Comparisons between skeletal and dental age assessment in unaccompanied asylum seeking children

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KEYWORDS

age assessment, dental age, skeletal age, agreement, independent observers

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ABSTRACT

Background: For children with disputed date of birth, age assessments based on skeletal and dental development are recommended.
Aim: The aim of this retrospective study was to compare and contrast the results of age assessments from these two methods performed on unaccompanied asylum seeking children in Norway. In addition the aim of the analysis was to see if the skeletal age assessment from hand-wrist was operator sensitive.
Materials and methods: Age assessments performed from January 2010 to December 2014 were analysed. Skeletal development of hand-wrist was graded according to Greulich and Pyle (1959). Dental development of the wisdom teeth was scored on orthopantomograms according to Moorrees, Fanning and Hunt (1963) and age assessed from tables published by Liversidge (2008) and Haavikko (1970). In the statistical analysis agreement between the two age assessments was defined according to the asylum seeker's age being assessed to be older or younger than 18 years. The statistical analysis included 3333 boys and 486 girls.
Results: The agreement was 83% for boys and 79% for girls. Approximately 70% of the boys and girls were 18 years or older by both methods. It was more common that the skeletal age was assessed older than 18 years and dental age younger than 18 years for both genders. It could be demonstrated that the age assessment based on skeletal maturation was not operator sensitive.
Conclusion: The analyses demonstrate that there is good agreement between the two age assessments, but a method to combine the results would increase the reliability of the age assessments.

INTRODUCTION

An unaccompanied minor is a child without the presence of a legal guardian. In immigration law unaccompanied minors or children are generally defined as foreign nationals or stateless persons below the age of 18 years. They arrive on the territory of a state unaccompanied by a responsible adult. It also includes children who are left unaccompanied after they entered the territory of state.[1] Unaccompanied asylum seeking children (UASC) require protection, but have special rights different from adult asylum seekers. Many UASC come from countries disrupted by war and civil conflicts. The birth of the child is frequently not registered and they arrive in Europe

without documentation of age. According to The Universal declaration on Human rights (1948) everyone has the right to know their age and it is the duty of the country in which they apply for asylum to try to find their chronological age by the best methods available. Some of these children appear to be older than the given age and many European countries perform an age assessment procedure.[2]

Age assessment includes some form of measurement or grading of the development from childhood to an adult fully grown person and relates the measurement to chronological age. The recommendations are that age assessments should be performed from more than one independent physical trait in the same individual.[3] There is however no standard or scientific approach for combining the results of different methods. Existing reference datasets only contain one type of measurement per person (either bone or teeth). In addition, existing tables are based on limited datasets and the description of associated uncertainties is incomplete.

Age assessments from skeletal development in children and young adults are commonly graded from the maturation and closure of the bony symphysis. The most widely used method is grading the development of the symphysis in the hand and wrist, but clavicle and ribs are also used.[4-7] The atlas by Greulich and Pyle has widespread acceptance.[4] It is based on 1000 radiographs of children and contains reference images of left hand and wrist for boys and girls separately. Along with the reference radiographs are explanations regarding the gradual age related changes observed for each image. Age from skeletal development is assessed by comparing radiographs of the non-dominant hand of the subject with the nearest matching reference radiograph provided in the atlas.

In 1955 Gleiser and Hunt graded dental development from radiographs of the dentition.[8] The grading system was further developed by Moorrees, Fanning and Hunt (MFH) and since then this grading of tooth development has been used with variations in stages from 10 to 14.[9] The principle of these grading systems is that each stage of crown or root development corresponds to a mean or median age for that stage. This applies to all 32 teeth. In adolescents and young adults all teeth except for the wisdom teeth have completed development and grading is only possible from the four wisdom teeth.

There is international agreement that the recommendation is to use two or more independent age assessment methods.[10 11] A study from 1956[12] found a high correlation between scoring skeletal development according to Greulich and Pyle[4] and scoring dental development from first molar according to Gleiser and Hunt[8] for children aged 8 - 16 years. A Swedish study from 1971 using different tables and grading systems also showed a good agreement (r = 0.88) for children aged 6.5 -14.5 years.[13] Later studies have confirmed this agreement for children in the same age groups using various grading systems for skeletal and dental developments as well as different statistical analysis.[14-19] Few studies have compared age assessment from skeletal development and development of third molars.[7 20-23] Gelbrich et al. [18] have demonstrated that the skeletal maturation is independent from dental development and consequently these two age markers can be combined in age assessment.

The aim of the present study has been to compare and contrast the mean or median from two biologically independent age assessments performed on UASC in Norway. The age assessment is based on analysis of hand-wrist radiographs and dental examination. In addition the aim of the analysis was to see if the skeletal age assessment from hand-wrist was operator sensitive. The study is aimed at getting a better understanding of variations and differences between the two biological methods used for age assessment in Norway.

MATERIALS AND METHODS

The material consisted of all the dental and skeletal age assessments of age disputed UASC which have been performed in Norway between January 2010 and December 2014. These UASC had age assessment performed as part of their asylum application procedure in Norway and their chronological ages were unknown. The skeletal age assessments from these examinations were based on radiographic images of hand-wrist assessed by two consultants at the Radiology Department at Oslo University Hospital from January 2010 to July 2013 and by mainly one consultant at Unilabs, Oslo from July 2013 to December 2014. The dental age assessments were performed at the Institute of Clinical Dentistry, Faculty of Dentistry, University of Oslo, and carried out by four specially trained dentists and

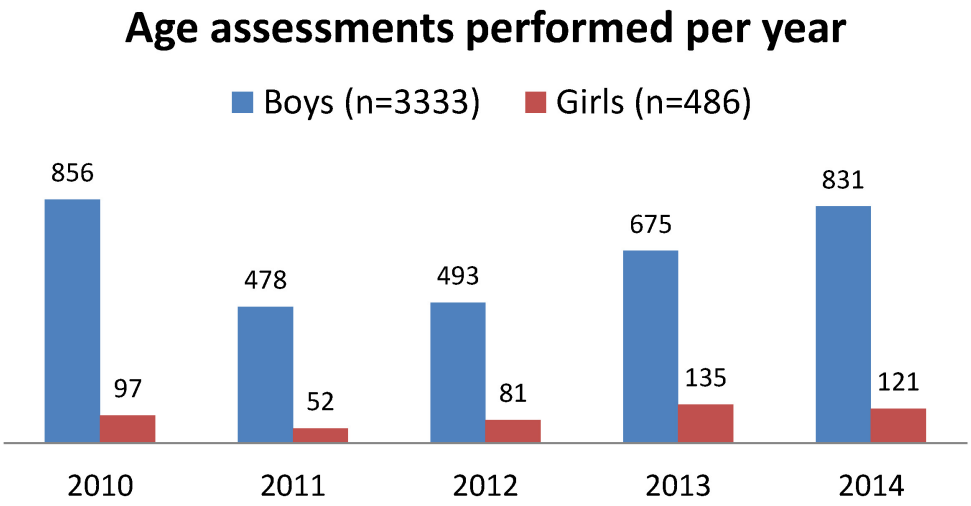
quality controlled by one dentist based on clinical and radiographic examination of the dentition. These two different biological age assessments were made on the same day by independent observers.

The radiographers assessed age from the fusion of the distal symphysis of the ulna which was graded according to the atlas by Greulich and Pyle.[4] For the purpose of this article the age assessments based on radiographs of the hand-wrist are called "skeletal age".
An oral examination was also performed and an age assessment given based on the clinical impression. From an orthopantomographic radiograph (OPG) the development of the mandibular third molars was graded according to MFH stages as described by Liversidge.[24] Age assessments were made from the development of the mandibular third molars (FDI nomenclature 38 and 48) according to the tables of Liversidge [24] and for maxillary third molars (FDI nomenclature 18 and 28) from the tables of Haavikko.[25] The dental age was given as the average age of the four assessments reduced to the nearest integer figure with the exception of one (or in few instances two) teeth being obviously delayed in development. When there was a marked discrepancy between clinical impression and assessment age from tooth development the assessed age was adjusted accordingly. For UASC with congenitally missing third molars root development on the second molar was graded and age assessed according to the tables by Haavikko, and in addition the age was calculated from the size of the pulp cavity on periapical radiographs on maxillary central incisors.[26] A collated dental age assessment was given based on clinical and radiological evidence in this article called "dental age.
According to the atlas of Greulich and Pyle[4] the mean age for closure of the symphysis in the left hand are 18 years in girls and 19 years in boys. After this age a radiographic examination cannot tell anything more than that a girl is 18 years or older or that a boy is 19 years or older. In these cases, skeletal age is set to 18 years for girls and 19 years for boys. The age assessments were given as integers since this reflects the biological variation in development on which the age assessments were based.
Agreement between the two age assessments is defined according to the asylum seeker's age being assessed to be older or younger than 18 years. According to the UN Convention on the Rights of the Child (1989) this age differentiates a child from an adult and consequently their legal rights and obligations. There were four possible outcomes:

- *Agreement 1:* The UASC is 18 years or older from both age assessments.
- *Agreement 2:* The UASC is younger than 18 years from both age assessments.
- *Mismatch 1:* The UASC is 18 years or older from the skeletal age assessment and younger than 18 years from the dental age assessment.
- *Mismatch 2:* The UASC is younger than 18 years from the skeletal age assessment and 18 years or older from the dental age assessment.

The Mann-Whitney U test was used to compare the means of two independent groups of samples that do not necessarily follow a normal distribution. The significance level was 5%.

Figure 1: Number of age assessments per calendar year performed from January 2010 to December 2014



RESULTS

In total 3819 UASC were included in the statistical analysis, 3333 boys and 486 girls. From the first period there were 2416 UASC- of which 2124 were boys and 292 girls and from the second period 1403 UASC- of which 1209 were boys and 194 girls. Figure 1 shows the number of age assessments performed per year from 2010 to 2014 separated by gender.

Figure 2 shows the percentage of agreement and mismatch for boys and girls, respectively, for the age assessments performed from 2010 to 2014. The agreement was 83% for boys and 79% for girls and for both genders approximately 70% of the UASC were18 years or older by both methods (Agreement 1).

The mismatches showed that it was more common that the skeletal age was assessed older than 18 years and dental age younger than 18 years (Mismatch 1) for both genders. The discrepancy between skeletal age and dental age varied from -5 to 6 years and was more than one year in 11.6% of the boys and 12.6% of the girls (Figure 3).

Figure 2: Percentage of individuals with and without agreement for age assessments performed from 2010 to 2014. Agreement is defined according to the asylum seeker's age being assessed to be older or younger than 18 years. (A) Males. (B) Females

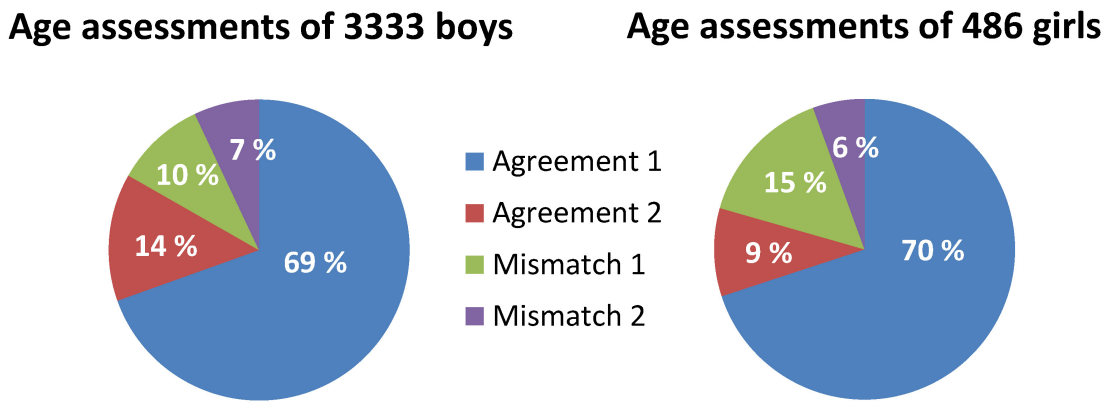
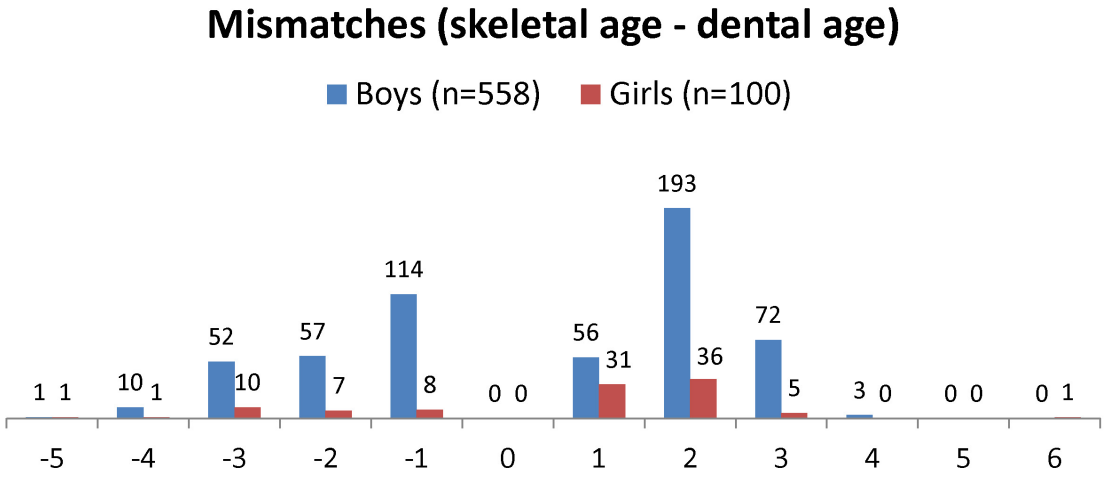


Figure 3: Mismatches between the two age assessments (skeletal age minus dental age) for both genders. For negative deviations skeletal age is lower than dental age and for positive deviations skeletal age is higher than dental age



Comparison between the two periods when radiologists from two different institutions assessed the skeletal age shows that the agreements for girls were 79.5% and 79.4%, respectively. In the same two periods the agreements for boys were 86.3% and 77.9%. The difference between the two agreements for boys is -8.4 with a 95% confidence interval from -11.2 to -5.5. The significant reduction in agreement for boys reflects that the percentage of UASC with skeletal age younger than 18 years and dental age 18 years or older (Mismatch 2) has increased from 4.0% in the first data period to 12.4% in the second data period.From the Mann-Whitney U test, the skeletal age assessment is significantly higher than the dental age assessment in both data periods for girls, so there has been no change over time in the relationship between the two age assessments for girls. The statistical tests also show that the skeletal age assessment is significantly higher than the dental age assessment in the first data period for boys. In the second period there were a larger proportion of boys with a lower skeletal age assessment than dental age assessment. Although there was no significant difference between the two age assessments in the second period, there has been a change over time in the relationship between the two age assessments for boys. There are several factors that may explain this change. Firstly, there is a significantly larger group of UASC with older age markers in the first data period compared to the second period (Figure 4). In the first data period 77.4% of the boys have a combined age assessment of 18 years or older. In the second period it is 59.2%.

Secondly, in both periods boys from Afghanistan, Somalia or Eritrea represented 81.7% and 80.4% of the total number of age assessments. However, the number of UASC- from these countries varied in the two periods, as shown in Table 1. Table 2 shows the agreement between the dental and skeletal age assessments in the two periods, for all countries of origin together and separately for Afghanistan, Somalia and Eritrea. These data provide no basis to conclude that there have been different interpretations among the operators performing the skeletal age assessments in the two data periods.

Figure 4: Combined age assessments for boys in the two data periods, separated in nine different age groups

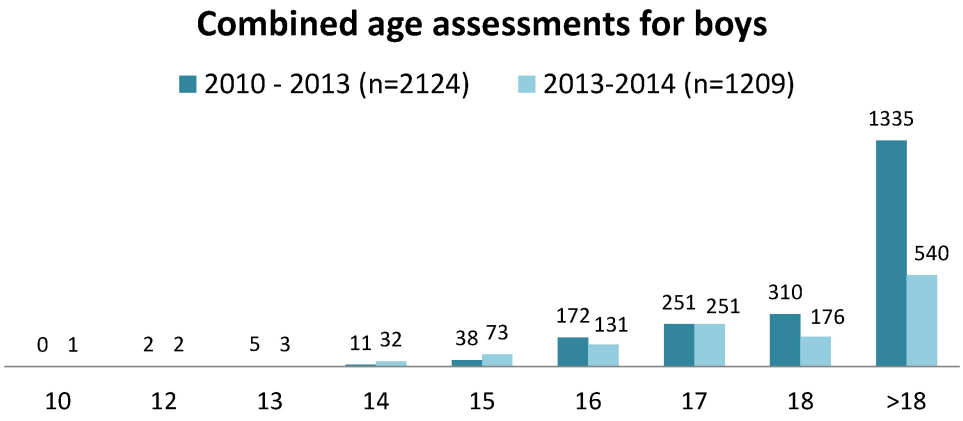


Table 1: Percentage boys from the three major countries of origin over the two periods

	Afghanistan	Somalia	Eritrea	Sum
January 2010 – July 2013	59.6%	17.7%	4.5%	81.7%
August 2013 – December 2014	29.4%	19.8%	31.2%	80.4%

Table 2: Percentage boys with agreement between dental and skeletal age assessments over the two periods, for all countries of origin together and separately for the three major countries of origin. Agreement is defined according to the asylum seeker's age being assessed to be older or younger than 18 years

	All	Afghanistan	Somalia	Eritrea
January 2010 – July 2013	86.3%	84.6%	89.9%	80.2%
August 2013 – December 2014	77.9%	76.1%	89.5%	69.0%

DISCUSSION

This retrospective study confirms that there were more boys than girls arriving as UASC in Norway. They were mainly from Afghanistan, Somalia and Eritrea which are countries where the infrastructure including registration of births are hampered by wars and conflicts and the children cannot document their age. The figures do not reflect the immigration in 2009 and 2010 as there was a considerable backlog in age assessment from previous years and for the whole period only age disputed children had an age assessment performed. This might explain the high figure of UASC with age assessment older than 18 years. In 2012 the Norwegian government introduced new regulations regarding UASC permission to remain in Norway after they turned 18 years. Only children, who were younger than 16 years when their application was granted, were guaranteed permission to remain in Norway. This might partly explain the lower average age for boys in the second data period (Figure 4).

The most common biological methods to assess age in children and young adults are to grade the dental and skeletal development. A scientific method to combine these two individual biological markers has not been devised and age assessments are either based on the average of the methods or the lowest age assessment is chosen. The chronological age in this retrospective study was unknown but the number of age assessments is considerably higher than in other studies. This allows for a comparison between the two methods. The agreement between the two methods was 83% for boys and 79% for girls. This agreement strongly supports the claim that the combined age assessment is correct. In 11.6% of the boys the difference in age assessment between the two methods was more than one year whereas this was the case for 12.6% of the girls. Although girls seem to show a greater variation in the timing of dental development,[24 25] there was little difference between the genders in this review.

Both the skeletal and dental age assessments are based on a grading system with defined stages in the development from immature to full maturation. This implies that the development is registered in a stepwise manner and the two age assessment systems are not synchronised. Therefore a one year difference might not express a real difference, but a mismatch in timing between the grading systems.

Dental age assessments in adolescents with congenitally missing wisdom teeth are difficult. The maxillary second molar is, according to Haavikko, fully formed at the age of 16.2 years for boys and 15.1 years in girls. The age assessment based on the pulp size of central incisors according to Kvaal[26] will in these age groups greatly overestimate age, but the pulp size will indicate whether the applicant is a teenager or an adult.

The atlas of Greulich and Pyle is widely used in age assessment and it has been shown that there is good agreement between operators.[27] Although skeletal development is influenced by malnutrition and starvation this deprivation has to be longstanding and catch-up to normal growth is restore once normal calorie intake is restored.[28] Teeth are less influenced by nutritional status,[29] but wisdom teeth show greater biological variation than the other teeth in a developing dentition.[25 30] Age assessments using the Greulich and Pyle Atlas or from wisdom teeth show a wide 95% dispersion.[27 30] The development of wisdom teeth shows slightly wider variations than age assessments from the Greulich and Pyle Atlas. This retrospective study demonstrates that in practical cases there is a high level of agreement

between the age assessments derived from skeletal and dental development as has been shown in other studies.[19 22]

This study is not directly comparable with previously documented comparisons between dental and skeletal age markers. Most of the studies have been on younger children up to 15 years of age which have had hand-wrist and dental radiographs on the same day in preparation for orthodontic treatment,[14-18] and one study included deceased children.[19] In the present study very few UASC were assessed to be younger than 14 years. For both skeletal and dental age assessment the confidence interval increased with age and is widest for age assessments performed on third molars in the last stages of root development.[25]

Kullman et al.[21] looked at the correlations between the different age assessment methods in the 12 - 19 years age group and found better correlation with chronological age using skeletal age assessment methods rather than age assessment based on development of third molar. It is encouraging that in this retrospective study the agreement of the two methods was so high considering different factors controlling growth and development[18].

CONCLUSION

Age assessments from either Greulich and Pyle Atlas or from development of wisdom teeth demonstrate a standard deviation of approximately one year but the 95% confidence interval varies from 4.7 to 6.8 years in young adults.[27 30] These wide variations might be narrowed if the two methods could be combined. Until such tables can be produced the combinations of two independent age assessments demonstrate close agreement based on the available methods.

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