323). Class A shows the lowest percentage of only 2.8%, followed by class B with 34.9%. Class C shows the highest percentage of 62.3%.

Table 30 Distribution of Pell-Gregory depth according to sex

Classes		Sex		Total
		Male	Female	
A	n [a]	17	20	37
	hp [b]	45.9%	54.1%	100.0%
	vp [c]	3.2%	2.6%	2.8%
B	n	172	285	457
	hp	37.6%	62.4%	100.0%
	vp	32.6%	36.4%	34.9%
C	n	338	478	816
	hp	41.4%	58.6%	100.0%
	vp	64.1%	61.0%	62.3%
Total	n	527	783	1310
	hp	40.2%	59.8%	100.0%
χ^2 test [d]		χ^2 = 2.26	df = 2	p = 0.323

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.9.

The same analysis according to the side of the jaws is shown in Table 31. As it can be seen, there is a slight dominance of class C on the right side, however it is not statistically significant ($\chi2$ = 5.30, df = 2, p = 0.071).

Table 31 Distribution of Pell-Gregory depth according to side

Classes		Side		Total
		Right	Left	
A	n [a]	14	23	37
	hp [b]	37.8%	62.2%	100.0%
	vp [c]	2.3%	3.3%	2.8%
B	n	195	262	457
	hp	42.7%	57.3%	100.0%
	vp	32.2%	37.2%	34.9%
C	n	397	419	816
	hp	48.7%	51.3%	100.0%
	vp	65.5%	59.5%	62.3%
Total	n	606	704	1310
	hp	46.3%	53.7%	100.0%
χ^2 test [d]		$\chi^2 = 5.30$	df = 2	p = 0.071

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.12.

Table 32 shows the distribution of classes in the maxilla and mandible. It confirms the fact that there is a prevalence of class C in the maxilla and in the mandible (42.4% and 57.6% respectively). It can be clearly seen that there is higher percentage of Class C in the maxilla (70%), compared to the mandible with prevalence of 57.6% (Table 32). The results regarding the depth of impacted third molars are statistically significant ($\chi 2$ = 96.6, df = 2, p <0.001)

Table 32 Distribution of Pell-Gregory depth according to jaws

Classes		Jaw		Total
		Maxilla	Mandible	
A	n [a]	36	1	37
	hp [b]	97.3%	2.7%	100.0%
	vp [c]	7.2%	0.1%	2.8%
B	n	113	344	457
	hp	24.7%	75.3%	100.0%
	vp	22.8%	42.3%	34.9%
C	n	347	469	816
	hp	42.4%	57.6%	100.0%
	vp	70.0%	57.6%	62.3%
Total	n	496	814	1310
	hp	37.9%	62.1%	100.0%
χ^2 test [d]		$\chi^2 = 96.6$	df = 2	p < 0.001

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.0.

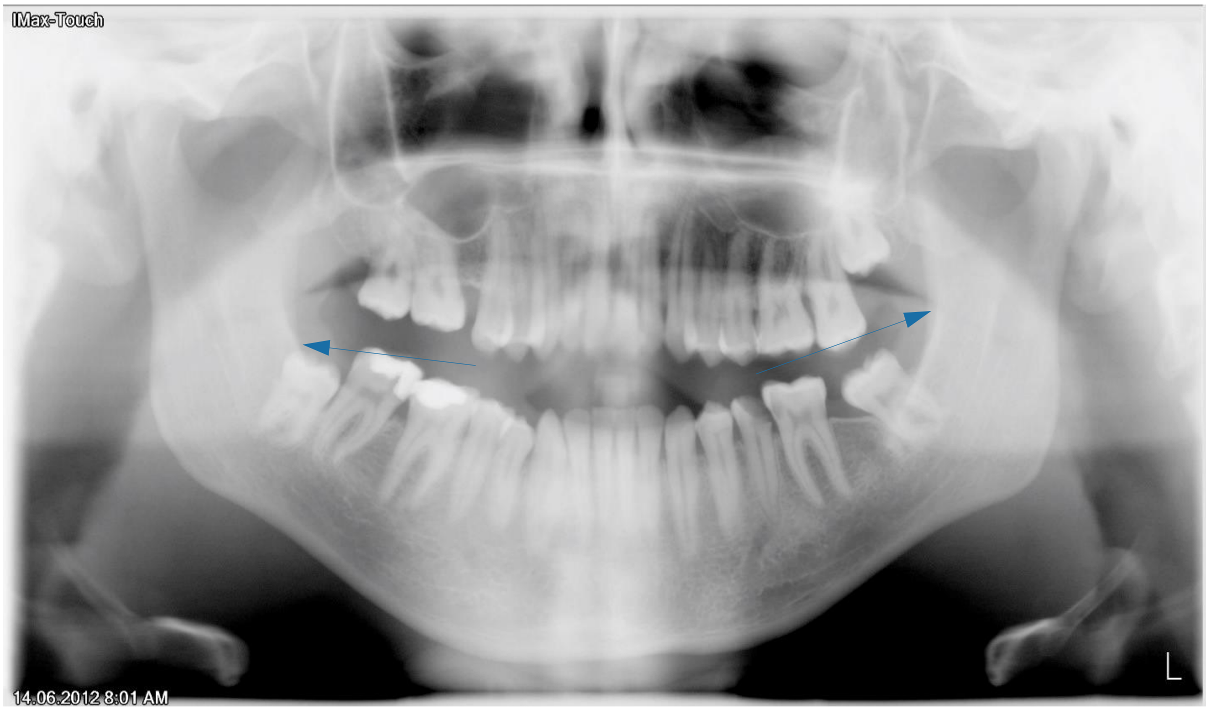

Figure 15 PAN of a male participant aged 23.60 years - impacted third maxillary molar, left side level C, and mandibular right side level B class I

The Pell-Gregory classification for class I-III applies only for impacted third molars in the mandible. The distributions of Pell-Gregory class I-III for those impacted third molars in the mandible are listed in Table 33.

Table 33 Distribution of Pell-Gregory class for impacted third molars in mandible

Pell-Gregory class			Total
Class I	Class II	Class III	
258	390	166	814
31.7%	48.0%	20.4%	100.0%

However, there is a statistically significant difference in the frequencies of Pell-Gregory classes according to the sex of participants PANs, as it can be seen from the results of the $\chi2$ test of the hypothesis of the independence of the class by sex of the participants PANs ($\chi2 = 10.98$, df = 2, p = 0.004) presented in Table 34.

As a matter of fact, the substantial difference lies in the fact that class III is statistically significantly more frequent in male participants (60.2%) compared to females (39.8%) and this is significantly different from the expected ratio, while class I and II appear to be in line with the approximately expected ratio of 45.7%: 54.3%.

Table 34 Distribution of Pell-Gregory class for impacted third molars in the mandible

Class		Sex		Total
		Male	Female	
I	n [a]	110	148	258
	hp [b]	42.7%	57.3%	100.0%
	vp [c]	29.6%	33.5%	31.7%
II	n	162	228	390
	hp	41.5%	58.5%	100.0%
	vp	43.5%	51.6%	48.0%
III	n	100	66	166
	hp	60.2%	39.8%	100.0%
	vp	26.9%	14.9%	20.4%
Total	n	372	442	814
	hp	45.7%	54.3%	100.0%
χ^2 test [d]		χ^2 = 10.98	df = 2	p = 0.004

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 46.2.

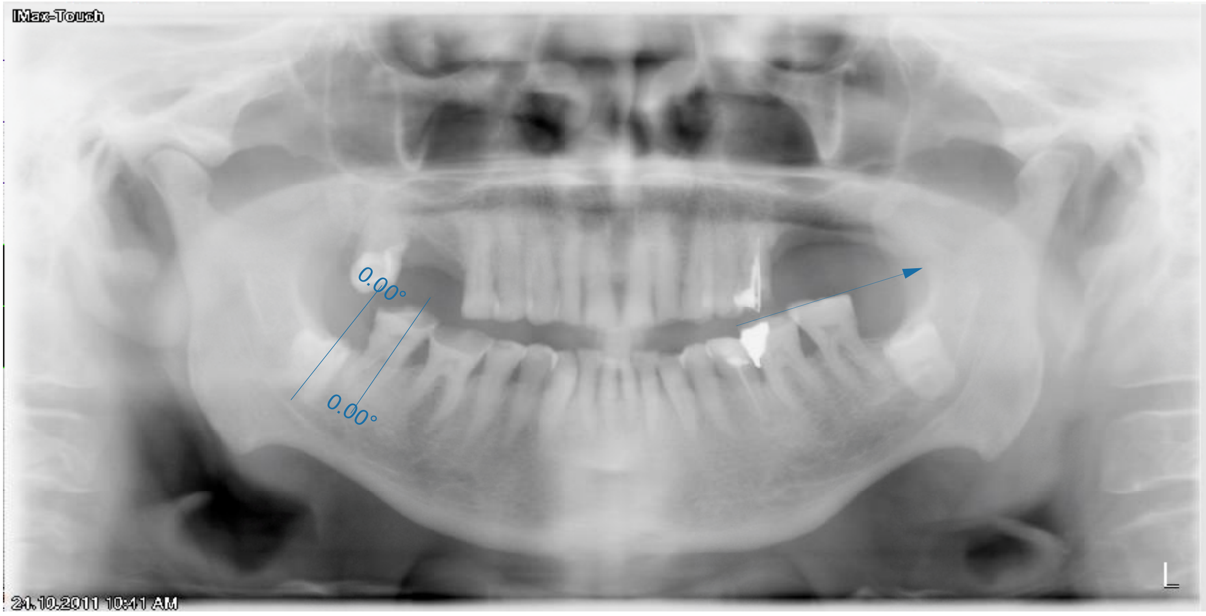

Figure 16 PAN of a male participant aged 64 years - impacted third molars in the mandible, left side level C class III, and right side level C class II

Figure 17 PAN of a female participant aged 33 years - impacted third molar in the mandible level B class III

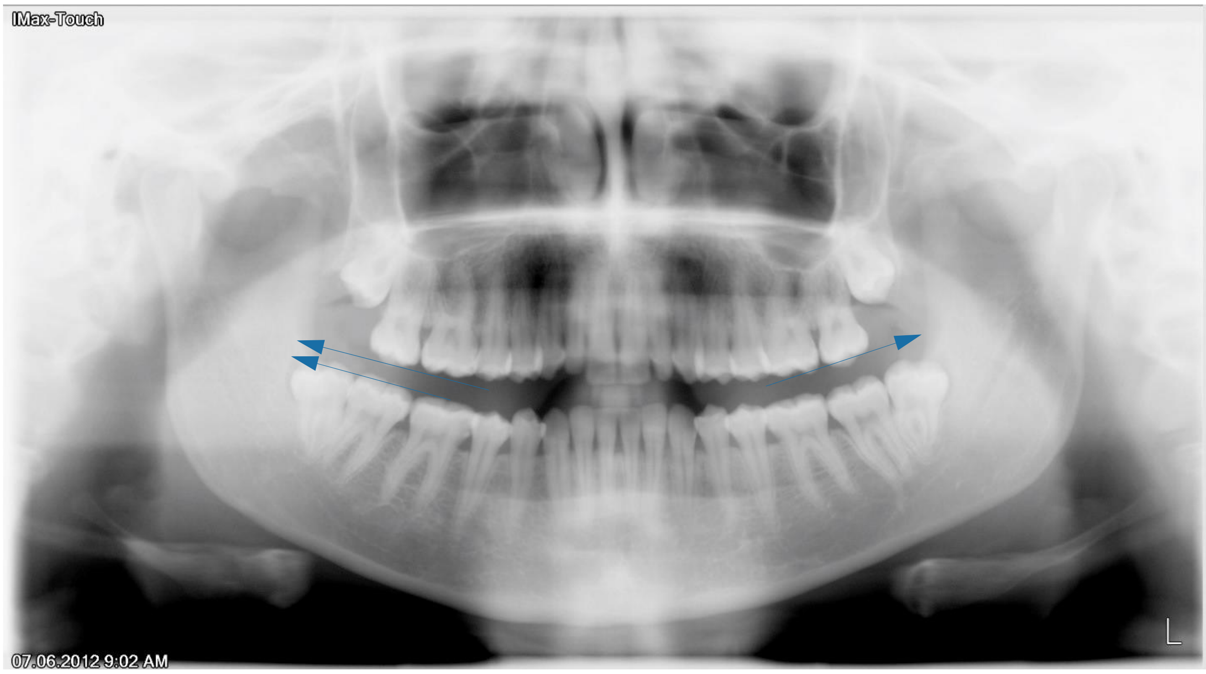

Figure 18 PAN of a male participant aged 37 years - impacted third molars in the maxilla, level C, and impacted third molar in the mandible right side level A, class II

4.7 Canine angulation

Canine angulations according to sex are shown in Table 35. The canine with distal angulation that occurs only in four cases is excluded from the statistical analysis. If it the canine with distal angulation had not been excluded, it would have been impossible to analyze those four cases. Overall, the predominant angulation is mesial occurring in 72.9% of participants PANs, vertical angulation occurs in 15.3%, horizontal angulation is less frequent occurring in 10.3 % of participants PANs, while distal angulation hardly ever occurs in 1.1% of participants PANs.

The total number of 373 canines represents 21% of all impacted teeth (373/1777 = 21%).

The distribution of angulations for impacted canines in the maxilla according to sex shows a statistically significant difference ($\chi2 = 16.51$, df = 2, $p <0.001$) (Table 35), however, impacted canines with distal angulation were excluded from testing due to low frequencies of such angulations. The difference was found in the vertical angulation, particularly in a considering number of cases in male participants PANs (59.6%), while the expected value of this angulation was 36.7%.

Table 35 Distribution of impacted canine angulation according to sex

Canine Angulation		Sex		Total
		Male	Female	
Mesial	n [a]	85	187	272
	hp [b]	31.3%	68.8%	100.0%
	vp [c]	62.0%	79.2%	72.9%
Distal	n	4	0	4
	hp	100.0%	0%	100.0%
	vp	2.9%	0%	1.1%
Vertical	n	34	23	57
	hp	59.6%	40.4%	100.0%
	vp	24.8%	9.7%	15.3%
Horizontal	n	14	26	40
	hp	35.0%	65.0%	100.0%
	vp	10.2%	11.0%	10.7%
Total	n	137	236	373
	hp	36.7%	63.3%	100.0%
χ^2 test [d]		$\chi^2 = 16.50$	df = 2	p = 0.001

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.4 when distal canine angulation is excluded from analysis.

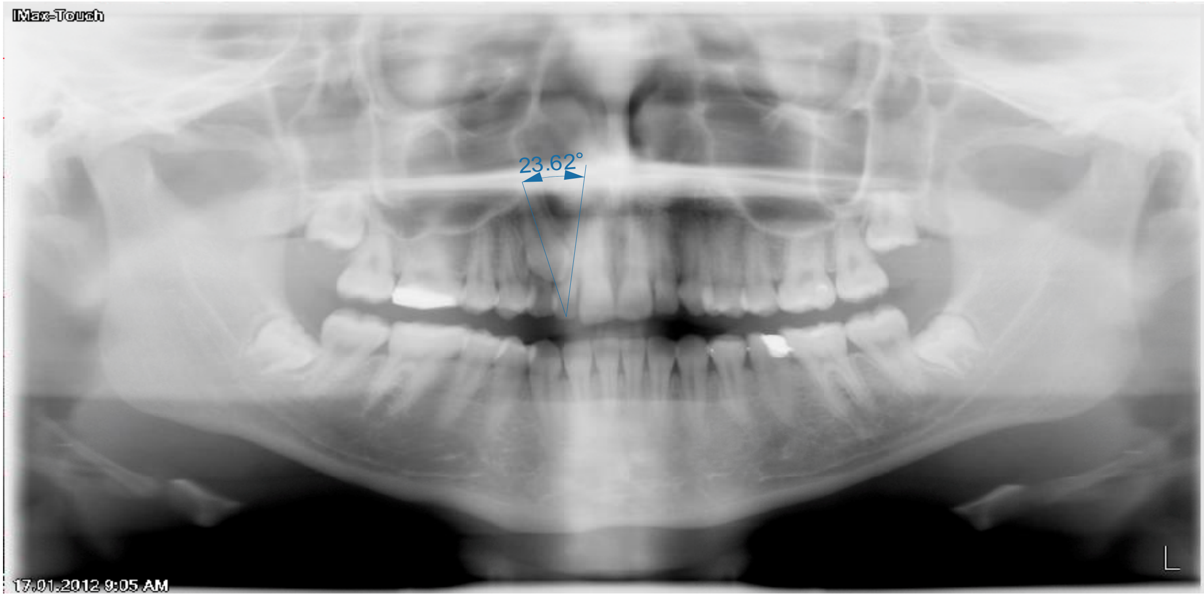

Figure 19 PAN of a female participant aged 16 years - impacted canine in the maxillary mesial angulation

The distribution of canine angulation according to the side of the jaws does not show any statistically significant differences regarding the side of the jaws ($\chi 2 = 4.21$, df = 2, p = 0.122), as the results of $\chi 2$ - test in Table 36 show, after the exclusion of canine with distal angulation.

Table 36 Distribution of canine angulation according to the side of the jaws

Canine Angulation		Sides		Total
		Right	Left	
Mesial	n [a]	145	127	272
	hp [b]	53.3%	46.7%	100.0%
	vp [c]	78.0%	67.9%	72.9%
Distal	n	1	3	4
	hp	25.0%	75.0%	100.0%
	vp	.5%	1.6%	1.1%
Vertical	n	24	33	57
	hp	42.1%	57.9%	100.0%
	vp	12.9%	17.6%	15.3%
Horizontal	n	16	24	40
	hp	40.0%	60.0%	100.0%
	vp	8.6%	12.8%	10.7%
Total	n	186	187	373
	hp	49.9%	50.1%	100.0%
χ^2 test [d]		$\chi^2 = 4.21$	df = 2	p = 0.122

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (0%) have expected count less than 5. The minimum expected count is 19.95 when distal canine angulation is excluded from analysis.

As it can be clearly seen from the results regarding the distribution of the canine angulation according to jaws presented in Table 37, the $\chi 2$ –test cannot be applied since 95.4% of canines occur in the maxilla.

Table 37 Distribution of canine angulation according to jaws

Canine Angulation		Jaw		Total
		Maxilla	Mandible	
Mesial	n [a]	265	7	272
	hp [b]	97.4%	2.6%	100.0%
	vp [c]	74.4%	41.2%	72.9%
Distal	n	3	1	4
	hp	75.0%	25.0%	100.0%
	vp	.8%	5.9%	1.1%
Vertical	n	51	6	57
	hp	89.5%	10.5%	100.0%
	vp	14.3%	35.3%	15.3%
Horizontal	n	37	3	40
	hp	92.5%	7.5%	100.0%
	vp	10.4%	17.6%	10.7%
Total	n	356	17	373
	hp	95.4%	4.6%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent

4.8 Premolar angulation

Since premolars were observed in a small number of PANs, statistical testing could not be performed; hence the distribution of premolar angulation has been described descriptively. Impacted premolars are only recorded in 65 PANs; therefore, the data in Table 38, 39 and 40 are not suitable for testing of any of the hypotheses.

The total number of 65 premolars represents 3.66% of all impacted teeth (65/1777 = 3.66%). Distributions of premolar angulations by sex of participants PANs and in total are shown in Table 38. As it can be clearly seen, impacted premolars in vertical and mesial angulations are more frequent compared to impacted premolars in distal and horizontal angulations. Due to the above mentioned reasons, it was impossible to test the premolar angulation while applying statistical methods.

Table 38 Distribution of premolar angulations according to sex

Premolar angulation		Sex		Total
		Male	Female	
Mesial	n [a]	11	10	21
	hp [b]	52.4%	47.6%	100.0%
	vp [c]	40.7%	26.3%	32.3%
Distal	n	7	4	11
	hp	63.6%	36.4%	100.0%
	vp	25.9%	10.5%	16.9%
Vertical	n	8	20	28
	hp	28.6%	71.4%	100.0%
	vp	29.6%	52.6%	43.1%
Horizontal	n	1	4	5
	hp	20.0%	80.0%	100.0%
	vp	3.7%	10.5%	7.7%
Total	n	27	38	65
	hp	41.5%	58.5%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent

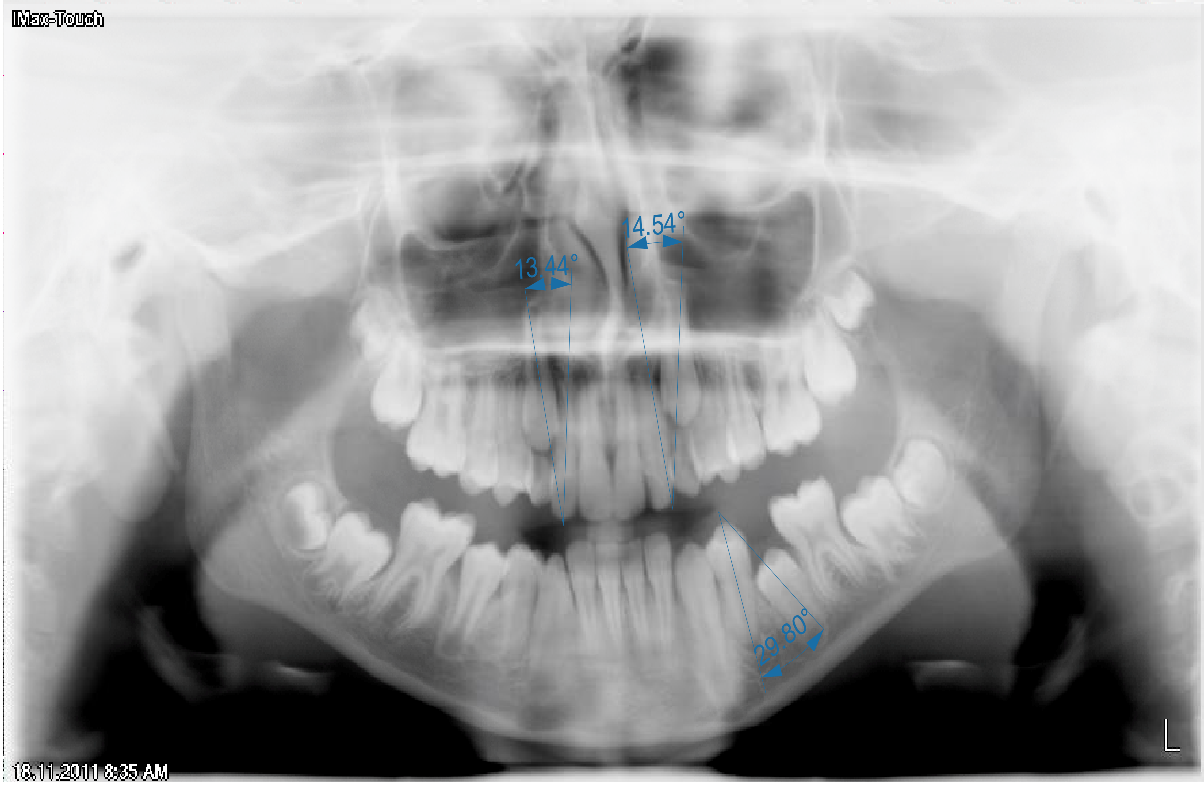

Figure 20 PAN of a male participant aged 15.5 years - impacted second premolar in the mandibular mesial angulation

The distribution of the premolar angulation according to the side of the jaws is shown in Table 39. Since impacted premolars occurred rarely, it was not possible to test them while applying statistical methods.

Table 39 Distribution of impacted premolars according to side of jaws

Premolar angulation		Side		Total
		Right	Left	
Mesial	n [a]	12	9	21
	hp [b]	57.1%	42.9%	100.0%
	vp [c]	32.4%	32.1%	32.3%
Distal	n	7	4	11
	hp	63.6%	36.4%	100.0%
	vp	18.9%	14.3%	16.9%
Vertical	n	17	11	28
	hp	60.7%	39.3%	100.0%
	vp	45.9%	39.3%	43.1%
Horizontal	n	1	4	5
	hp	20.0%	80.0%	100.0%
	vp	2.7%	14.3%	7.7%
Total	n	37	28	65
	hp	56.9%	43.1%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent

The distribution of impacted premolars angulations according to jaws is shown in Table 40. However, similar to previous tables, it was not possible to test the angulation of premolars while applying statistical methods due to a small number of impacted premolars.

Table 40 Distribution of premolars according to jaws

Premolar angulation		Jaw		Total
		Maxilla	Mandible	
Mesial	n [a]	13	8	21
	hp [b]	61,9%	38,1%	100,0%
	vp [c]	41,9%	23,5%	32,3%
Distal	n	5	6	11
	hp	45,5%	54,5%	100,0%
	vp	16,1%	17,6%	16,9%
Vertical	n	9	19	28
	hp	32,1%	67,9%	100,0%
	vp	29,0%	55,9%	43,1%
Horizontal	n	4	1	5
	hp	80,0%	20,0%	100,0%
	vp	12,9%	2,9%	7,7%
Total	n	31	34	65
	hp	47,7%	52,3%	100,0%

[a] number of cases, [b] horizontal percent, [c] vertical percent

4.9 Incisor angulation

The distribution of incisors by level of impaction and angulation has been described descriptively since this group of teeth is too small for statistical testing. Such teeth were found only in 26 PANs; therefore the data listed in Table 41 are not suitable for hypothesis testing.

The total number of 26 incisors is 1.46% of the total percentage of impacted teeth in participants PANs (26/1777 = 1.46%), while twenty of them were localized in the maxilla and 20 in the mandible.

Table 41 Distribution of incisors according to sex and jaws

Incises	Sex		Side		Jaw		Total
	Male	Female	Right	Left	Maxilla	Mandible	
Mesial	9	6	10	5	14	1	15
Distal	4	0	1	3	3	1	4
Vertical	2	5	3	4	2	4	7
Total	15	11	14	12	20	6	26

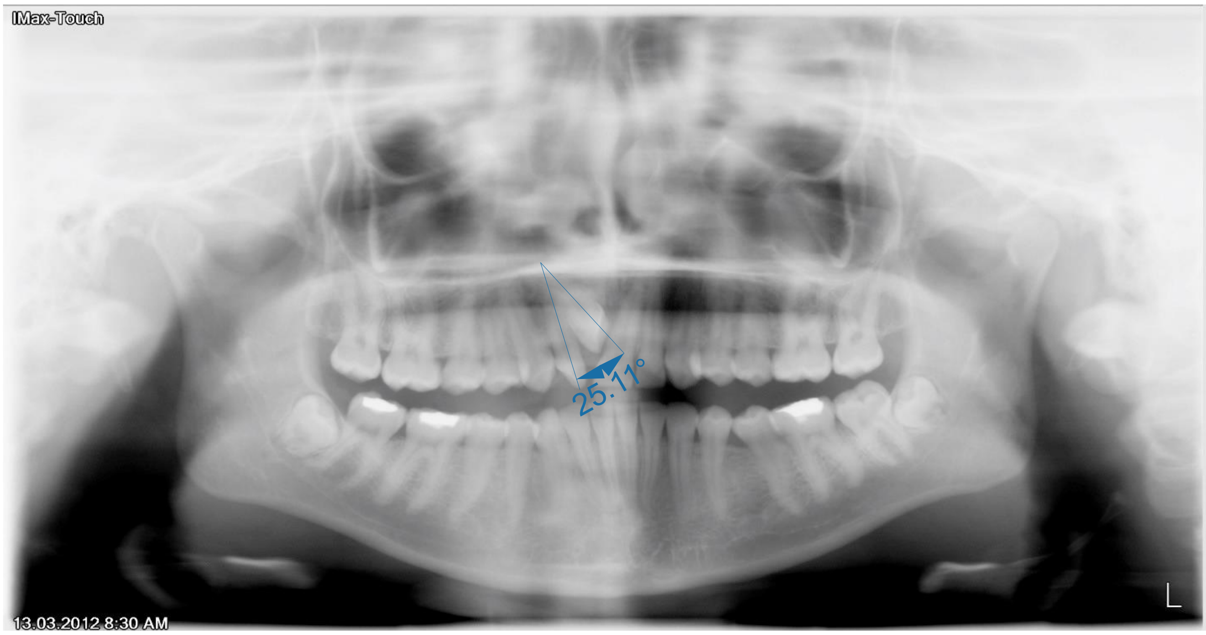

Figure 21 PAN of a female participant aged 17.25 years – impacted maxillary central incisor tends to be angulated mesially

4.10 Pathologies associated with impacted teeth

Pathologies associated with impacted teeth in our research are recorded in a small number of cases. Table 42 shows the number of pathologies associated with impacted teeth. As it can be clearly seen in the table, low frequencies statistical test cannot be performed in a total number of impacted teeth due to pathologies. From the results of the pathologies associated with impacted teeth, it is evident that they occur in significant numbers only in impacted canines and third molars.

Table 42 Distribution of associated pathologies with impacted teeth according to teeth groups

Teeth		Number of associated pathologies			Total
		0	1	2	
Incises	n [a]	25	0	0	25
	hp [b]	100.0%	0.0%	0.0%	100.0%
	vp [c]	2.0%	0.0%	0.0%	1.4%
Canines	n	243	122	8	373
	hp	65.1%	32.7%	2.1%	100.0%
	vp	19.4%	26.3%	13.1%	21.0%
Premolars	n	65	0	0	65
	hp	100.0%	0.0%	0.0%	100.0%
	vp	5.2%	0.0%	0.0%	3.7%
First and second molars	n	4	0	0	4
	hp	100.0%	0.0%	0.0%	100.0%
	vp	0.3%	0.0%	0.0%	0.2%
Third molars	n	915	342	53	1310
	hp	69.8%	26.1%	4.0%	100.0%
	vp	73.1%	73.7%	86.9%	73.7%
Total [d]	n	1252	464	61	1777
	hp	70.5%	26.1%	3.4%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent. Due to low frequencies, test is not possible.

In Table 43, it can be seen that caries occurs only in impacted third molars. This results in caries pathology with a prevalence of 1.9% in the total number of 1777, while its prevalence is 2.6% in the total number of 1310 impacted third molars.

Table 43 Distribution caries of impacted and /or adjacent teeth according to teeth groups

Teeth		Caries of impacted and /or adjacent teeth		Total
		No	Yes	
Incisors	n [a]	25	0	25
	hp [b]	100.0%	0.0%	100.0%
	vp [c]	1.4%	0.0%	1.4%
Canines	n	373	0	373
	hp	100.0%	0.0%	100.0%
	vp	21.4%	0.0%	21.0%
Premolars	n	65	0	65
	hp	100.0%	0.0%	100.0%
	vp	3.7%	0.0%	3.7%
First and second molars	n	4	0	4
	hp	100.0%	0.0%	100.0%
	vp	0.2%	0.0%	0.2%
Third molars	n	1276	34	1310
	hp	97.4%	2.6%	100.0%
	vp	73.2%	100.0%	73.7%
Total	n	1743	34	1777
	hp	98.1%	1.9%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent. Due to low frequencies, test is not possible.

Table 44 shows that periodontal bone loss of more than 5mm of adjacent tooth appears only in impacted third molars, resulting in its prevalence of 4.6 % in the total number of 1777 impacted teeth and a prevalence of 6.3 % in the total number of 1310 impacted third molars.

Table 44 Distribution of periodontal bone loss of adjacent tooth of more than 5 mm according to teeth groups

Teeth		Periodontal bone loss of adjacent tooth of more than 5 mm		Total
		No	Yes	
Incises	n [a]	25	0	25
	hp [b]	100.0%	0.0%	100.0%
	vp [c]	1.5%	0.0%	1.4%
Canines	n	373	0	373
	hp	100.0%	0.0%	100.0%
	vp	22.0%	0.0%	21.0%
Premolars	n	65	0	65
	hp	100.0%	0.0%	100.0%
	vp	3.8%	0.0%	3.7%
First and second molars	n	4	0	4
	hp	100.0%	0.0%	100.0%
	vp	0.2%	0.0%	.2%
Third molars	n	1229	81	1310
	hp	93.8%	6.2%	100.0%
	vp	72.5%	100.0%	73.7%
Total	n	1696	81	1777
	hp	95.4%	4.6%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent. Due to low frequencies test is not possible.

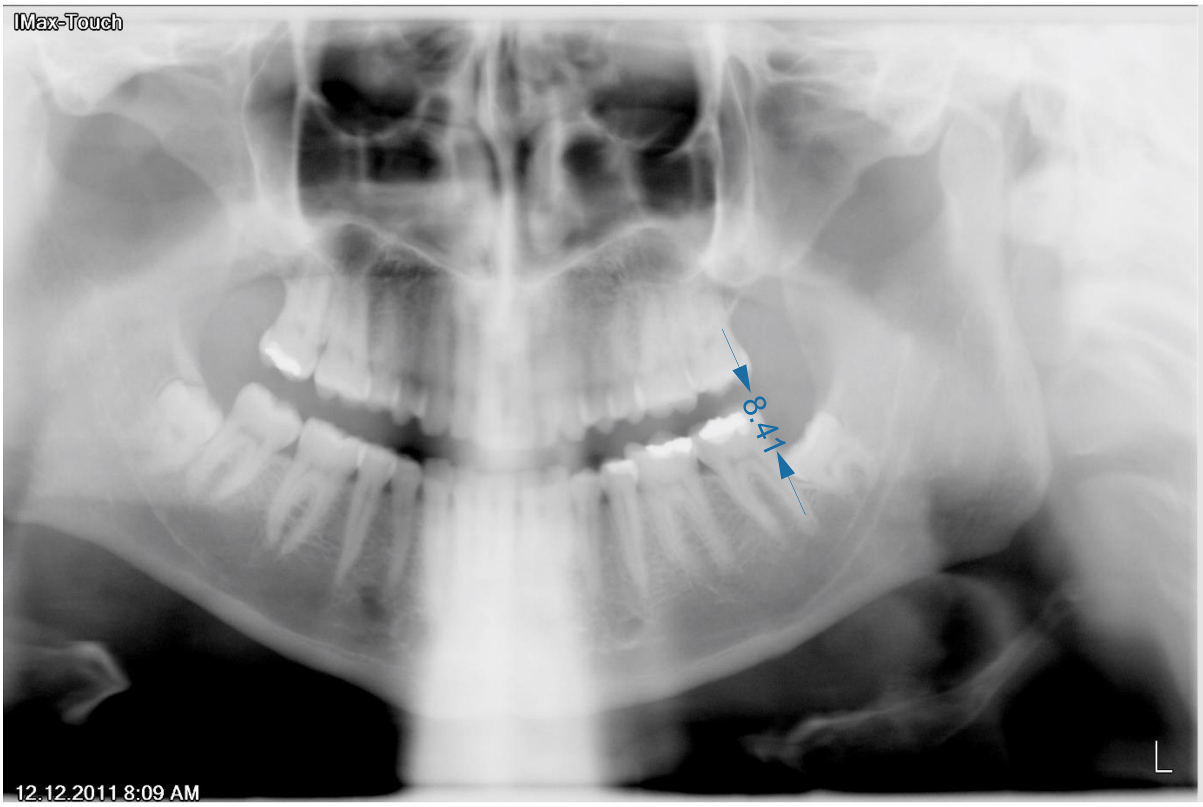

Figure 22 PAN of a male participant aged 27 years - impacted third molars in the mandible and periodontal bone loss of more than 5 mm

In Table 45, it can be clearly seen that the prevalence of root resorption is 25.2% in total number of 1777 impacted teeth. Of these, 28.6% of adjacent tooth resorption was found in lateral incisors and 71.4% of adjacent tooth resorption was detected in second molars.

Table 45 Distribution root resorption of adjacent tooth according to teeth groups

Teeth		Root resorption of adjacent tooth		Total
		No	Yes	
Central incises	n [a]	25	0	25
	hp [b]	100.0%	0.0%	100.0%
	vp [c]	1.9%	0.0%	1.4%
Lateral incises	n	245	128	373
	hp	65.7%	34.3%	100.0%
	vp	18.4%	28.6%	21.0%
First premolars	n	65	0	65
	hp	100.0%	0.0%	100.0%
	vp	4.9%	0.0%	3.7%
First molars	n	4	0	4
	hp	100.0%	0.0%	100.0%
	vp	0.3%	0.0%	.2%
Second molars	n	991	319	1310
	hp	75.6%	24.4%	100.0%
	vp	74.5%	71.4%	73.7%
Total	n	1330	447	1777
	hp	74.8%	25.2%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent. Due to low frequencies test is not possible.

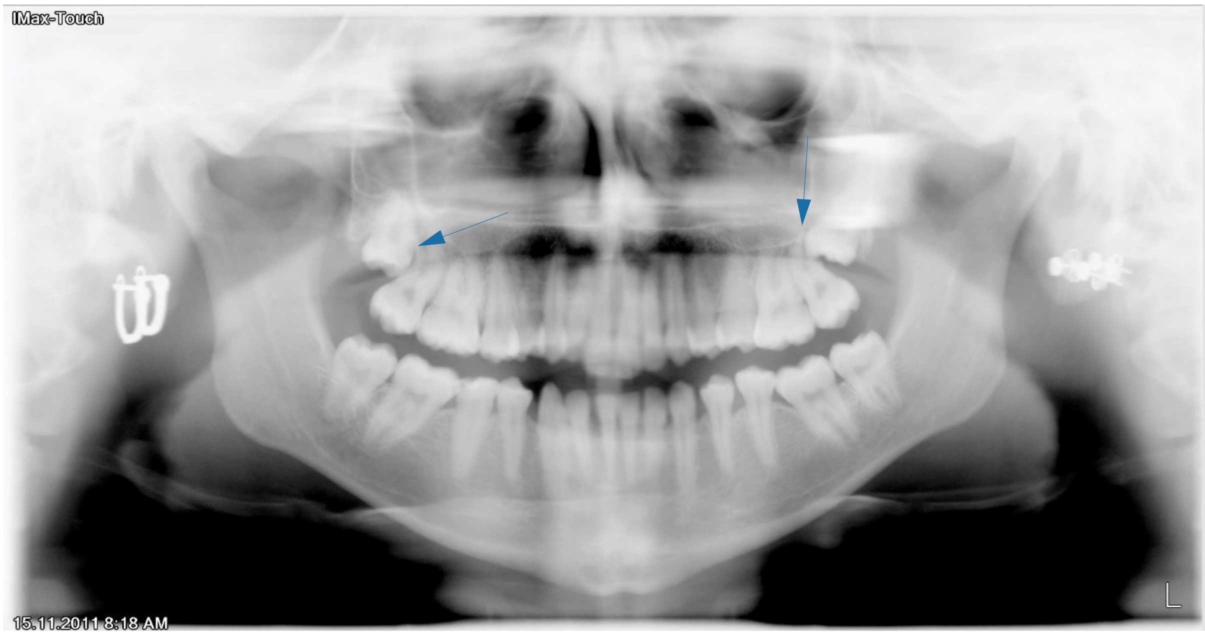

Figure 23 PAN of a female participant aged 20 years - root resorption of adjacent tooth

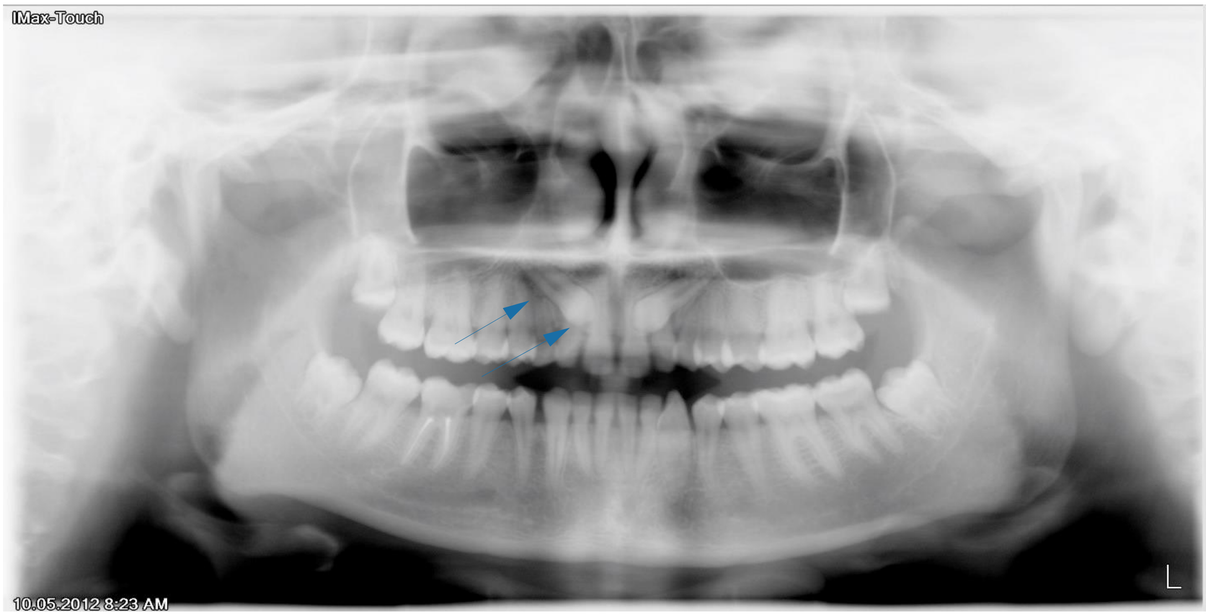

Figure 24 PAN of a female participant aged 21 years - impacted canines in the maxilla and root resorption of adjacent tooth

As it can be clearly seen in Table 46, an increased pericoronal gap occurs only in impacted third molars, which in relation to total impacted third molars has the prevalence of 1.1%, while in relation to total number of impacted teeth the prevalence is 0.8%.

Table 46 Distribution of increased pericoronal gap according to teeth groups

Teeth		Increased pericoronal gap		Total
		No	Yes	
Incises	n [a]	25	0	25
	hp [b]	100.0%	0.0%	100.0%
	vp [c]	1.4%	0.0%	1.4%
Canines	n	373	0	373
	hp	100.0%	0.0%	100.0%
	vp	21.2%	0.0%	21.0%
Premolars	n	65	0	65
	hp	100.0%	0.0%	100.0%
	vp	3.7%	0.0%	3.7%
First and second molars	n	4	0	4
	hp	100.0%	0.0%	100.0%
	vp	0.2%	0.0%	0.2%
Third molars	n	1295	15	1310
	hp	98.9%	1.1%	100.0%
	vp	73.5%	100.0%	73.7%
Total	n	1762	15	1777
	hp	99.2%	0.8%	100.0%

[a] number of cases, [b] horizontal percent, [c] vertical percent. Testing is not possible due to low frequencies.

Figure 25 PAN of a male participant aged 30 years - impacted third molar in the mandibular left side and pericoronal gap increase amounting to over 4mm.

In our research, further interpretation of pathologies associated with impacted teeth will be only for impacted third molars since pathologies associated with other teeth groups are only few or missing entirely.

4.10.1 Pathologies associated with impacted third molars

Numerous pathologies associated with impacted third molars (caries of impacted and/or adjacent teeth, periodontal bone loss of adjacent tooth of more than 5mm, root resorption of adjacent tooth and increased pericoronal gap) have been reduced to the maximum: two pathologies per impaction in 53 (4.0%) of them, 342 (26.1%) of them had one pathology, while 915 had moderate pathological changes, and 69.8% of 1310 impacted third molars did not have any associated pathological changes.

According to the results of $\chi 2$ test, no statistically significant differences were found between males and females in the number of pathologies associated with impacted third molars ($\chi 2 = 0.89$, df = 2, p = 0.639). As the data in Table 47 show, zero pathological changes for impacted third molars occurred at the similar ratio for males and females (71.2% : 69%). Furthermore, similar ratio was for impacted third molars that occurred with one (25.2% : 26.7%) or two (3.6% : 4.3%) pathologies associated with their impaction.

Table 47. Prevalence of number of pathologies according to sex for impacted third molars of participants PANs

Number of pathologies	PAN of male n (%)	PAN of female n (%)	Total n (%)
0	375 (71.2)	540 (69.0)	915 (69.8)
1	133 (25.2)	209 (26.7)	342 (26.1)
2	19 (3.6)	34 (4.3)	53 (4.0)
Total	527 (100)	783 (100)	1310 (100)
χ^2 test	$\chi^2 = 0.89$	df = 2	p = 0.639

0 cells (.0%) have expected count less than 5. The minimum expected count is 21.32.

The results in Table 48 show that there were no statistically significant differences in the prevalence of pathologies between male and female participants PANs. Caries of impacted and/or adjacent teeth occurred in 1.7% of males and in 3.2% of females, periodontal bone loss of adjacent tooth of more than 5 mm occurred at similar ratios of males to females (5.5% : 6.6%) as root resorption of adjacent teeth.

Table 48. Prevalence of pathologies according to sex for impacted third molars of participants PANs

Pathologies associated with impacted third molars in PAN	PAN of male n (%)	PAN of female n (%)	Total n (%)
Caries of impacted and /or adjacent teeth	9 (1.7)	25 (3.2)	34 (2.6) [a]
Periodontal bone loss of adjacent tooth of more than 5 mm	29 (5.5)	52 (6.6)	81 (6.2) [b]
Root resorption of adjacent tooth	127 (24.1)	192 (24.5)	319 (24.4) [c]
Increased pericoronal gap	6 (1.1)	9 (1.1)	15 (1.1) [d]
Total	527 (100)	783 (100)	1310 (100)

a, b, c, d Fisher's exact test is not significant.

A comparison of the right and left sides of the jaws showed that there were no statistically significant differences (Table 49) ($\chi 2$ = 0.032, df = 2, p = 0.984). The rates of pathological lesions observed between right and left side had an equal prevalence for impacted third molars with one and two pathologies being at 26.2%: 26.0%, respectively 4.1%: 4.0%.

Table 49. Prevalence of number of pathologies of impacted third molars according to site of jaws in participants PANs

Number of pathologies	OPG of right n (%)	OPG of left n (%)	Total n (%)
0	422 (69.6)	493(70.0)	915 (69.8)
1	159 (26.2)	183 (26.0)	342 (26.1)
2	25 (4.1)	28 (4.0)	53 (4.0)
Total	606 (100)	704 (100)	1310 (100)
χ^2 test	$\chi^2 = 0.032$	df = 2	p = 0.984

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 24.52.

As the results in Table 50 show, statistically, there were no significant differences in the prevalence of pathologies associated with impacted third molars for both sides of jaws, right and left. The rate of pathologies observed for caries were (2.5%: 2.7%), periodontal bone loss (5.9%: 6.4%), root resorption (25.6%: 23.3%) and increased pericoronal gap (0.5%: 1.1%).

Table 50. Prevalence of pathologies of impacted third molars according to site of jaws in participants PANs

Pathologies for third impacted molars in PANs	Right n (%)	Left n (%)	Total n (%)
Caries of impacted and /or adjacent teeth	15 (2.5)	19 (2.7)	34 (2.6) [a]
Periodontal bone loss of adjacent tooth of more than 5 mm	36 (5.9)	45 (6.4)	81 (6.2) [b]
Root resorption of adjacent tooth	155 (25.6)	164 (23.3)	319 (24.4) [c]
Increased pericoronal gap	3 (0.5)	12 (1.7)	15 (1.1) [d]
Total	606 (100)	704 (100)	1310 (100)

a, b, c, d Fisher's exact test is not significant.

The number of pathologies associated with impacted third molars is statistically significantly different for the maxilla and the mandible (Table 51) ($\chi 2 = 62.20$, df = 2, p <0.001). It can be clearly seen that higher percentage of pathological changes associated with one impacted third molar occurred in the maxilla (36.9%), compared to the mandible where only one pathology occurred (19.5%). A larger number of impacted third molars without pathological changes have been found in the mandible (77.6%), compared to the maxilla (57.1%).

Table 51 Distribution of number of pathologies associated with impacted third molars according to jaws of participants PANs

Number of pathologies	Maxilla n (%)	Mandible n (%)	Total n (%)	
0	283 (57.1)	632 (77.6)	915 (69.8)	
1	183 (36.9)	159 (19.5)	342 (26.1)	
2	30 (6.0)	23 (2.8)	53 (4.0)	
Total	496 (100)	814 (100)	1310 (100)	
χ^2 test	$\chi^2 = 62.20$	df = 2		$p < 0.001$

[a] number of cases, [b] horizontal percent, [c] vertical percent, [d] 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.07

The results in Table 52 clearly show that the prevalence of root resorption was the most frequent pathological condition with a prevalence of 24.4% in our studied impacted third molars. This was followed by over 5mm periodontal bone loss of the distal part of the second molar in 6.2% of cases and caries occurring in 2.6% of cases. An increased pericoronal gap of the dental follicle over 4mm around impacted third molars had the lowest prevalence of only 1.1% (Table 52).

Table 52 Prevalence of pathologies associated with impacted third molars according to jaws of participants PANs.

Pathologies	Maxilla n (%)	Mandible n (%)	Total n (%)
Caries of impacted and /or adjacent teeth	33 (6.7)	1 (0.1)	34 (2.6) [a]
Periodontal bone loss of adjacent tooth of more than 5 mm	33 (6.7)	48 (5.9)	81 (6.2) [b]
Root resorption of adjacent tooth	163 (32.9)	156 (19.2)	319 (24.4) [c]
Increased pericoronal gap	15 (3.0)	0 (0.0)	15 (1.1) [d]
Total	496 (100)	814 (100)	1310 (100)

b Fisher's exact test is not significant.

a Fisher's exact test, chi-square value = 51.99, df = 1, $P < 0.001$. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.87.

c Fisher's exact test, chi-square value = 31.39, df = 1, $P < 0.001$. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 120.78.

d Fisher's exact test is not significant.

5. DISCUSSION

Undoubtedly the most important objective of this research was to determine the prevalence of impacted teeth and pathologies associated with them in a Kosovar population. To our knowledge, this is the first study to estimate such prevalence.

Selection of population for studying the prevalence of impacted teeth and pathologies associated with them is very difficult, because a random sample of the general population is essential to determine the exact rate of prevalence. Such samples are very challenging since taking radiographs of young individuals exclusively for research purposes is a matter of considerable debate from ethical point of view and, also, associated with high costs. Consequently, most commonly used method is to examine already taken radiographs of patients at the university dental clinics or skulls (9, 21-22, 59).

The literature review shows that tooth impaction is a frequent pathology, influencing people around the globe and patients with impacted teeth, respectively third molars are increasing in number every year (62). Therefore, determining prevalence of impacted teeth and their etiology has been subject of several studies for a very long period of time since diagnosing impacted teeth early helps taking preventive oral health care measures that are therapeutically more successful (2, 6, 8, 10, 21-24).

In our research, the prevalence of impacted teeth in the total number of 5515 PANs of Kosovar participants, is estimated to be 16.6% in males and 18.3% in females, which makes a prevalence of impacted teeth amounting to around 17.6%, with 1777 impacted teeth. Similar frequency of impacted teeth was reported by Aitasalo et al. (99) with their prevalence being 14.1% in a sample of 4063 PAN and 22.3% in a study by Alattar et al. (100). Compared to our study, the data from the Hong Kong Chinese population gave a higher rate of impacted teeth (28.4%), which could be explained by the fact that the study conducted in a Chinese population included very young patients. For example, a 17 year- old patient was included in the study for the prevalence of impacted third molars (21).

In our study, the average value of impacted teeth showed that in the total number of 970 PANs, 51% of PANs had at least one impacted tooth. However, it is of utmost importance to emphasize that most of our patients with one or more impacted teeth in PANs were up to 30 years old, more precisely: 701 of the total of 970 PANs with one impacted teeth were identified in that age group. Similarly, impacted teeth predominating in the younger age groups were reported by Gisakis et al. (22) in Greek population, in a study where the majority of patients (41-50%)

with one or more impacted teeth were up to 30 years old. Comparable predisposition was reported also by Chu et al. (21). Furthermore, our data showed that impaction phenomenon at the older age groups falls and it becomes stabilized within the range of 5.7% - 2.8%, for one or more than one impacted teeth in PANs in the age groups 51 - 77 years. A comparable predisposition of impacted teeth phenomenon decreasing in older age groups was reported by Gisakis et al. where impaction reduced as age increased and after age 50 years it remained constant within the range of 8.7-9.2% (22). Similar tendency was reported in a Chu et al. study (21).

In our research, the predominance of impaction phenomenon in younger age group might be a reflection of the relatively higher proportion of participants in those two age groups in the total number of our samples. This age specific predominance might be a result of a growing increase in dental awareness in younger population since in a post conflict Kosovo, more precisely, since 2000; more focus has been put on the rise of awareness about the importance of oral health. However, we should always bear in mind the fact that decrease in impaction prevalence as the age increases, might be due to the already extracted impacted teeth in older patients.

In relation to sex, there was a no statistically significant difference in teeth impaction between male and female participants. Similar to our data, Aitasalo et al. (99) and Gisakis et al. (22) also obtained similar findings regarding sex, no statistically significant difference was found in their study results too.

The number of impacted teeth between the maxilla and the mandible in our research was almost the same in both jaws. Nine hundred and six of the 1777 impacted teeth were localized in the maxilla (51%) and 871 (49%) in the mandible. Compared to our research, Dachi et al. (23) obtained different results on tooth impaction: the maxilla has been established as predominant location for tooth impaction. However, study results of Gisakis et al. (22) showed that there was a different relationship between the maxilla and the mandible, pointing to a higher impaction rate in the mandible.

Similar to previous study reports, this research also showed that the highest prevalence of impacted teeth per tooth type belonged to impacted third molars (73.7%), second most often impacted teeth were canines (21.0%) and they were followed by lover levels of impacted premolars (3.7%) (21-22, 101-102), whereas impacted incisors had a prevalence of only 1.4%, while first and second molars occurred rarely in few cases (just 0.2%), which again was similar to a considerable number of previous studies (21-23, 99-100).

The differences regarding distribution of impacted teeth, those related to sex, differences regarding the maxilla and the mandible, and also variations in their prevalence in our research compared to other research could be a result of a number of factors such as hereditary and racial characteristics, variations in sampling, selected age group, radiographic criteria and definition of impaction.

5.1 Prevalence of impacted third molars

5.1.1 General prevalence

In this study of 5515 PANs of Kosovar participants, the incidence of impacted third molars was estimated at around 73.7% in a total number of impacted teeth, with 710 PANs showing at least one impacted teeth. The prevalence of impacted third molars in the current study is similar to a previous study with similar research methods by Morris and Jermal who reported a frequency of 66% in a study of 5000 participants in the USA and those of Quek et al. who reported a frequency of 69%. Obiechina et al. observed the prevalence of impacted third molars of 72.09%, while impaction in Scandinavian communities ranged from 22 to 76.1% (33, 65, 82, 99, 101-102). Our study results point to higher rates than those of Eliasson et al. (33%) (103), Hashemipour et al. (44.3%) (62) and Pillai et al. (50.20%) (69). Furthermore, our findings are considerably higher compared to Hattab et al. (70) who reported an incidence of 28.2% of impacted third molars and Hellman (104) an incidence of 15.3% in 433 students at Columbia University. On the other hand, our findings are significantly lower than those of Gisakis et al. (22) who reported a prevalence of 91.6% in Greek population. Kramer et al. (67) reported a prevalence of 94.8% in 3,748 radiographs and Kazemian et al. (105) reported a prevalence of 95.6% in 10,000 participants.

Similar to the above mentioned reasons, a different prevalence of impacted third molars that has been reported in our research and previous research could be explained by differences in hereditary and racial characteristics, number of sample, study age groups or the definition of impaction.

5.1.2. Prevalence of impacted third molars in relation to age

As already emphasized, only the PANs of 18 year- old participants, and of those older than 18, were included for impacted third molars study. The prevalence was 71.3%, which was a significantly lower prevalence compared to data of a previous study with a similar sample age group by Chu et al. (98.1%) (22). This might have been influenced by the fact that in Chu et al. study, the age range for impacted third molars was from 17 years.

On the other hand, studies that analyzed PANs of patients with younger age groups from 18 to 40 years found a varying prevalence of impacted third molars, with their frequencies from 44.3% to 68.8% (64-65).

Therefore, considering the age sample of our research and that in previous research, a different prevalence of impacted third molars might have been highly influenced by age range and sample size of the study.

5.1.3 Distribution of impacted third molars in the maxilla and the mandible

The results evaluating the distribution of impacted third molars between the maxilla and the mandible in our study confirmed the predominance of impacted third molars in the mandible (62.1%). Our distribution findings were similar to findings of Quek et al. (65) and Ayranci et al. (71) in the Middle Black Sea region of Turkey, wherein it was noted that impacted third molars occurred 3.2, respectively 1.33, times more often in the mandible than in the maxilla. However, some studies have reported higher percentage of impacted third molars in the maxilla compared to the mandible. The results of studies by Dachi et al. (21.9%) (24), Hattab et al. (54%) (70) and Kramer et al. (63%) (67 confirmed the predominance of impacted third molars in the maxilla.

There is insufficient literature on the subject of factors influencing the impacted teeth distribution between dental arches. So far, the majority of the researchers in this field have considered genetic factors and alterations in everyday diet risk factors for, and possible causes of this prevalence (21-22, 69).

5.1.4. Distribution of impacted third molars in relation to sex

Female patients outnumbered male patients in our study, and this could be related to female patients having higher levels of self-concern and care about oral health and esthetics. A similar phenomenon of female predominance has been reported in other studies by Pedro et al. and Quek et al. (60, 65).

However, despite a higher frequency of female participants, our study showed no statistically significant difference between males and females related to impaction of third molars (46.3%: 53.7%). This finding of no sex predilection correlates with previous studies of Dachi et al., Kramer et al., Hattab et al. and Ayranci et al. (23, 67, 70-71). The absence of sex predominance in third molar impaction conflicts with some authors' assertions that the initial eruption of the third molars in females stimulates the jaws to stop growing, whereas in males, the growth continues beyond the time of eruption of the third molars (31, 62, 105). Furthermore, in contrast to our findings, studies by Hashemipour et al. and Quek et al. revealed a higher percentage of impacted third molars in females (62, 65), whereas, Haidar and Shalhoub reported a higher prevalence of third molar impaction in males (34%) than in females (29%) (64).

5.1.5 Prevalence of angulation

As mentioned previously in the text, angulations and impaction depth of impacted third molars should be taken in consideration while making decision and planning the surgical procedure since they provide a crucial evaluation of the difficulty of extraction (73-74).

In our study, the evaluation of the angulation of impacted third molars using Winter's classification showed that out of 1310 impacted third molars, mesio-angular impaction was the most prevalent (33.8%). Our findings of mesio-angular predominance was consistent with the study conclusions by Hattab et al. (50%) and Obiechina et al. (48.20%) (70, 82). However, it was inconsistent with Pillai et al. who reported that vertical angulation of impacted third molars was most frequent (46.6%), followed by mesio-angular angulation (69). Similar results of the predominance of vertical angulation were reported by Haidar and Shalhoub (64).

5.1.6 Depth of impacted third molars

The evaluation of the depth of impacted third molars using the Pell-Gregory classification showed that 816 (62.3%) of impacted third molars were classified as class C. The maxilla showed a higher prevalence of deeply impacted third molars, with class C prevalence of 70.0% compared to the mandible (57.6%). Similar results were obtained in research by Ventä et al, Pillai et al., and Quek et al. (34, 65, 69). Compared to our study, Kruger et al. reported the highest prevalence of deeply impacted third molars in the mandible (80).

There was no significant relationship between the level of impaction and sex.

5.1.7 Classes of impacted third molars in mandible

The current study revealed that a large number of impacted third molars in the mandible have half of their crown in ramus (48%) and are classified as class II according to Pell-Gregory. This finding is in agreement with other studies that found that class II was the most common impaction for impacted third molars in the mandible (15, 62).

Variation in the findings about angulation and depths of impacted third molars, in some cases, could be explained with authors using dissimilar classification for angulation types and depth. However, we should never diminish the importance of racial, hereditary and nutritional alterations (62, 65, 69).

5.2 Prevalence of canine impaction

The second most frequently impacted teeth after impacted third molars in our study were impacted maxillary canines, with a total number of 356 out of their total number of 373.

Impacted maxillary canines had absolutely a higher prevalence of 95.4% compared to impacted mandibular canines with a prevalence of 4.6%. In our study, impacted maxillary canines had the highest prevalence; hence our findings are similar to previous studies by Chu et al., Gisakis et al. and Aydin et al. (21-22, 87). In our research, impacted mandibular canines were recorded in a total number of 17 cases. Our finding was relatively similar to findings by Aydin et al. (0.44%) and by Ericson and Kurol that reported a prevalence of 0.35% (87-88). The mandible has been reported an uncommon location for impacted canines, which has been confirmed by previous studies. In the present research, the frequency of impacted mandibular canines was relatively low compared to that of impacted maxillary canines (22, 87-88).

This higher prevalence of canines might be attributed to their development and eruption path, since maxillary canines are last teeth to develop and they also travel one of the longest routes until they erupt into the dental arch (89-91).

5.3 Other teeth impaction

Impacted maxillary premolars and impacted mandibular premolars were the third most frequently impacted teeth with a frequency of 3.6%. Despite being third, their prevalence was noticeably lower compared to canines and third molars impaction. Similar results to our study (65 impacted premolars), were obtained in a study in a Hong Kong Chinese population with a total number of 24 impacted maxillary and mandibular premolars (22). In our study, the number of second impacted mandibular premolars was not large. There were 25 impacted mandibular premolars in our study, whereas only 15 impacted mandibular premolars were reported in Chu et al. study (22). However, compared to our research, a number of other studies reported that among premolars, impacted mandibular premolars are reported to have a higher rate of prevalence than their maxillary counterparts (106-107).

Still, despite a low frequency of impacted premolars in our study, in a total, premolar impaction was second to canine impaction, which is similar to findings of other studies (21-22).

In the present study, impacted incisors were reported in a total number of 25, with impacted maxillary permanent central incisors having a total number of 13 impacted incisors, while only one case of impacted mandibular lateral incisor has been reported. Gisakis et al. (22) obtained similar results. There were no cases of central and lateral incisor impaction in the mandible and only one case of impacted maxillary central incisor was detected.

Impacted first and second molars are extremely rare cases of impaction. In all those rare cases of impaction, almost always they present very complex cases for oral surgeons and orthodontists.

Studies have reported their frequency ranges from 0.03% to 0.3% (108-109). In our research, there were zero cases of impacted mandibular first molars, while in total there were only four cases (0.2%) of impacted first and second molars occurring unilaterally. Despite being reported that impacted first and second molars have a slight predilection for males, our data showed that 3 out of 4 cases were found in females (0.3%). Similar to our findings, Chu et al. reported of only 7 cases of impacted first and second molars, while a study in a Greek population reported 13 cases of impaction (21-22).

Findings about the prevalence of impacted teeth, apart from those related to third molars and canines in Kosovar population, showed similarity to majority of other studies.

5.4 Prevalence of pathologies

Bearing in mind the fact that it is of utmost importance to have data on the prevalence of pathologies associated with the impacted teeth, respectively of third molars, one of the main focuses of our study was also its prevalence in a Kosovar population.

When complete results of pathologies associated with impacted teeth were considered together, it could be clearly seen that 70.5% of all cases were not influenced by pathological changes.

Only 26.1% of impacted teeth were affected by at least 1 of the 4 pathological changes that we studied in our research. Considering that the most common finding of teeth impaction were third molars, which was also confirmed by the results of our study, it is clearly understandable why majority of studies have been on third molars impaction and their associated pathologies.

5.4.1 Pathologies associated with impacted third molars

Despite the extraction of impacted teeth, that is, impacted third molars being one of the most frequent procedures, due to their high prevalence, dental practitioners and oral surgeons experience challenges to agree about constant principles on the subject of extraction of asymptomatic impacted teeth (95, 110-113).

According to a National Institute for Dental Research conference held in 1979 dedicated exclusively to impacted third molar, there is almost no disagreement concerning the removal of impacted third molars when pathologies are associated with them (114). There are factors relating to the removal of impacted third molars and they all should correspond to basic and established principles of surgical technique. Dental surgeons should agree, based on training and experience, that surgery should take place as soon as possible once the diagnosis has been made for root resorption of adjacent tooth, a non-restorable caries of adjacent or impacted tooth, bone destruction, follicle disease and infections (114). On the other hand, the guidelines for extraction of impacted third molars have been established by Scottish Intercollegiate Guideline Network, which was updated in 2005. It is considerably vital to highlight the statement that they excluded a prophylactic extraction of asymptomatic impacted third molars (115). This extraction exclusion was as a result of scarce evidence of pathologies associated with impacted third molars and absence of support for prophylactic extraction of these teeth (111,115).

In our research, the assessment of root resorption in the maxilla and the mandible for impacted third molars showed a prevalence of 24.4% in total. Root resorption was the most frequent pathology recorded in our samples. Our finding of root resorption is similar to Nemcovsky et al. (24.2%), whereas other authors reported a lover prevalence of root resorption compared to our findings (116). In Nitzan et al. study, the prevalence of root resorption was 7.5% (117), while van der Linden et al. reported a prevalence of 0.9% (92). Even lover prevalence was reported by Chu et al. in only 13 (0.4%) cases of adjacent tooth resorption (21). Severin reported of zero root resorption of adjacent tooth as a result of impacted third molars (118). However, in recent studies, some researchers used cone beam computed tomography (CBCT) to investigate the root resorption and their prevalence rates were significantly higher compared to our study and other studies based on PAN examination, with the prevalence varying between 31.9% and 49.43% (119-120). This could be explained by the fact that CBCT allows for geometrically accurate measurements in three different planes, thus revealing even minor defects (119).

Variation of root resorption prevalence can be explained by diverse definitions of root resorption in different studies. Stanley et al. (121) emphasized that it is very complex to decide radiologically if coronal radiolucency of second molar adjacent to impacted third molar is due to caries or root resorption.

The periodontal bone loss of the distal part of the second molar more than 5mm below the cementoenamel junction in our research sample was (6.2 %) and this was second largest pathology associated with impacted third molars. On the other hand, it was the most frequent pathology reported in data by Chu et al. (9%) (21). Van der Linden et al., reported a comparable finding to our study of periodontal bone loss of 4.9%, pathology which was mostly located in the mandible (92). In our study, the maxilla had slightly higher prevalence of periodontal bone loss of 6.7%, compared to the mandible with only 5.9%. Mercier and Precious specified that it is perplexing to compare periodontal bone loss in different studies due to the use of different definitions of the same conditions. There is also a likelihood that the above-mentioned use of different definitions of the same conditions occurred in our research (122).

Out of 1310 impacted third molars identified in our research, caries occurred only in 2.6% of them. Since caries was not a dominating pathology in our study our findings are dissimilar to findings of a study by van der Linden et al. ,who used a similar methodology to our research, where the percentage of caries in impacted third molars or adjacent tooth was 7.1 % and 42.7%, respectively (92). Caries was also the most common pathology in a retrospective study in a group of Jordanians, amounting to 22.5% of impacted third molars in the mandible (111). Nevertheless, caries figures found in our study might be underrated because diagnosis of caries was based only on PAN's.

In previous radiographically based research, increased coronal radiolucency surrounding impacted third molar over 4 mm reported the prevalence of no more than 1% (58,115). In our research, we observed coronal radiolucency of merely 1.1%. Nevertheless, in studies when a space of >3mm was used for widened coronal radiolucency, the prevalence of the pathology was reported as high as 4.6% (92). Therefore, in order to avoid confusing a follicular space enlargement with a developing dentigerous cyst, Stephens et al. (123) underscored the significance of focus during evaluation of coronal radiolucency alterations. He believed that inaccuracy occurs when follicular space >2.5mm in radiographic examinations is classified as cyst. On the other hand, follicular tissues of radiologically normal teeth when examined histologically showed that in 34% to 46.5% of cases histological findings revealed dentigerous cyst formation (124-126).

Consequently, the radiographic finding itself may not be an outstandingly reliable indicator of the absence of disease within the dental follicle.

5.4.2 Pathologies associated with non-impacted third molars

Despite the fact that there is only limited information available on the prevalence of pathologies associated with non-third impacted molars, our findings showed a low prevalence of four pathologies occurring in any group of impacted teeth.

Our findings clearly show that caries of impacted teeth, periodontal bone loss of adjacent tooth of more than 5 mm and increase in pericoronal gap of more than >5mm, occur only in the cases of impacted third molars. Also, during our research we did not come across any study that presented data about the above- mentioned pathologies associated with non-third molar impacted teeth.

However, in our study, the only pathology that occurred, apart from impacted third molars, was root resorption of adjacent tooth. Our results show that in 356 impacted maxillary canines, resorption to adjacent tooth occurred roughly with a prevalence of 28.6%. In contrast to our findings, data from the only study that we found about pathologies associated with impacted non-third molar teeth, were found in a study in Turkish population, in which root resorption of an adjacent tooth was a very rare finding. It was reported in only 2 cases for canines impacted to their adjacent teeth, in a total number of 1356 impacted non-third molar teeth. In the same study, the most common associated pathological change was cystic, with a prevalence of 5.6% (94).

6. CONCLUSION

Notwithstanding some limitations, the conclusions drawn from the study are:

1. Prevalence of impacted teeth in the Kosovo population was 17.6%, with no sex predilection.
2. Similar prevalence of impacted teeth was recorded in the maxilla and the mandible (51.0%: 49.0%).
3. The highest frequency of impacted teeth was in the age groups between 18-30 years.
4. Impacted third molars had the highest prevalence of impaction 73.7%, in a total number of impacted teeth,
5. Impacted third molars had no significant correlation between sex and jaws.
6. The highest frequency of impacted third molars was recorded in the 18-30 year age groups.
7. The most prevalent pattern of impacted third molars was a mesioangular position (33.8%).
8. Most impacted third molars recorded a class C depth of impaction (62.3%)
9. Second most often impacted teeth in the Kosovar population are impacted canines with a prevalence of 21.0%.
10. Other teeth had a much lower prevalence, premolars (3.7%), incisors (1.4%) and impacted first and second molars(only 0.2%).
11. Root resorption of adjacent tooth had the highest prevalence of pathologies associated with impacted teeth (25.2 %).
12. Root resorption of adjacent tooth was the single pathology that did not occur only in impacted third molars (71.4%) but also in canines (28.6%).
13. Increased coronal radiolucency had the lowest prevalence of pathologies of 1.1% and occurred only in impacted third molars.

Bearing in mind the fact that early detection of impacted teeth is essential from the therapeutic point of view and that the majority of participants in this study were affected by impaction were young adults, we believe that the results of this study might encourage them to be screened for impacted teeth earlier, respectively for impacted third molars, before the impaction becomes too severe.

Furthermore, the findings of our research could contribute to the development of strategies that will efficiently tackle pathologies derived from impacted teeth through prevention, thus eliminating the impact of the risk that could arise due to the lack of treatment.

On the other hand, data on the prevalence of impacted teeth in a certain population, respectively Kosovo population, might effectively facilitate research in the future: samples of impacted teeth will be compared locally and worldwide. Moreover, such data could contribute to the creation of globally standardized evaluation criteria for impacted teeth.

The prevalence of impacted teeth is also vital for establishing anthropological data for the population of Kosovo. Therefore, considering the fact that there is a lack of studies on prevalence of impacted teeth in a Kosovo population and, also, that their etiology has never been studied, further research on this topic should be conducted in the Kosovo region.

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8. APPENDIX

ID	Sex	Age	Impacted teeth	Caries of impacted and /or adjacent teeth	Periodontal bone loss of adjacent tooth of more than 5 mm	Root resorption of adjcent tooth	Inreased in pericoronal gap	Pell-Gregory Class I/II/III	Pell-Gregory Depth Class A/B/C	Winter Angulaion	Canine Angulation	Premolar Angulation	Incisor
1	2	19	28	2	1	2	2	0	3	1			
1			18	2	2	2	2	0	2	1			
2	2	20	23	2	1	1	2	0	0	0	1		
3	2	17	28	2	1	1	2	0	2	3			
3	2	17	48	2	1	1	2	2	2	1			
4	1	16	18	2	1	1	2	0	3	3			
4	1	16	28	2	1	1	2	0	3	3			
5	2	16	28	2	1	1	2	0	3	1			
6	1	16	23	2	1	1	0	0	0	0	1		
7	1	15	23	2	1	1	0	0	0	0	1		
8	1	14	23	2	1	1	0	0	9	0	1		
9	2	19	13	2	1	1	0	0	0	0	1		
9	2	19	18	2	1	1	2	0	3	3			
9	2	19	28	2	1	1	2	0	3	3			
10	2	19	18	2	1	1	2	0	3	3			
10	2	19	13	2	1	1	0	0	0	0	1		
10	2	19	28	2	1	1	2	0	3	3			
10	2	19	38	2	1	1	2	1	2	1			
10	2	19	48	2	1	1	2	1	3	1			
11	1	20	18	2	1	1	2	0	3	3			
11	1	20	38	2	1	1	2	1	2	1			
11	1	20	48	2	1	1	2	1	2	1			
12	1	18	18	2	1	1	2	0	3	1			
12	1	18	18	2	1	1	2	0	2	1			
13	2	22	13	2	1	1	0	0	0	0	1		
13	2	22	23	2	1	1	0	0	0	0	1		
13	2	22	38	2	1	1	2	1	2	1			
13	2	22	48	2	1	1	2	1	2	1			
14	2	21	38	2	2	2	2	2	2	2			
15	2	15	33	2	2	1	2	0	0	0	4		
16	2	18	18	2	2	1	2	0	3	2			
16	2	18	28	2	2	1	2	0	3	2			
16	2	18	38	2	2	1	2	2	2	1			
16	2	18	48	2	2	1	2	2	2	1			

9. CURRICULUM VITAE

Zana Sejfija was born on January 12th 1983 in Prishtina, Kosovo. She has graduated at the Faculty of Medicine, School of Dentistry, University of Pristina, Kosovo in 2009 and achieving title Doctor of Dental Medicine.

In 2012 she started working as a teaching Assistant of Human Dental Anatomy and Morphology in Faculty of Medicine, School of Dentistry in University of Prishtina.

In academic years 2013/2014 and 2014/2015 she attended Edinburgh Napier University as an Associate Researcher in project of Experimental Biomedicine.

In December 2015 she started her PhD studies at the School of Dental Medicine, University of Zagreb, Croatia.

In 2016 she finished her residency in Oral Surgery at the University Dental Clinical Center of Kosovo, achieving title Specialist of Oral Surgery and in 2017 she started working as a clinical specialist in the Department of Oral Surgery at University Dental Clinical Center of Kosovo.

She was in the organizing committee of several conferences in Kosovo, as well she has actively participated in numerous international scientific conferences and is the author and co-author of several scientific posters and papers.

List of published articles

Scientific articles:

1. Zejnullahu VA, Isjanovska R, **Sejfija Z,** Zejnullahu VA. Surgical site infections after cesarean sections at the University Clinical Center of Kosovo: rates, microbiological profile and risk factors. BMC Infect Dis. 2019 Aug; 19(1):752.
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3. Agani-Bajrami Z, Benedetti Alberto, Hamiti-Krasniqi Vjosa, Ahmedi J, **Sejfija Z ,** Loxha-Prekazi L, Murtezani Arben, Rexhepi-Namani A, Ibraimi Z. Cortisol level and Hemodynamic Changes During Tooth Extraction at Hypertensive and Normotensive Patients. Med Arch 2015 Apr;69(2):117.
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5. Bajrami D, Stavileci M, Dragidella A, **Sejfija Z.** In vitro antifungal effect of Biodentine™ against Candida albicans. Journal of International Dental and Medical Research. (Accepted Article in Press)

Recent Abstract:

1. **Sejfija Z,** Sejfija O, Agani Z, Kamberi B, Ahmedi J, Maloku B. Complications of odontogenic infections. Abstracts of the 2nd International congress of the School of Dental Medicine, University of Zagreb and Academy of Operative Dentistry, 5-6 March 2016, Zagreb. Acta stomatol Croat. 2016;50(2):172-3.