Korelacija između stadija zrelosti cervikalne kralježnice i dentalne dobi u saudijskom uzorku

Correlation between Cervical Vertebral Maturation Stages and Dental Maturation in a Saudi Sample

Zavod za ortodonciju Stomatološkog fakulteta Sveučilišta Taif, Sauditjska Arabija
Orthodontic Department, Faculty of Dentistry, Taif University, Saudi Arabia

Sažetak
Svrha rada: Svrha je ovoga istraživanja usporediti stadij sazrijevanja cervikalne kralježnice i dentalnu dob s analizom stupnja kalcifikacije zuba. Ispitanici i metode: U istraživanje je bilo uključeno 405 ispitanika odabranih među ortodontskim pacijentima saudijskog podrijetla koji su došli u Kliniku za ortodonciju specijaliziranoga stomatološkog centra u zapadnoj regiji Saudije. Dentalna dob procijenjena je prema stupnju razvoja gornjih i donjih trećih kutiljaka, a skeletna zrelost prema stadijima sazrijevanja cervikalne kralježnice. Statistička analiza provedena je primjenom Kruskal-Wallisova, Mann-Whitneyova, Chi-kvadrat t-testa te Spearmanove korelacije za usporedbu među skupinama. Rezultati: Žene su bile mlade od muškaraca po stadijima sazrijevanja cervikalne kralježnice. CS1 – CS2 prikazuje razdoblje prije vrhunca rasta, CS3 – CS5 je pubertetski rast, a CS6 razdoblje nakon vrhunca rasta. Prosječna dob i standardna devijacija za stadije CS2, CS3 i CS4 bila je 12,09 ± 1,72 godine, 13,19 ± 1,62 i 14,88 ± 1,52. Spearmanov koeficijent korelacije između sazrijevanja cervikalne kralježnice i dentalne dobi bilo je 0,166 i 0,612 i 0,243 i 0,832 za oba spola za gornje i donje treće kutiljake. Razine značajnosti za sve koeficijente postavljene su na 0,01 i 0,05. Zaključak: Rezultati ovog istraživanja pokazuju da je skeletna zrelost za oba spola rasla s porastom dentalne dobi. Kad je riječ o ženama, zabilježeno je ranije skeletno sazrijevanje. Ovo istraživanje zahtijeva daljnju analizu na većem uzorku koji obuhvaća cijelu denticiju.

INTRODUCTION

Orthodontic treatment is most favorable and effective during pubertal growth and hence growth assessment and prediction are significant in planning treatments for dental and maxillofacial abnormalities (1, 2). To evaluate the growth assessment and maturation many features such as body height, body weight, secondary sexual characteristics, dental and skeletal development are used. Dental maturity can be determined by the stage of tooth formation and numerous studies have found that dental maturity is associated with skeletal maturity. At present, analysis of cervical vertebrae is extensively used to evaluate skeletal maturity due to its simplicity and reproducibility from a routine diagnostic lateral cephalogram for orthodontic treatment (3, 4). Various authors have noted that developmental stages of certain teeth show a high correlation with skeletal maturity (5). Yet few studies (6, 7) have been carried out to determine the association between tooth calcification stage and cervical vertebral maturation (CVM) stage. The aim of the present study was to investigate the correlation between the CVM stages...
Ispitanici i metode

Ovo istraživanje obuhvatilo je ukupno 405 pacijenata ko-
ji su se liječili u Klinici za ortodonciju specijaliziranih sto-
matooloških centara u zapadnoj regiji Sudijske Arabije. Svi
sudionici bili su saudijskog podrijetla. Odabrani su digital-
ni ortopantomogrami i lateralni kafalogrami u kombinaciji s
kliničkim zapisima 255 djevojčica i 150 dječaka u dobi od 9
do 20 godina. Kriteriji za uključivanje bili su:
• kvalitetan digitalni ortopantomogram i lateralni kafalo-
gram
• bez bolesti ili intervencija koje utječu na razvoj ili prisut-
nost trećih kutnjaka.

Pacijenti su isključeni iz istraživanja prema sljedećim kri-
terijima:
• bilo kakve kongenitalne anomalije zuba ili kongenitalne
anomalije drugoga, trećega i četvrtoega cervicalnog kra-
ležnika, poput fuzije između cervicalnih kralježaka ili pri-
sutnosti sekundarnih osiku
da
• pacijenti koji su imali bilo kakve sistemske bolesti koje bi
mogle utjecati na razvoj (poput prehrabrenih poremećaja,
endokrinih poremećaja, sindroma i dugotrajne konzuma-
cije lijezika).

Dentalna zrelost: Dentalna dob analizirana je prema faza-
ma kalcifikacija gornjih i donjih trećih kutnjaka. Razvoj zuba
kategoriziran je u različite skupine – od A (najmanji stupanj
razvoja) do H (potpuni razvoj) (8).

Skeletna zrelost: Skeletna zrelost vrijednovana je skeletnom
dobi i to korištenjem metode stadija zrelosti cervicalne kra-
ležnice (CVM), procjenjujući morfologiju (oblik i donji gra-
dni konkavitet) triju cervicalnih kralježaka (C2, C3 i C4)
prema šest stupnjeva zrelosti (C1 – C6) koje su predstavljali
Bacetti i suradnici (9, 10).

Sve digitalne radiografije pregledane su na istom računa-
lu. Faze razvoja cervicalne kralježnice i formiranje zuba za
svakog je pacijenta procijenio ortodont, bez poznavanja do-
bi ili spola.

Statističke metode

Analiza je obavljena korištenjem statističkog paketa SPSS
V22.0 (IBM Corporation, New York, SAD). Razlika u propor-
ciji analizirana je Kruskal-Wallisovim H-testom, nakon čega je
sljedio Mann-Whitneyjev U-test za usporedbu među skupina-
ma i Chi-quadrat test. Razlika u srednjim vrijednostima anali-
zirana je t-testom. Stadiji razvoja kutnjaka stavljeni su u kore-
laciju s razvojnim stadijima cervicalne kralježnice koristeći se
Spearmanovim koeficijentom korelacije. Svi statistički testovi
bili su dvostrani, a razina značajnosti postavljena je na p < 0.05.

Rezultati

Tablice 1. i 2. pokazuju distribuciju stadija zrelosti gor-
njih i donjih trećih kutnjaka prema dobi i spolu. U skupini
od 9 do 12 godina razvojni stadiji za gornje treće kutnjake bi-
li su C, B i D, a za donje treće kutnjake C i D, a zatim B. U

Materials and methods

The present study consisted of a total of 405 patients at-
tending orthodontic clinics of the specialized dental cen-
ters in western region of Saudi Arabia. All participants of the
study were only of Saudi origin. Digital panoramic radi-
ographs and lateral cephalograms along with clinical records of
255 girls and 150 boys aged 9-20 years were selected. The inclusions were:
• A high quality digital panoramic radiograph and lateral
cephalogram
• No history of medical or surgical disease affecting the
presence and development of third molar teeth.

The following exclusion criteria were considered and the
following patients were excluded from the investigation:
• Patients with any congenital tooth anomalies or congeni-
tal anomalies of the 2nd, 3rd and 4th cervical vertebrae such
as fusion between cervical vertebrae or presence of sec-
ondary osicle were eliminated.
• Patients having any systemic diseases that could affect
growth (such as nutritional disturbance, endocrine disor-
ders, syndromes, and long term consumption of medica-
tion) were excluded.

Dental maturity: The assessment of dental maturity was
done according to the calcification stages of upper and lower
third molar teeth. The development of teeth was categorized
into different groups, ranging from A (least development) to
H (complete development) (8).

Skeletal maturity: The Skeletal maturity was evaluated by
skeletal age using cervical vertebra maturation (CVM) stage
method, assessing the morphology (shape and inferior bor-
der concavity) of three cervical vertebrae (C2, C3, and C4)
consisting of six maturity stages (C1-C6) presented by Bacet-
ti et al. (9,10).

All digital radiographs were viewed on the same comput-
er. The stages of cervical vertebrae development and tooth for-
mation of each patient were assessed by an orthodontist with-
out having knowledge of age or gender.

Statistical method

The analysis was performed using the Statistical Package
SPSS statistic V22.0 (IBM Corporation, New York, USA). The
difference in proportion was tested using Kruskal-Wallis H fol-
lowed by Mann-Whitney U test for inter group compar-
ison, and Chi-Square tests. The difference in mean was
tested using t-test. Molar stages were correlated with cervi-
cal vertebra developmental stages using the Spearman’s corre-
lation coefficient. All statistical tests were two-sided, and the
significance level was set at p < 0.05.

Results

Table 1 and 2 show the distribution of upper and lower
third molar stages according to age and gender. In 9-12
years group the common upper third molar stages were C,
B and D respectively, while the common lower third molar

ovoj doboj skupini nije bilo stadija F, G i H. U skupini od 13 do 16 godina bili su prisutni svi razvojni stadiji trećih kutnjaka. U skupini od 17 do 20 godina bio je najčešći stadij D. U doboj skupini djece starije od 20 godina stadij H bio je najčešći na gornjim i donjim trećim kutnjacima. U ženskoj skupini ovoga saudijskog uzorka, najčešći razvojni stadij trećeg kutnjaka bio je D, a u muškoj skupini D i H.

U tablici 3, je distribucija kronološke dobi za sve ispitanike prema stadijima razvoja gornjih i donjih trećih kutnjaka prema dobi i spolu. Ova tablica pokazuje da je stadij H dominantna stadij u doboj skupini onog doba 17-20 godina, a stadij D dominantna stadij u doboj skupini doba 13-16 godina. U muškoj skupini ovog uzorka je stadij H dominantna stadij u doboj skupini doba 20 godina, a stadij D dominantna stadij u doboj skupini doba 13-16 godina. U ženskoj skupini ovoga uzorka je stadij D dominantna stadij u doboj skupini doba 13-16 godina, a stadij H dominantna stadij u doboj skupini doba 20 godina.

**Tablica 1.** Distribucija ispitanika sa stadijima razvoja gornjih trećih kutnjaka prema dobi i spolu

| Dob u godinama • Age in years | Stadiji razvoja gornjih trećih kutnjaka • Upper third molar stages | Ukupno • Total |
|--------------------------------|-------------------------------------------------|---------------|
| 9-12                          | A 6  B 32  C 38  D 28  E 8  F 0  G 0  H 28  NA 140 |
| 13-16                         | A 0  B 12  C 52  D 138  E 72  F 38  G 8  H 10  NA 342 |
| ≥ 17                          | A 0  B 0  C 34  D 28  E 76  F 66  G 122  H 2  NA 328 |

**Kruskal-Wallis H, p 0,0001 • Kruskal-Wallis H, p value 0.0001**

**Spol • Gender**

| Muški • Male | 2 20 42 60 36 38 8 68 26 300 |
| Zenski • Female | 4 24 48 140 72 76 66 64 16 510 |

Chi-kvadrat, p 0,0001 • Chi-square, p value 0.0001

**Tablica 2.** Distribucija ispitanika sa stadijima razvoja donjih trećih kutnjaka prema dobi i spolu

| Dob u godinama • Age in years | Stadiji razvoja donjih trećih kutnjaka • Lower third molar stages | Ukupno • Total |
|--------------------------------|-------------------------------------------------|---------------|
| 9-12                          | A 6  B 28  C 48  D 34  E 8  F 0  G 0  H 16  NA 140 |
| 13-16                         | A 4  B 16  C 48  D 148  E 90  F 12  G 4  H 14  NA 342 |
| ≥ 17                          | A 0  B 0  C 40  D 30  E 72  F 60  G 122  H 0  NA 328 |

**Kruskal-Wallis H, p 0,0001 • Kruskal-Wallis H, p value 0.0001**

**Spol • Gender**

| Muški • Male | 6 18 50 70 46 20 8 68 14 300 |
| Zenski • Female | 4 26 50 142 92 64 56 68 8 510 |

Chi-kvadrat, p 0,0001 • Chi-square, p value 0.0001

**Tablica 3.** Distribucija kronološke dobi svih ispitanika prema stadijima razvoja gornjih i donjih trećih kutnjaka

| Stadiji razvoja gornjih trećih kutnjaka • Age (Mean ± SD) | Muški • Male | 22 10.73 ±1.31 0.12 |
|-----------------------------------------------------------|--------------|---------------------|
|                                                           | Zenski • Female | 12 10.42 ±1.06 |
|                                                           | Muški • Male | 21 12.14 ±1.67 0.16 |
|                                                           | Zenski • Female | 13 12 ±1.85 |
|                                                           | Muški • Male | 25 14.14 ±1.19 0.07 |
|                                                           | Zenski • Female | 25 12.24 ±1.43 |
|                                                           | Muški • Male | 26 15.08 ±0.87 0.18 |
|                                                           | Zenski • Female | 62 14.79 ±1.72 |
|                                                           | Muški • Male | 23 18.17 ±1.92 0.08 |
|                                                           | Zenski • Female | 44 16.34 ±1.84 |
|                                                           | Muški • Male | 33 19.05 ±1.38 0.14 |
|                                                           | Zenski • Female | 99 18.39 ±1.54 |

**CS1** 34 10.62 ±1.2

**CS2** 34 12.09 ±1.72

**CS3** 50 13.19 ±1.62

**CS4** 88 14.88 ±1.52

**CS5** 67 16.97 ±2.05

**CS6** 132 18.55 ±1.52

**Tablica 3.** Distribution of chronological ages for all subjects grouped by cervical vertebra developmental stage

| Stadiji razvoja gornjih trećih kutnjaka • Age (Mean ± SD) | Muški • Male | 22 10.73 ±1.31 0.12 |
|-----------------------------------------------------------|--------------|---------------------|
|                                                           | Zenski • Female | 12 10.42 ±1.06 |
|                                                           | Muški • Male | 21 12.14 ±1.67 0.16 |
|                                                           | Zenski • Female | 13 12 ±1.85 |
|                                                           | Muški • Male | 25 14.14 ±1.19 0.07 |
|                                                           | Zenski • Female | 25 12.24 ±1.43 |
|                                                           | Muški • Male | 26 15.08 ±0.87 0.18 |
|                                                           | Zenski • Female | 62 14.79 ±1.72 |
|                                                           | Muški • Male | 23 18.17 ±1.92 0.08 |
|                                                           | Zenski • Female | 44 16.34 ±1.84 |
|                                                           | Muški • Male | 33 19.05 ±1.38 0.14 |
|                                                           | Zenski • Female | 99 18.39 ±1.54 |

**CS1** 34 10.62 ±1.2

**CS2** 34 12.09 ±1.72

**CS3** 50 13.19 ±1.62

**CS4** 88 14.88 ±1.52

**CS5** 67 16.97 ±2.05

**CS6** 132 18.55 ±1.52

**Tablica 3.** Distribution of chronological ages for all subjects grouped by cervical vertebra developmental stage

| Stadiji razvoja gornjih trećih kutnjaka • Age (Mean ± SD) | Muški • Male | 22 10.73 ±1.31 0.12 |
|-----------------------------------------------------------|--------------|---------------------|
|                                                           | Zenski • Female | 12 10.42 ±1.06 |
|                                                           | Muški • Male | 21 12.14 ±1.67 0.16 |
|                                                           | Zenski • Female | 13 12 ±1.85 |
|                                                           | Muški • Male | 25 14.14 ±1.19 0.07 |
|                                                           | Zenski • Female | 25 12.24 ±1.43 |
|                                                           | Muški • Male | 26 15.08 ±0.87 0.18 |
|                                                           | Zenski • Female | 62 14.79 ±1.72 |
|                                                           | Muški • Male | 23 18.17 ±1.92 0.08 |
|                                                           | Zenski • Female | 44 16.34 ±1.84 |
|                                                           | Muški • Male | 33 19.05 ±1.38 0.14 |
|                                                           | Zenski • Female | 99 18.39 ±1.54 |

**CS1** 34 10.62 ±1.2

**CS2** 34 12.09 ±1.72

**CS3** 50 13.19 ±1.62

**CS4** 88 14.88 ±1.52

**CS5** 67 16.97 ±2.05

**CS6** 132 18.55 ±1.52
1.62 i 14.88 ± 1.52; žene su bile mlade od muškaraca u cervikalnim stadijima.

Tablica 4. prikazuje koeficijente korelacije između razvojnih stadija cervicalne kralježnice i trećih kunjaka u gornjoj i donjoj čeljusti.

| Stadiji vratne kralježnice i dentalna dob | Felemban |
|------------------------------------------|----------|
|                                           |          |

Rasprava

Mnogi biološki pokazatelji, poput sazrijevanja kostana-ga zgloba (11), cervicalnih kralježaka (9, 10) i razvoja zuba (12), korišteni su za procjenu razvojne dobi. Osim rendgenske snimke ručnoga zgloba, za procjenu koštanog sazrijevanja stariji su koristiti kirurgi, anatomove i analizom CVM-a. Na kafelogramu se razvojne promjene cervicalnih kralježaka koriste za procjenu stupnja fiziološke zrelosti pojedinca koji raste i za izračunavanje kostane dobi. Mnogi istraživači slažu se da se evaluacija cervicalnih kralježaka na rutinskom lateralnom kafelogramu dublje može upotrijebiti za predviđanje mandibularnog rasta (9, 13 – 15). CVM objašnjava cijelo razdoblje puberteta i među razvojnim stadijima cervicalne kralježnice i trećih Kunjaka u gornjoj i donjoj čeljusti.

| Tablica 4. Korelacijski koeficijenti između stadija sazrijevanja cervicalne kralježnice i trećih umnjaka kod ispitanika | Table 4. Correlation coefficients between cervical vertebra developmental stages and third molar stages of subjects: |
|---------------------------------------------------------------|---------------------------------------------------------------|
| Stadiji gornjih trećih umnjaka • Upper third molar stages    | CS1 CS2 CS3 CS4 CS5 CS6 |
| Stadiji donjih trećih umnjaka • Lower third molar stages     | 0.267a 0.166b 0.287a 0.542a 0.246a 0.631a 0.536a 0.612a 0.198a |
| Dob u godinama • Age in years                                 | 0.732a 0.542a 0.532a 0.486a 0.631a 0.429a |

Korelacijski koeficijenti između stadija sazrijevanja cervicalne kralježnice i trećih umnjaka kod ispitanika.

Table 4 shows the correlation coefficients between cervical vertebra developmental stages and third molar stages of subjects:

Discussion

Many biological indicators such as skeletal maturation of hand-wrist (11), cervical vertebrae (9, 10) and dental development (12) have been used to evaluate for developmental age estimation. In addition to hand-wrist radiographs, the evaluation of CVM was used for assessing the skeletal maturation. On cephalometric radiographs, the developmental changes of cervical vertebrae were used to evaluate the degree of physiological maturation of a growing individual and also to calculate the bone age. Many researchers agree that evaluation of cervical vertebrae with routine lateral skull cephalograms are correlated and can be used to predict mandibular growth (9, 13-15). CVM explains the complete pubertal growth period by recording all significant phases in craniofacial growth during adolescence and young adulthood which is valid for both genders (9, 10, 16). Few researchers suggested a slight association between dental and skeletal maturity (16, 17). According to some studies, dental maturity with levels of calcification of teeth is considered to be a significant biologic factor (18). Some researchers have found that CVM is a reliable method for skeletal maturity assessment (5, 9, 16, 17, 19). Furthermore, they concluded that an additional x-ray exposure, apart from the routine lateral cephalometric projection, is not required.

This study investigated the interrelationship between cervical vertebrae maturation and dental ages of Saudi children. Some authors have found that developmental stages of certain teeth such as canines and second molars have a strong correlation with skeletal maturity (3, 4, 19, 20). However, the timing of third molar development showed the highest variability compared to all other developing teeth (21).

In the present study, an assessment of skeletal maturity was done using the CVM on lateral cephalograms, and a routine diagnostic radiograph was used for orthodontic treatment. The study investigated the interrelationship of dental age using the third molars and skeletal maturity by assessing the maturity stages of cervical vertebrae. A recent study by Chen J et al., dental calcification stages were used to determine dental maturity, while skeletal maturity was evaluated.
stupnja kalcifikacije zuba i zrelosti cervikalne kralježnice (6). Distribucija kronološke dobi svih ispitanika prema stadiju sazrijevanja vratnih kralježaka prikazana je u tablici 3. Na temelju procjene CVM-a, srednja kronološka dob djevojaka bila je nešto niža negoli dječaka, pri čemu je svaki stadij nastupio ranije kod ženskih negoli muških ispitanika. U fazi CS2 i CS4 srednja kronološka dob bila je 12.09 ± 1.72 godina i 14.88 ± 1.52 godina (tablica 3.). U CVM metodi CS1 – CS2 pokazuje razdoblje prije vrhunca rasta, CS3 – CS5 je pubertetski rast, a CS6 razdoblje nakon vrhunca rasta (tablica 3.). Ovi rezultati u skladu su s ranijim istraživanjima Baccettijsa i suradnika (9, 10). Rezultati dobiveni Spearmano-vim koeficijentom korelacijskim između sazrijevanja cervikalnih kralježaka i zuba kretali su se između 0.166 i 0.612, 0.243 i 0.832 za oba spola za gornje i donje treće kutnjake. Razine značajnosti za sve koeficijente postavljene su na 0.01 i 0.05 (tablica 4.).

Prema stajalištu nekoliko istraživača, proučavanje odabra-nih zuba umjesto cijele denticije daje veće koeficijente kore-lacije između dentalne i skeletne zrelosti, jer se smanjuje vjerojatnost slučajnih pogrešaka (17, 22, 23). Čini se da se povezanost između zuba i kostura razlikuje prema zemlji-snim regijama i rasama / etničkim skupinama (24).

U ovom istraživanju stupnjevi kalcifikacije zuba korišteni su za određivanje dentalne zrelosti, a skeletna zrelost vrijedno-vana je CVM metodom koja se našiško upotrebljava. Mala, ali statistički značajna korelacija pronadena je između stup-nja kalcifikacije zuba i zrelosti cervikalne kralježnice. Koefici-jenti korelacije između stupnjeva kalcifikacije gornjih trećih kutnjaka sako skeletne zrelosti bili su slabo pozitivni i varirali su od 0,166 do 0,0287, osim za stupanj CS5 za koji je postaja-la umjerena pozitivna korelacija (tablica 4.). Za donje treće kutnjake zabilježena je umjerena pozitivna korelacija između cervikalne kralježnice (CS4, CS5 i CS6) i razvojnih stadija u rasponu od 0,471 do 0,832.

U istraživanju koje su proveli Chen i suradnici, CVM i stupanj kalcifikacije zuba, osim trećih kutnjaka, korelirali su u rasponu od 0,601 do 9,911. Krailassiri i suradnici (25) te Uysal i suradnici (17) pronašli su slabe korelacije, a Engstrom i suradnici (26) snažnu korelaciju. U ovom saudijskom uzor-ku pronadena je snažna pozitivna korelacija između stadija sazrijevanja cervikalnih kralježaka i kornjega trećeg kutnjaka. U rasponu od 0,166 do 0,0287, osim za stupanj CS5 kod koje-ga je postojala umjerena pozitivna korelacija. Za donje treće kutnjake ustanovljen je snažan pozitivni koeficijent između razvojnih stadija cervikalne kralježnice CS4, CS5 i CS6, u rasponu od 0,471 do 0,832. Mnogi su istraživači naveli da je sazrijevanje mandibularnog očnjaka snažnije povezano s pubertetskim rastom od bilo kojega drugog zuba (4), a neki su-geriraju da drugi pretkutnjak ima najveću korelaciju s košta-nim sazrijevanjem (25). Zaključeno je da drugi kutnjak ima prednost zbog svojega duljeg razdoblja razvoja do kasnije do-bi iz odnosu na druge zube (5, 27, 28).

Skeletna zrelost porasla je zajedno s povećanjem dentalne dobi za oba spola. Kod ženskih ispitanika zabilježeno je ran-i početak svakog stadija skeletnog sazrijevanja. U jednoj fazi na vrhunca rasta te su razlike bile najveće. Sve korelacije između skeletne i dentalne zrelosti bile su statistički značajne. by CVM method and statistically significant correlation was found between tooth calcification stage and cervical vertebra maturation stage (6).

A distribution of chronological ages of all subjects according to cervical vertebra maturation stages is shown in Table-3. Based on CVM assessment, the mean chronological age of girls was slightly lower than that of boys, with each stage being constantly earlier in female than in male subjects. In stage CS2 and CS4, the mean chronological age was 12.09 ± 1.72 years and 14.88 ± 1.52 years respectively (Table-3). In CVM method, CS1-CS2 show the period before the peak of growth, during CS3-CS5 it’s the pubertal growth spurt and CS6 is the period after the peak of the growth (Table-3). The results of the present study are in compliance with those obtained in earlier studies by Baccetti et al. (9, 10). The results of Spearman correlation coefficients between cervical vertebrae and dental maturation were between 0.166 and 0.612, 0.243 and 0.832 for both genders for upper and lower third molars respectively. The significance levels for all coefficients were the same at 0.01 and 0.05 (Table-4).

According to a number of researchers, the study of selected teeth rather than the entire dentition gives higher correlation coefficients between dental and skeletal maturity since the probability of accidental errors will be reduced (17, 22, 23). The association between the teeth and skeleton also appear to vary among geographic regions and races/ethnic groups (24).

In the current study, dental calcification stages were used to determine dental maturity and skeletal maturity was evaluated by CVM method, which is a widely used method. A low but statistically significant correlation was found between tooth calcification stage and cervical vertebra maturation stage. The correlation coefficients between calcification stages of upper third molars and skeletal maturity was a weak positive and was ranging from 0.166 to 0.0287, except for CS5 stage in which there was a moderate positive correlation [Table-4]. For lower third molars, there was a moderate positive correlation between cervical vertebra (CS4, CS5 and CS6) and the developmental stages ranging from 0.471 to 0.832.

A study by Chen et al., the CVM and dental calcification stages of the teeth except the third molars showed correlations ranging from 0.601 to 0.911. Krailassiri et al. (25) and Uysal et al. (17) have reported weak correlations, while Engstrom et al. (26) found a strong correlation. In this Saudi sample there was a weak positive correlation between CVM stages and upper molar ranging from 0.166 to 0.0287, except for CS5 stage in which there was a moderate positive correlation. For lower third molar stages, there was a moderate positive correlation between cervical vertebra developmental stages CS4, CS5 and CS6, ranging from 0.471 to 0.832. It has been recommended by many researchers that the matu-ration of the mandibular canine is more strongly associated with the pubertal growth spurt than any other teeth (4) and some investigators have suggested that the second premolar has the highest correlation with skeletal maturation (25). It has been concluded that the second molar has an advantage over other teeth because of its longer period of development until a later age (5, 27, 28).
Skeletal maturity increased together with the increase in dental ages for both genders. A constantly earlier occurrence for each skeletal maturation stage was observed in females. At some stage, in the peak growth period, these differences were more marked. All correlations between skeletal and dental stages were statistically significant. Further research using a larger sample of Saudi children is needed to come to more reliable conclusions.

Conclusions

Due to its practical applications, the CVM stage method appears to be a powerful diagnostic tool. The CVM stage method may be helpful for the assessment of period active growth for long term effects of orthodontic/orthopedic treatment approach. It can be used to identify the sufficient time for intervention for the late correction of facial deformities. Tooth calcification stage was significantly correlated with CVM stage in a study of Saudi sample. When planning the orthodontic treatment, it is useful to consider both dental and skeletal maturity.

Acknowledgements

The author wish to thank Dr. Manjunatha Bhari Sharanesha, Associate Professor in Oral Biology and Dr. Sakeeni, Assistant Professor in Preventive and Community Dentistry, Faculty of Dentistry, Taif University, Taif, KSA for helping in manuscript preparation, editing and critical appraisal of statistics.

Conflict of interest

None declared
5. Kumar S, Singla A, Sharma R, Virdi MS, Anupam A, Mittal B. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod. 2012 May;82(3):501-6.

6. Chen J, Hu H, Guo J, Liu Z, Liu R, Li F, Zou S. Correlation between dental maturity and cervical vertebral maturity. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010 Dec;110(6):777-83.

7. Heravi F, Imanimoghaddam M, Rahimi H. Correlation between cervical vertebral and dental maturity in Iranian subjects. J Calif Dent Assoc. 2011 Dec;39(12):891-6.

8. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973 May;45(2):211-27.

9. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod. 2002 Aug;72(4):316-23.

10. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod. 2005;11:119-29.

11. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod. 1982 Apr;52(2):88-112.

12. Perinetti G, Contardo L, Gabrielli P, Baccetti T, Di Lenarda R. Diagnostic performance of dental maturity for identification of skeletal maturation phase. Eur J Orthod. 2012 Aug;34(4):487-92.

13. O'Reilly M, Yanniello GJ. Mandibular growth changes and maturation of cervical vertebrae—a longitudinal cephalometric study. Angle Orthod. 1988 Apr;58(2):179-84.

14. Franchi L, Baccetti T, McNamara JA Jr. Mandibular growth as related to cervical vertebral maturation and body height. Am J Orthod Dentofacial Orthop. 2000 Sep;118(3):335-40.

15. Grave K, Townsend G. Cervical vertebral maturation as a predictor of the adolescent growth spurt. Aust Orthod J. 2003 Apr;19(1):25-32.

16. Flores-Mira C, Burgessb CA, Jensend RJ, Pitcher MR, Major PW. Correlation of skeletal maturation stages determined by cervical vertebrae and hand-wrist evaluations. Angle Orthod. 2006 Jan;76(1):1-5.

17. Uysal T, Sari Z, Bagciftci FA. Relationships between dental and skeletal maturity in Turkish subjects. Angle Orthod. 2004 Oct;74(5):657-64.

18. Demirjian A, Buschang H, Tanguy R, Patterson DK. Interrelationships among measures of somatic, skeletal, dental, and sexual maturity. Am J Orthod. 1985 Nov;88(5):433-8.

19. Goyal S, Goyal S, Gugnani N. Assessment of skeletal maturity using the permanent mandibular canine calcification stages. J Orthod Res. 2014;2:11-6.

20. Kumar S, Singla A, Sharma R, Virdi MS, Anupam A, Mittal B. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod. 2012 May;82(3):501-6.

21. Liversidge HM. Timing of human mandibular third molar formation. Ann Hum Biol. 2008 May-Jun;35(3):294-321.

22. Bağaran G, Ozer T, Hamamcı N. Cervical vertebral and dental maturity in Turkish subjects. Am J Orthod Dentofacial Orthop. 2007 Apr;131(4):447-e13-20.

23. Różyło-Kalinowska I, Kolasa–Rączka A, Kalinowski P. Relationship between dental age according to Demirjian and cervical vertebrae maturity in Polish children. Eur J Orthod. 2011 Feb;33(1):75-83.

24. Chaillet N, Nyström M, Demirjian A. Comparison of dental maturity in children of different ethnic origins: international maturity curves for clinicians. J Forensic Sci. 2005 Sep;50(5):1164-74.

25. Kraliassiri S, Anuwongnakroh N, Dechkunakorn S. Between dental calcification stages and skeletal maturity indicators in Thai individuals. Angle Orthod. 2002 Apr;72(2):155-66.

26. Engstrom C, Engstrom H, Sagne S. Lower third molar development in relation to skeletal maturity and chronological age. Angle Orthod. 1983 Apr;53(2):97-106.

27. Al-Emran S. Dental age assessment of 8.5 to 17 Year-old Saudi children using Demirjian’s method. J Contemp Dent Pract. 2008 Mar 1;9(3):64-71.

28. Grover S, Marya CM, Avinash J, Pruthi N. Estimation of dental age and its comparison with chronological age: accuracy of two radiographic methods. Med Sci Law. 2012 Jan;52(1):32-5.