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JRC SCIENCE FOR POLICY REPORT

# Medical Age Assessment of Juvenile Migrants

*An Analysis of Age Marker-Based Assessment Criteria*

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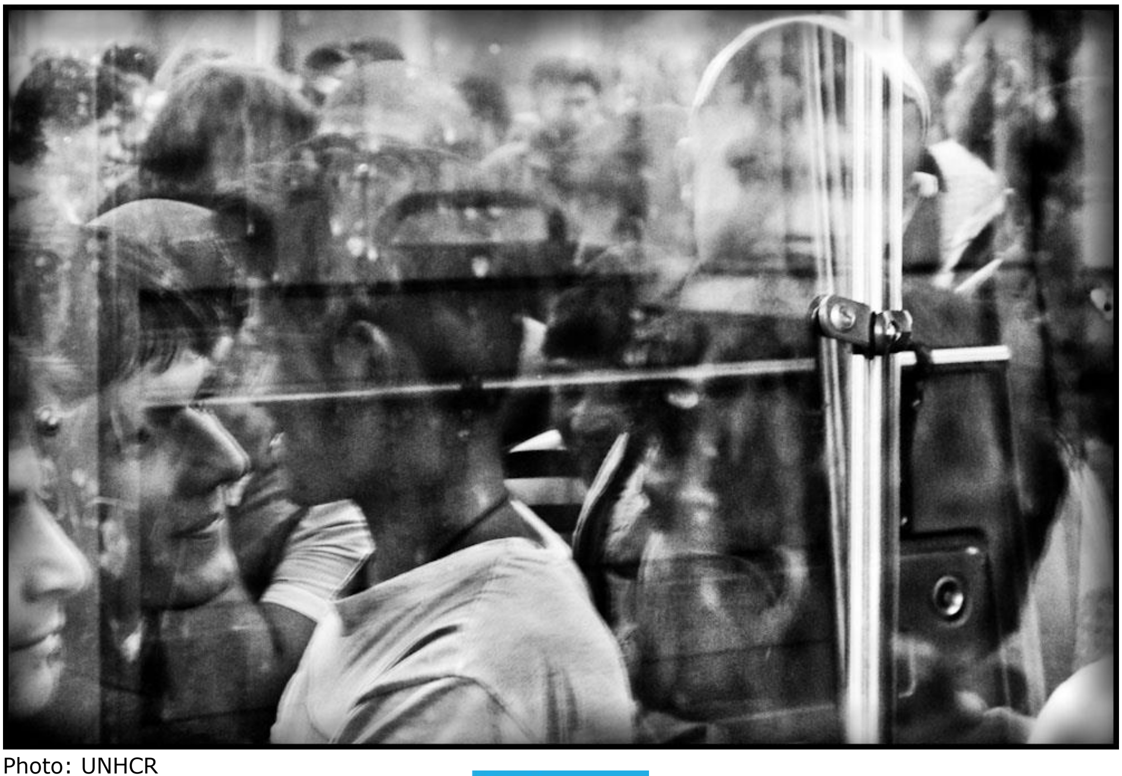

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## Executive Summary

The arrival of unaccompanied minors in Europe had reached a peak in 2015 when almost 100.000 of them filed an application for asylum. Even if the figures have significantly dropped since then, it cannot be expected that the phenomenon will disappear. European policy makers have recognised this long before the 2015 peak. The European Commission released in 2010 an "Action Plan on Unaccompanied Minors", followed by the most recent Communication on "The protection of children in migration" (2017)[1]. The aim is to protect this particularly vulnerable group as much as possible according to European human rights standards.

An important aspect of the reception of unaccompanied minors is the question of their age. In fact, as these young people frequently arrive without reliable documents, their age might be called into question. This is of great importance as there is a significant difference in conditions for the reception of persons below or above 18 years of age. Regardless of the potential granting of international protection, minority status guarantees a wide range of rights and legal safeguards in accordance with the UN Convention of the Rights of the Child (CRC) and the Common European Asylum System (CEAS).

This fact puts into focus **age assessment**, the attempt by authorities to estimate the (chronological) age of a person, in the absence of reliable documentation regarding age. As there is no such simple technique for humans as counting the age rings of trees, any existing age assessment approach is subject to discussions and possibly even disagreements.

Ultimately, however, the 18 years mark remains the baseline for the application of relevant international legislation as, for example, stated in the last recast of the Qualification Regulation: *'minor' means a third-country national or stateless person below the age of 18 years.*[2] If protection of minors is of overriding importance, then the risk of their false categorisation as adults needs to be reduced to an absolute minimum.

The European Asylum Support Office (EASO) has contributed intensively to the debate with its recently updated "Practical Guide on age assessment". First, the guide provides an overview of the significant differences on age assessment practices across European Member States. Second, it helps navigate through the legal and technical aspects related to individual approaches through competent advice and reference. In particular, it provides practical guidance and tools for the implementation of the best interests of the child when assessing the age of a person using a multidisciplinary and holistic approach.

In the "Practical Guide", EASO categorises age assessment methods according to their level of intrusiveness, "intrusiveness" being measured in terms of health and ethical impacts. Priority should be given to the least intrusive methods, before other methods can be used if age is still in doubt.

**Medical methods** are usually the ones considered as more problematical for a number of reasons. Probably the most important class of medical methods are those based on the **observation of age markers**, i.e. somatic indicators that change in a given way with age. As a large number of scientific studies has investigated this relationship in detail, it is assumed that this method allows for reliable and reproducible conclusion about the true age of a person**.**

This ambitious claim is not unchallenged. In addition to doubts about the real precision of medical methods, there are also health and ethical issues. On the other hand, the high potential to establish age estimation on objective criteria, thereby reducing the dependence on individual expert opinion, has raised high expectations and attention on age markers. The current report aims to analyse to what extent these expectations can be met.

As was mentioned above, there is the **risk of false categorisation of minors into adults** that threatens the protection of the fundamental rights of minors. The report

[1] COM(2017) 211 final of 12.04.2017
[2] COM(2016) 466 final, Qualification Regulation, Art. 2,10.

places this risk (and other risks that are identified in the report) at the centre of consideration and analyses the issues with respect to these risks.

What are these issues? As said before, a number of physiological indicators (the age markers) have been identified by scientists that correlate well with a person's age; to be more precise, they correlate with **age ranges**. These ranges have been quantified in numerous studies, done with different focuses and study populations. Reviewing these studies leads to the following main findings:

- The knowledge about age markers is spread over a wide range of scientific publications, with no single point of access. Thus, age estimation by competent experts may not involve all available information and may be based instead on an individual expert's selection of these publications, and therefore not on the best available knowledge as a whole.
- The reporting of age ranges (rather than fixed estimates like "16,4" or "19,5") is frequently interpreted as "statistical uncertainty". This has led to the practice of providing a "most likely age" based on sometimes questionable statistical reasoning. This practice of using averages instead of ranges is the main source of criticism about age markers. In fact, such an interpretation can have far-reaching negative consequences for minors.
- Age markers are observed by medical imaging devices that in most cases involve X-Rays. Though less critical imaging techniques exist, the dominant part of existing scientific records is X-Ray-based. This creates a health issue.

However, these issues do not necessarily create unresolvable obstacles for the practical application of age marker-based assessment. The report also finds that:

- There exist reliable practices in Europe that do take due account of the information available for the different age ranges. These practices use the lack of detail below the level of the "age range" (the impossibility to fix the exact age) always in favour of the person in question.
- Insufficient significance of one single age marker can be compensated through the combined use of several age markers. Again, the information combined needs to be used in a responsible and cautious manner to avoid misinterpretation.
- A number of already identified studies could help to validate the underlying set of data and relax the dependency on X-Ray images. This can further improve the authenticity of the conclusion and reduce the potential health risks.

In summary, by managing the identified risks properly, age marker-based assessment could provide a child-safe, human rights compliant, and scientifically-sound practice that authorities can rely upon.

The findings of this report have been synthesized into a proposal towards the establishment of a **child-safe age marker medical assessment scheme**, with special focus of the European context. The main pillars of the proposal are

1. The establishment of a comprehensive, scientifically sound and agreed **Catalogue of Age Markers**. This catalogue would provide for each age marker the reference images and the corresponding data about observed age ranges.
2. The development of an **Age Marker Assessment Protocol** that describes how from a set of images on the status of the age markers a decision shall be inferred about whether minority or majority can be excluded without reasonable doubt.
3. The establishment of an **Age Marker Diagnostics Centre** that can host a number of permanently available experts in the age diagnostics of juveniles. Such a cost saving centralised service would guarantee full availability of relevant expertise and would facilitate a uniform application of the Catalogue of Age Markers and the Age Marker Assessment Protocol.

# 1 Introduction

## 1.1 Why age assessment matters

The arrival of unaccompanied minors in Europe had reached a peak in 2015 when almost 100.000 of them filed an application for asylum (see Figure 1). Even if the figures have significantly dropped since then, it cannot not be expected that the phenomenon will disappear. European policy makers have recognised this long before the mentioned peak. Both in its "Action Plan on Unaccompanied Minors"[3] (2010) and in its recent communication on "The protection of children in migration"[4] (2017), the European Commission calls on the Union and the Member States to strengthen support and protection of children in this situation, in accordance with the principles set out in the UN Convention for the Rights of the Child (CRC) and the UN Refugee Convention.

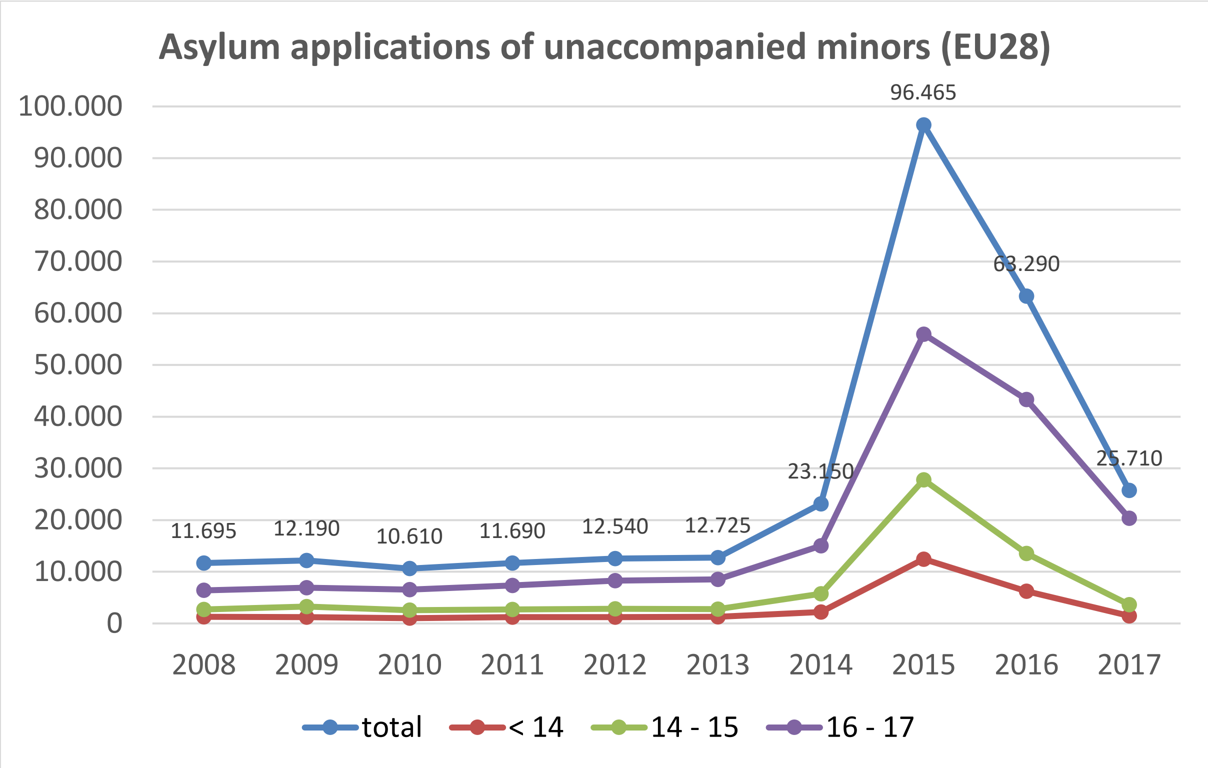



*Figure 1: Asylum applications of unaccompanied minors[5]*

A recurring question in this context is the problem of age determination, given the legitimate interest in clarifying whether a young individual arriving at the EU borders, without documents or proof of identity, qualifies for child protection or not.

However, a study conducted by the European Asylum Support Office (EASO) revealed that a large number of age assessment related methodologies (both medical and non-medical) are in use across Member States. Their use is regulated by individual national policies and there are no common standards [34]. A similar study conducted by the Fundamental Rights Agency (FRA) confirmed these findings [33] as well as a recent report of the Council of Europe's Committee on Migration, Refugees and Displaced Persons [34]. This is not conducive to assuring that the results of age assessments are mutually recognised by Member States, as the Commission suggested in its latest proposal to revise the European Asylum Procedure[6].

[3] COM(2010) 213 final
[4] COM(2017) 211 final
[5] Source: EUROSTAT. For 2017, 75% of unaccompanied minors registered in Germany and Italy
[6] "A Member State shall recognise age assessment decisions taken by other Member States on the basis of a medical examination (…)". COM(2016) 467 final (Proposed Asylum Procedure Regulation), Art 24,6

## 1.2 Where to start from

Age assessment is defined to be "the process by which authorities seek to estimate the chronological age or range of age of a person in order to establish whether an individual is a child or an adult" [2]. In this context, the main question is the **distinction between children and adults** because this question decides on the principle pathway that has to be followed. Whatever methodology is applied to make this distinction, there is the risk of a false assessment that would assign a child the status of an adult. In order to decide on the usefulness of a methodology, the associated risk needs to be quantified.

> **Risk 1 (Age Assessment in general):**
>
> **A child could be falsely assessed as being an adult.**

But age assessment is not only applied to make the distinction between child and adult. A more precise indication about a **particular age (or age range)** becomes important for the question of how long a person, assigned to the status "child", remains in that status. Usually, authorities also require an indicative age for anyone that presumably is considered a child. If, for example, an age of 16,5 years is assigned to that person, it would mean that after 1,5 years the same person is considered adult. Thus, there is also the risk that this indicative age is set too high or, in other words, a child would be considered adult before actually turning 18.

> **Risk 2 (Age Assessment in general):**
>
> **The indicative age assigned to a child could be too high**

In any case, age assessment has possible far-reaching consequences for persons undergoing such an assessment [2].

As a result of the study mentioned before, EASO released in 2013 a handbook on Age Assessment, entitled "Age Assessment Practice in Europe" [1], that provides an overview of existing practices in the Member States along with a set of (non-binding) recommendations. Since then, the handbook has been completely revised, mainly with respect to the full coverage of all Member States, the consideration of procedural updates and a stronger focus on the best interests of the child (BIC) and the procedural safeguards. As such, the new edition, released in February 2018 and entitled "Practical Guide on age assessment" [2], reflects the changes with regard to children in the ongoing revision of the Common European Asylum System (CEAS). It is currently the most comprehensive reference on age assessment related issues in the European context.

According to the "Practical Guide",[7] investigations with regard to persons where the claimed age is in doubt shall start with the "least intrusive methods" first.[8] Any kind of medical age assessment should only be applied as a last resort. Furthermore, the "Practical Guide" contains the following main elements:

- Description about the context in which age assessment is going to be used, about which actors are involved and about the basic principles. According to the mission of EASO, the description mainly focusses to asylum cases in line with the Asylum Procedures Directive.
- Procedural measures and safeguards, all derived from the BIC principle. This addresses aspects like the "benefit of doubt",[9] care and accommodation up to the potential case of detention. The "Practical Guide" takes into account the envisaged changes of the Asylum Procedures Directive, in particular a stronger emphasis of

[7] In the following, the term "Practical Guide" shall make reference to [2].
[8] "Practical Guide" [2], p. 31
[9] "Practical Guide" [2], p. 22. On p. 36, it is stated that the benefit of doubt is not applied in at least 6 Member States.

BIC and the role of the guardian. Furthermore, it promotes the conduct of a best interests assessment (BIA) "prior to any decision affecting the child"[10].

- Overview of the age assessment tools and methods in use. Generally, a "multidisciplinary and holistic approach" is encouraged that takes into account physical, psychological, developmental, environmental and cultural factors[11]. The "Practical Guide" then lists all currently known medical and non-medical methods with a discussion of pros and cons. For all the methods, EASO has also compiled a detailed overview on which methodological aspect is applied in each Member State. The "Practical Guide" does not rule out any of the methods (except of sexual maturation observation and estimations based on physical appearance) but lists a number of criteria that should be considered when deciding on the selection of a method.

In summary, for age assessment, EASO suggests to follow the gradual approach as depicted in Figure 2, besides the implementation of proper safeguards. In case of doubt about the age, assessment should start with non-medical methods, then apply first radiation-free medical methods, before, as a "last resort", contemplating the use of any methods involving the use of radiation. In addition, the final result shall be challengeable according to the rules set out in the Asylum Procedures Directive.

## 1.3 Overview of methods

This section will very briefly summarise the methods described comprehensively in the EASO "Practical Guide" [2], following the classification given there,[12] namely non-medical methods and medical methods (the latter either with or without potentially harmful radiation). With respect to medical methods, subject of this report, a first identification of additional risks will be done, in accordance with the findings of [2]. Non-medical methods are listed only for the sake of completeness.

### 1.3.1 Non-medical methods

| Method | Characteristics | Risks |
|---|---|---|
| Further assessment of evidence | Analysis of documents that, even without containing the age, can provide some information on the estimative age of the applicant. | Lack of common understanding on what type of documents can be accepted or not |
| Age assessment interview | An interviewer attempts to reconstruct a chronological sequence of life events out which the age can be indirectly deducted. | Can reveal special needs but tends to be subjective with potential wide margin of error. |
| Psychosocial assessment | An interviewer attempts to assess the mental rather than physical maturity. | Besides wide margin of error, it may be psychologically intrusive if the person has to recall traumatic events. |

All the listed methods strongly depend on the opinion of the experts involved in conducting the interviews, with criteria developed individually by the concerned authorities.

[10] "Practical Guide" [2], p. 21
[11] "Practical Guide" [2], Chapter 3
[12] "Practical Guide" [2], Chapter 4

### 1.3.2 Medical methods

Medical methods are usually based on so-called age markers (to be explained in next chapter). The relevant information can be obtained by simple visual observation or by medical imagining techniques like X-rays or others. Because of its potential health implications, a distinction is made in the EASO handbook between "radiation free" techniques (i.e. without potentially harmful radiation) and those involving radiation.

***"Radiation free" methods[13]***

| **Method** | **Characteristics** | **Risks** |
|---|---|---|
| Ultrasound | Usage of medical sonography to observe age markers | Ruled out by EASO because of deficiencies in the identification of phases with reasonable precision. |
| Dental observation | Visual inspection of the maturity of teeth (without X-rays) | Even though tooth mineralisation is not affected by ethnicity or nutrition, it can only confirm that the specific case follows the average or not |
| Magnetic resonance imaging (MRI) | Observation of age markers through a technique based on strong magnetic fields, electric field gradients and radio waves | Though observation of age markers is good and does not involve harmful radiation, relevant devices remain expensive and the imaging processes can be long. |
| Physical development assessment | Comparison of height, weight and skin[14] rating in relation to a set of reference values. It includes also the option of sexual maturation observation. | Very inaccurate and in case of sexual maturation observation also in stark contrast to ethical aspects (requires nudity or the examination of genitalia), thus ruled out by EASO |

***Radiation methods[15]***

| **Method** | **Characteristics** | **Risks** |
|---|---|---|
| X-ray | Observation of various age markers by X-ray technique | Health and ethical issues about the usage of potentially harmful radiation for migration control purposes only. |
| Computed Tomography (CT) | Observation of age markers by computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional images | Similar to X-rays, but with higher radiation exposure on average. |

[13] "Radiation free" in the sense of the EASO "Practical Guide" [2]
[14] Not with respect to skin colour; see also [22]
[15] Category in the sense of the EASO "Practical Guide" [2], meaning involving potentially harmful radiation. See also section 2.5.2.

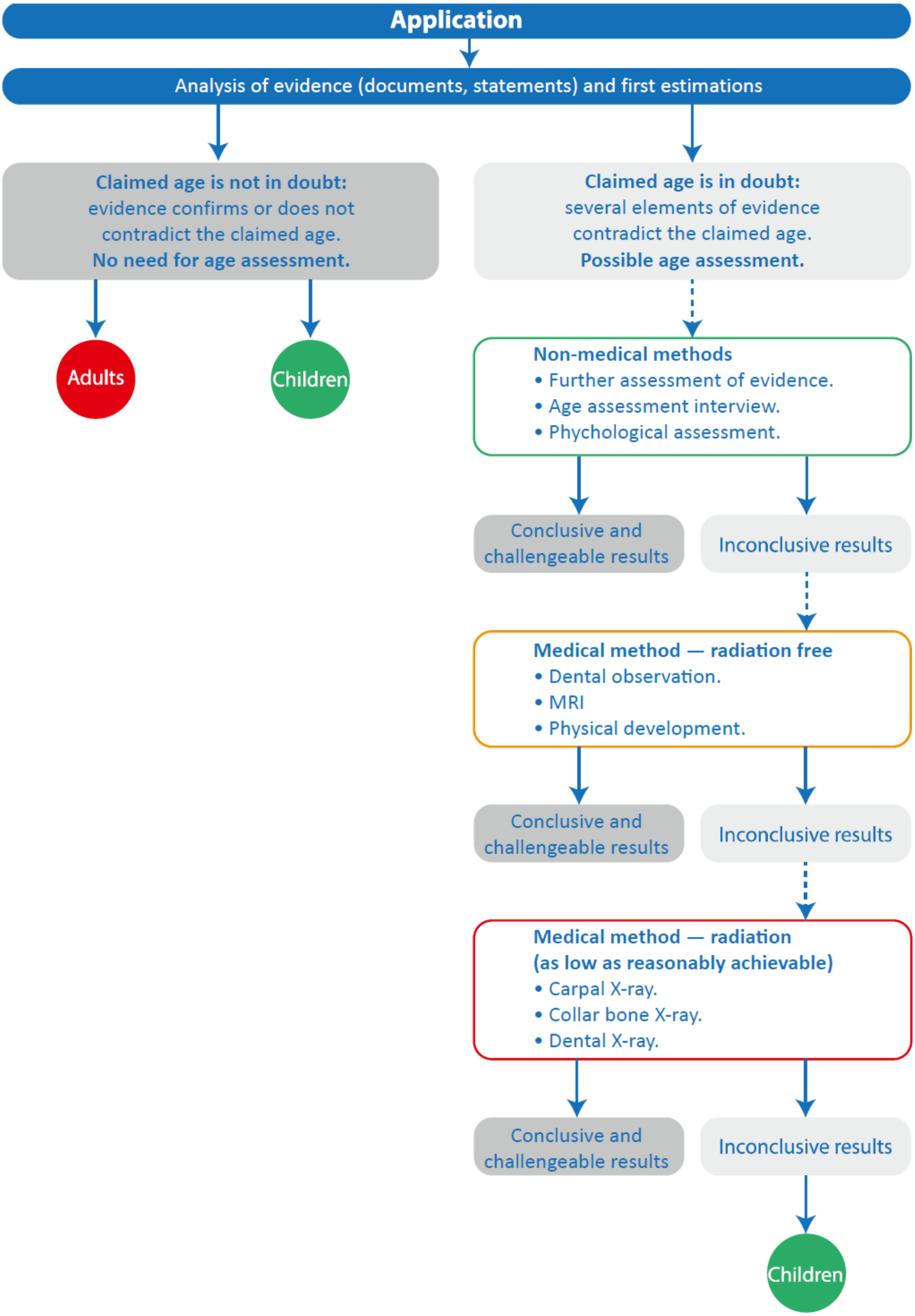



*Figure 2: EASO Flowchart of the methods for the gradual implementation of age assessment*[16]

[16] Source: EASO "Practical Guide" [2], p. 44

On the basis of this first overview on methods, two further risks (on top of the ones mentioned in section 1.2) can be identified for persons undergoing medical age assessment: the risk of potentially inhuman or degrading practices (like sexual maturity observation); and the potential health risk of radiation exposure. Whilst the risk of inhuman or degrading practice can also occur for non-medical methods, radiation risks can come only through medical examinations.

**Risk 3 (Age Assessment in general):**

**The person undergoing age assessment could experience inhuman or degrading practices.**

**Risk 4 (Medical Age Assessment):**

**Radiation could be harmful for the person undergoing age assessment**

## 1.4 JRC's Investigation on Age Assessment

As part of the Commission's Action Plan on Unaccompanied Minors,[17] the JRC organised on 22-23 June 2017 in Ispra (Italy) a dedicated workshop on Age Assessment. Particular focus was on medical age assessment (MAA). The workshop was structured into:

- Identification of the legal, technical and ethical constraints regarding age assessment of children in migration
- Expert briefing on medical age assessment
- Identification of research gaps or missing technical elements for the improvement of current best practices in age assessment

The workshop delivered valuable insights and conclusions across all these areas, but the present report summarises only the relevant findings (and results of further investigations) on **age marker-based age assessment**.

In particular, the report will address the associated risks of medical age assessment on any person that undergoes this procedure as already mentioned in sections 1.2 and 1.3 as summarised in Table 1.

The next chapters will show that the associated risks depend strongly on a comprehensive understanding of the reasoning behind age markers and the closure of certain knowledge gaps.

| | |
|---|---|
| **Risk 1** | A child could be falsely assessed as being an adult. |
| **Risk 2** | The indicative age assigned to a child could be too high. |
| **Risk 3** | The person undergoing age assessment could experience inhuman or degrading practices. |
| **Risk 4** | Radiation could be harmful for the person undergoing age assessment. |

*Table 1: Risks of Medical Age Assessments to Children*

[17] COM(2010)213 final

# 2 Age Markers Based Age Assessment

## 2.1 The rationale behind age markers

Age markers (sometimes also called ageing markers) are physiological aspects (like a bone or a tooth) that run through phases that are distinguishable from each other and where each phase is linked to a specific period of chronological age.

Figure 3 shows as an example the main phases of clavicle bone ossification in which a small piece of bone fuses with a neighbouring bone (upper row: schematic view, lower row: real images). In phase 1, the smaller bone does not exist yet. Phase 2 shows the appearance of the smaller bone, phase 3 sees them fused together (but still distinguishable). In phase 4, the two bones are merged, with only the seam visible. Finally, in phase 5 the two bones have merged into one, seamless bone.

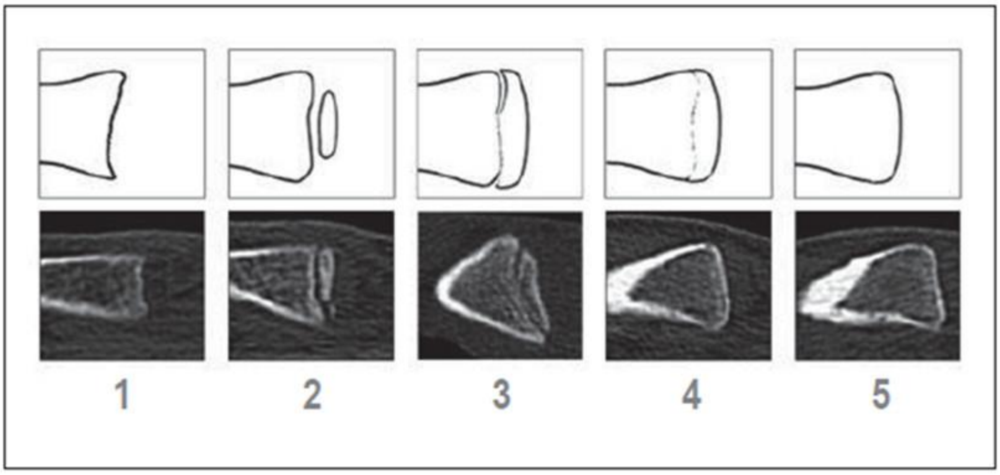



*Figure 3: Main phases of clavicle ossification*[18]

Each phase is associated with a certain period of chronological age as schematically depicted in Figure 4. Thus, any attempt to assign a precise age (e.g. "16,4 years") to any of these phases would not make sense at all.

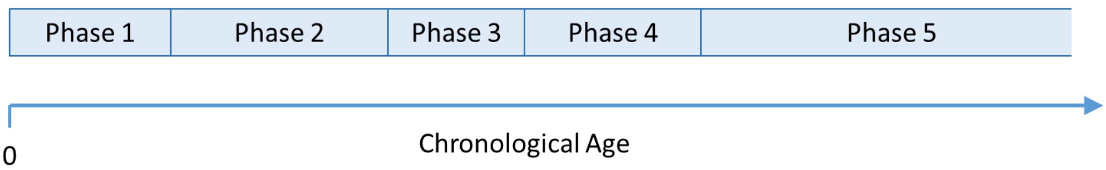



*Figure 4: Schematic composition of an age marker in phases of chronological age*[19]

Moreover, the start and end of each phase are not exactly the same for each human in terms of chronologogical age. It may be dependent on factors like gender, ethnicity or nutrition. Only a selected series of observations exist that provide data about the respective range of chronological age for each phase. Consequently, available data for a particular phase may overlap with data for preceding or succeeding phases as depicted in Figure 5.

[18] Source: Dtsch Arztebl Int 113: 44-50
[19] Sketch only illustrates principle and does not reflect the real phase periods.

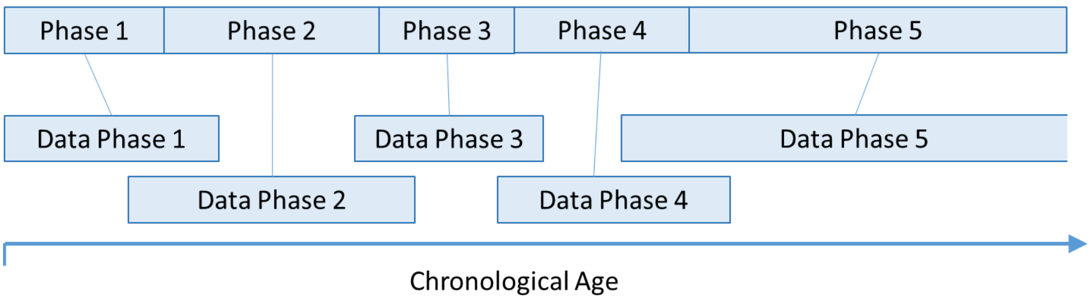



*Figure 5: Phases of age markers and available data*

There are a number of known issues (or risk factors) with this approach that may affect the responsible handling of age markers in view of its accuracy (i.e. Risks 1 and 2):

| **Issue/Risk Factor** | **Consequence** |
|---|---|
| Phase Identification: There is continuous transit from one phase to the next phase. Where exactly does one phase end and the next start? | It requires comprehensive experience to assign an observed image to a particular phase [30], [35]. There are attempts to use automatic techniques (pattern recognition) but this is still in its infancy [31], [48]. It is clear from the above that a false link would allow for wrong conclusions. |
| Assignment of "average values" ("most likely age"): Due to significant lengths of phases (also seen as the "inaccuracy" of this method), the assignment of any average value of chronological age seems obvious and is used in practice. However, it makes little sense as long as the probability distribution (describing the distribution of sample values) is unknown. | If the phase overlaps the critical age around 18 and the average is above 18, the margin of error would not be used in favour of the person in question. Thus, the usage of average values should be avoided, or at least the full age period be reported. If at all, "most likely values" for minimum and maximum age per phase should be reported. |
| Number of defined phases versus accuracy: The phases may be potentially divided into sub-phases with smaller duration, provided each sub-phase has a clear characteristic that can be distinguished from other sub-phases (see Figure 9 on page 17 as an example).The more distinguishable phases exist for a certain age marker, the smaller the width of the corresponding age intervals (i.e. the difference between maximum and minimum age). | If the intervals are small, corresponding age predictions gets more precise. However, the more such phases exist, the greater the difficulty in distinguishing them with neighbouring phases (Figure 6). |
| Outliers: It cannot be excluded that persons exist that have a chronological age outside the range of currently observed data for a particular phase (see the box "Statistics of Age Markers" on page 14). | The quantification of the likelihood of such cases has not been intensively studied in scientific literature. The likelihood decreases with the number of samples already acquired but to what extent needs to be elaborated. |

| Issue/Risk Factor | Consequence |
|---|---|
| Abnormalities: The considerations and conclusions above belong to the observation of persons with no particular health peculiarities. However, there exist also a number of persons where the development of the relevant physical aspects are affected by certain abnormalities. Such abnormalities can lead to bone formations that differ significantly from the reference images. | Any abnormality needs to be recognised. This requires comprehensive knowledge of the involved experts about these abnormalities. In the presence of an abnormality, age marker-based age assessment cannot be applied. |

*Table 2: Risk factors of age markers*

Thus, the most accurate statement about the age of a person (in the absence of any physical abnormality) who has been assigned to a certain age marker's phase is:

**The person's true chronological age lies most likely between the minimum and maximum[20] age reported for that phase.**

This statement seems weak at first glance, in particular if the relevant length of the phase is large (e.g. 4 years or more). However, the significance of medical age assessment unfolds its potential in the combination of more than one age markers (see section 2.4).

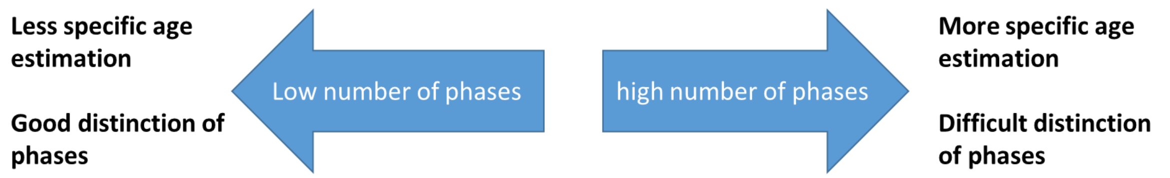



*Figure 6: Relation between number of phases and accuracy*

## 2.2 Important types of age markers

### 2.2.1 Wrist and hand bone

This age marker consists of the evaluation of the form and size of bone elements as well as the degree of epiphyseal ossification (see examples in Figure 7). Evaluation is done by either comparing against a radiographic atlas (most prominently the one of Greulich and Pyle from 1959 [23]) or at individual bone level according to the Tanner-Whitehouse approach [24].

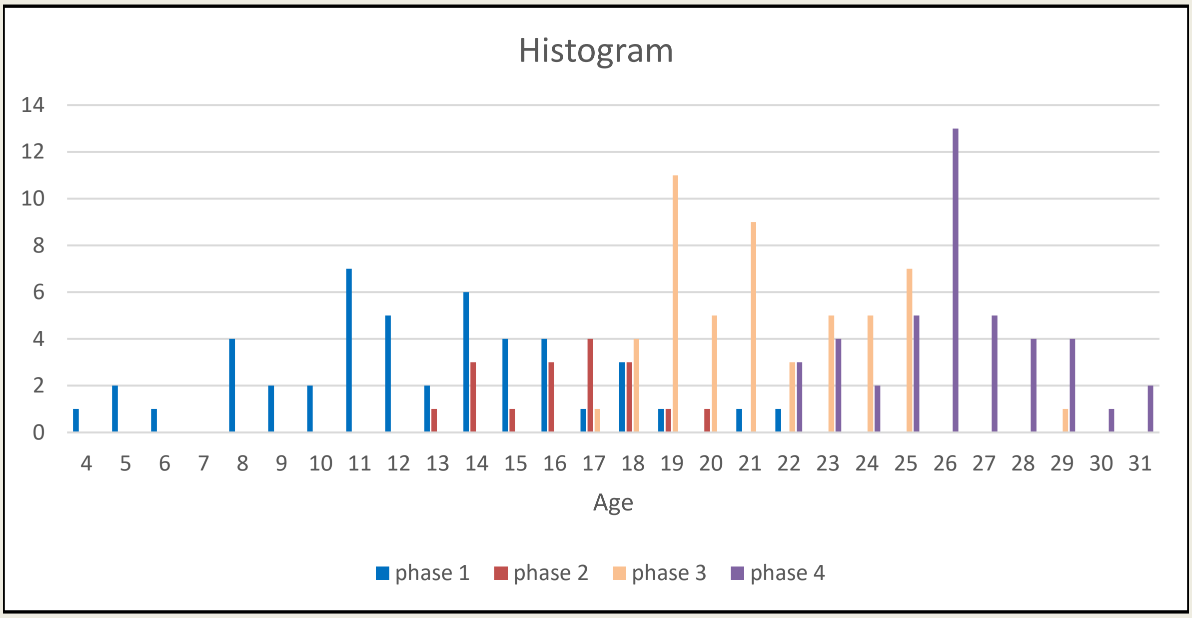
The Greulich and Pyle atlas distinguishes 31 images of males and 27 images of females. Each image is considered as an individual phase. For each of these phases, a number of studies have investigated the corresponding age distribution. Figure 8 [39] illustrates the distribution of data for individual phases that various studies have revealed in terms of box plots (males only). [21] The thick bar for each phase denotes the median of available data (i.e. 50% above that value, 50% below).

[20] In case the phase is the final one for the age marker in question, a maximum value is not defined. However, also for earlier phases the observed maximum values can be fairly beyond the values of later phases.

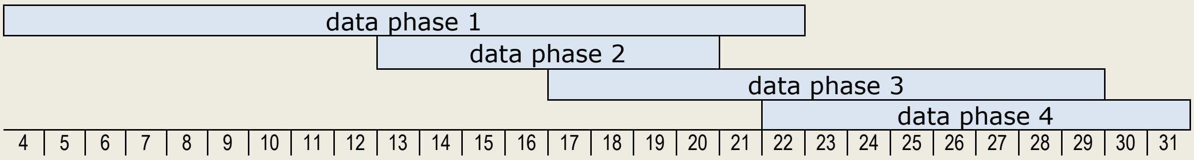
[21] See https://en.wikipedia.org/wiki/Box_plot

**Statistics of age markers: an illustrative example**

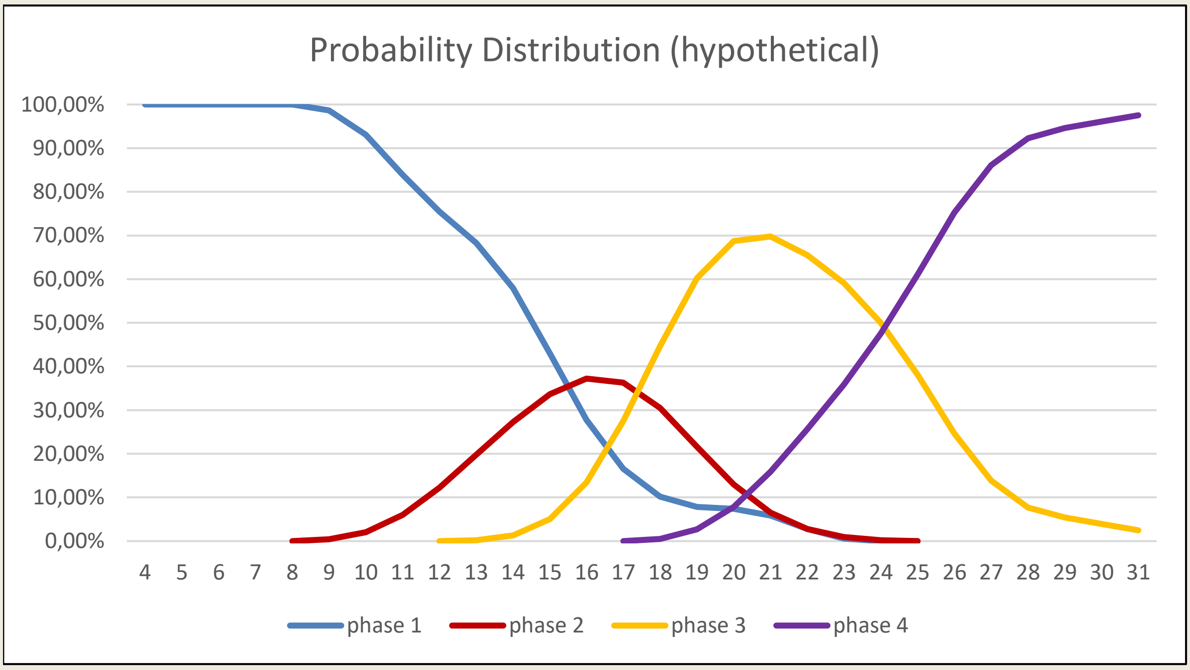
The example is taken from Butting [6]. It concerns the medial clavicular epiphysis (section 2.2.2) for which 4 phases were distinguished (details omitted here). The following histogram reflects the observation of these 4 phases at 158 male persons aged 4-31 years, with different number of members per age group.




In terms of phases (cf. section 2.1), this gives overlapping data for each phase:

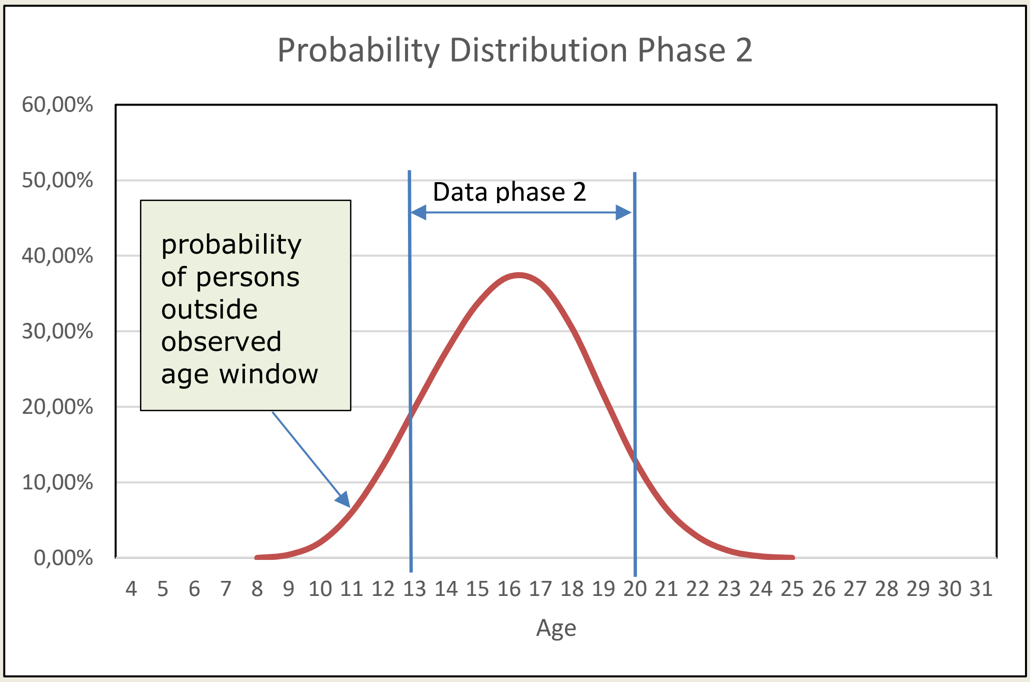



From the histogram, an approximation of the (unknown) probability distribution could be derived (here, the approximation has been simply built by applying some iterations on neighboring averages of the observed values, after normalization of age groups to avoid “age mimicry” [38]).



The example shows some typical characteristics of this type of studies:

1. There might be some **cases of doubt**, i.e. cases where the link of the obtained image to the corresponding phase cannot be established without doubt (cf. "Phase Identification" in Table 2). E.g., the author of the study reported about such doubts for two persons of age 21 and 22 that were finally linked to phase 1. Without these two cases, data for phase 1 would end at 19. This is remarkable as another study was mentioned with the same focus, but different group of test persons. That study had the oldest person in phase 1 at age 16.
2. The **probability distribution is not known** even though authors very often assume normal (or Gaussian) distribution without further justification. This leads then to questionable assertions about "confidence intervals" and "confidence levels" as this would require normal distribution. The hypothetical distribution in the example was only done for illustration purposes but does suggest knowledge of the real distribution.
3. The chosen hypothetical probability distribution has much likely led to an exaggeration of the width of the interval where the distribution is non-zero. However, this helps to visualize an important phenomenon as mentioned in Table 2 and depicted below: the **probability that persons exist outside the observed age window ("outliers").**




This probability is very often not zero but can only be quantified precisely if the probability distribution would be known.

In any case, the overall probability outside the chosen age window needs to be **below an acceptable threshold** as this is an important source of criticism against medical age assessment.

Thus, serious application of the chosen example study (or similar ones) for age assessment would suggest to establish:

- *more information about the underlying probability distribution*. A reasonable approximation could be created with further knowledge about bone growth models and other additional elements from medical research;
- *adaptation of the min-max-range* to leave the probability of outliers beyond an acceptable threshold. In the example above, assuming the real distribution as sketched, an interval from 9,5 to 22,5 years would leave the outlier probability roughly below 1%.

The referenced studies suggest that, for example, the minimum value for the last phase in males (31) is 16,1 years, that of the previous one (30) 15,6 years. These limits do not include certain observed outliers (dots in Figure 8). It is therefore impossible to exclude minority for males from the observation of the hand alone.

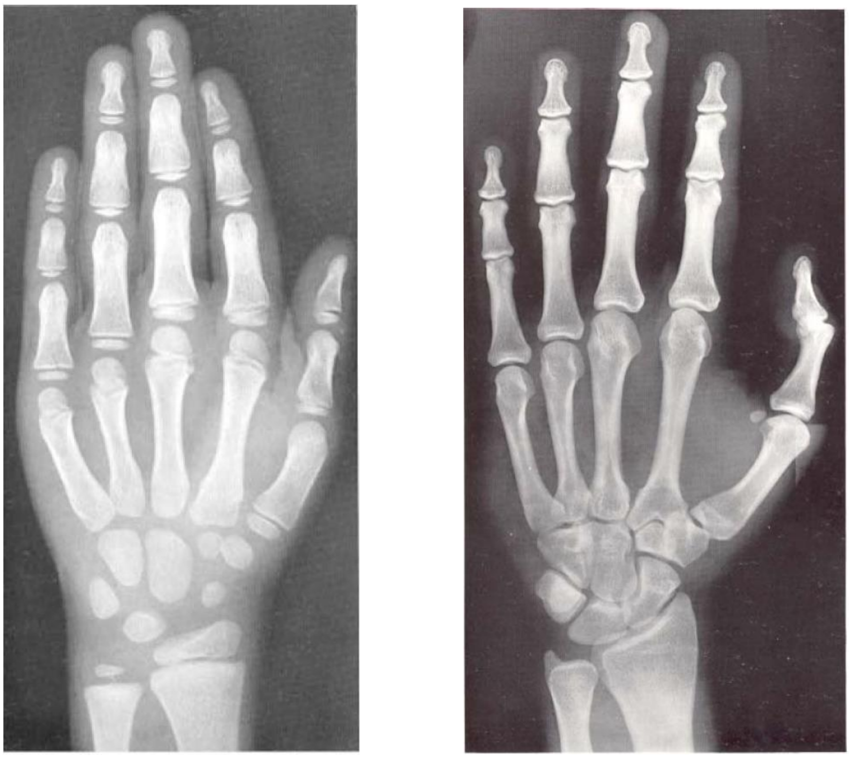


*Figure 7: Two images of hand/wrist bone development (image no. 16 and 31 for males)[22]*

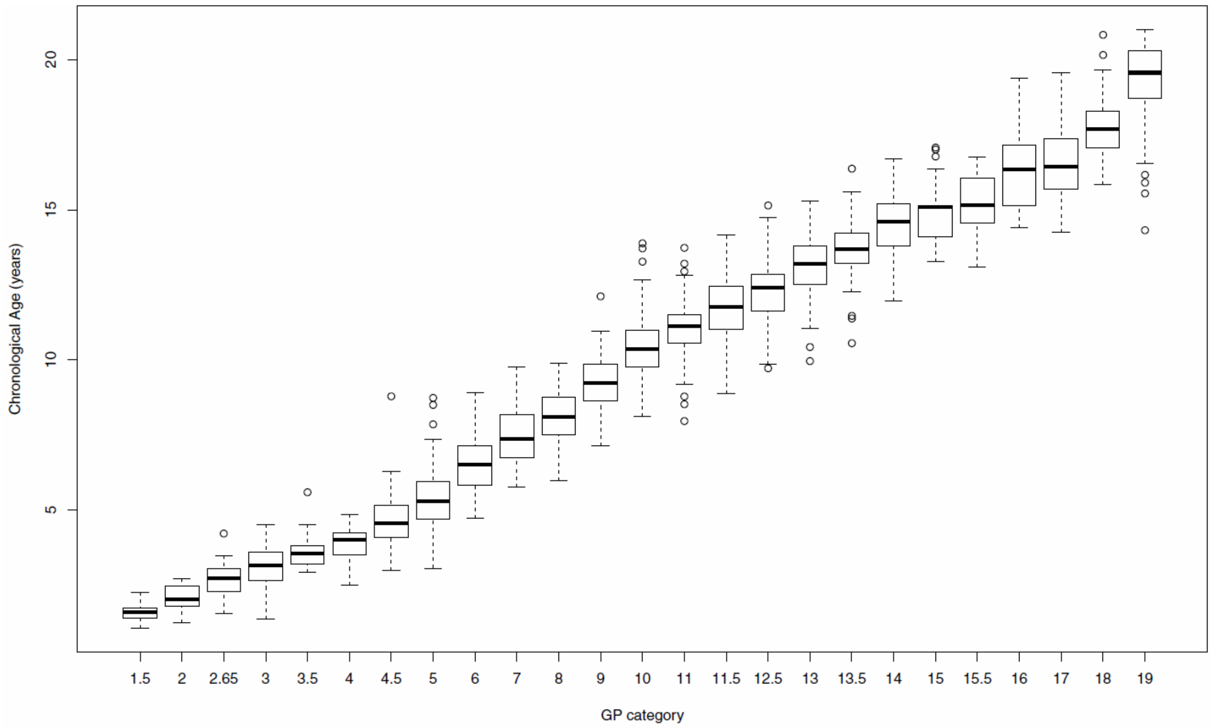



*Figure 8: Age Distribution of Greulich/Pyle categories of various studies (males only)[23]*

[22] Source: [23]
[23] Source: [39]

### 2.2.2 Collar bone

This age marker regards the fusion of the medial clavicle [10],[11],[15]. Figure 3 depicts the main phases of this fusion whilst Figure 9 distinguishes sub-phases for phases 2 and 3. Total fusion with no scar visible was first observed for both gender at the age of 26 at the earliest.

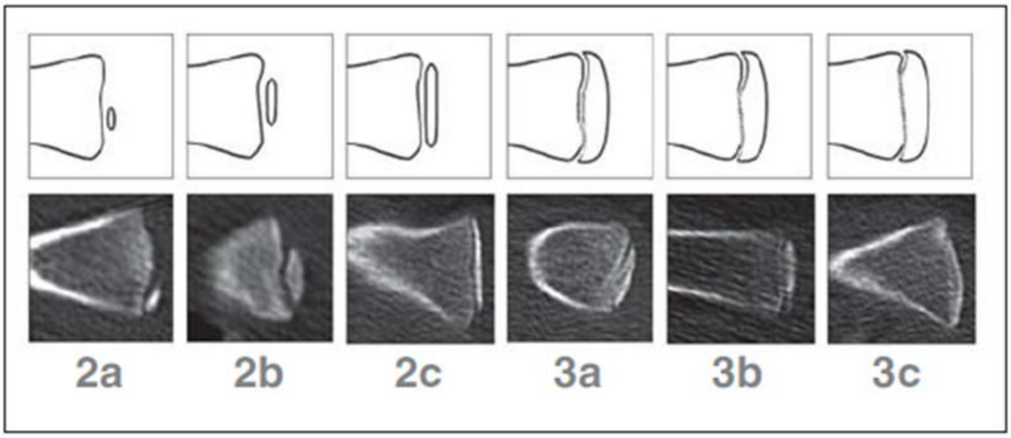



*Figure 9: Sub-phases (of phases 2 and 3) of clavicle ossification*[24]

The following table gives some important ranges for the phases 2a – 3c (Figure 9) for the most interesting adolescence between 15 and 19 years, both for males and females (data is taken from [36]):

| Phase | Males | Females |
|---|---|---|
| 2a | 14,4 – 20,0 years | 13,1 – 18,4 years |
| 2b | 16,1 – 20,4 years | 14,1 – 19,3 years |
| 2c | 17,1 – 20,2 years | 15,6 – 18,3 years |
| 3a[25] | 16,4 – 22,3 years | 16,8 – 23,3 years |
| 3b | 17,6 – 36,5 years | 16,4 – 24,4 years |
| 3c | 19,0 – 30,0 years | 19,4 – 26,5 years |

*Table 3: Age phases for clavicle development in adolescence*

As a consequence of the particular selection of test persons in the referenced study, the observed minimum values for each phase are not strictly increasing. This could suggest that not-yet-observed outliers could exist that have not been identified so far, or that a current minimum value represents an exceptional outlier that needs to be replaced.

### 2.2.3 Third molars

Though the observation may focus on teeth in general (sequential changes in the eruption and structure during childhood growth), mainly mandibular third molars provide relevant indications for the age periods towards 18 years [4],[7],[8],[9],[13],[14]. There

[24] Source: Dtsch Arztebl Int 113: 44-50
[25] Cave substaging can be further distinguished with levels 3aa, 3ab, 3ac

exist various phase classification schemes. The most important one according to Demirjian [18] uses 8 stages (see Figure 10). An additional distinction between retarded and non-retarded eruption of the third molars is made as this has an impact on the start of a phase.

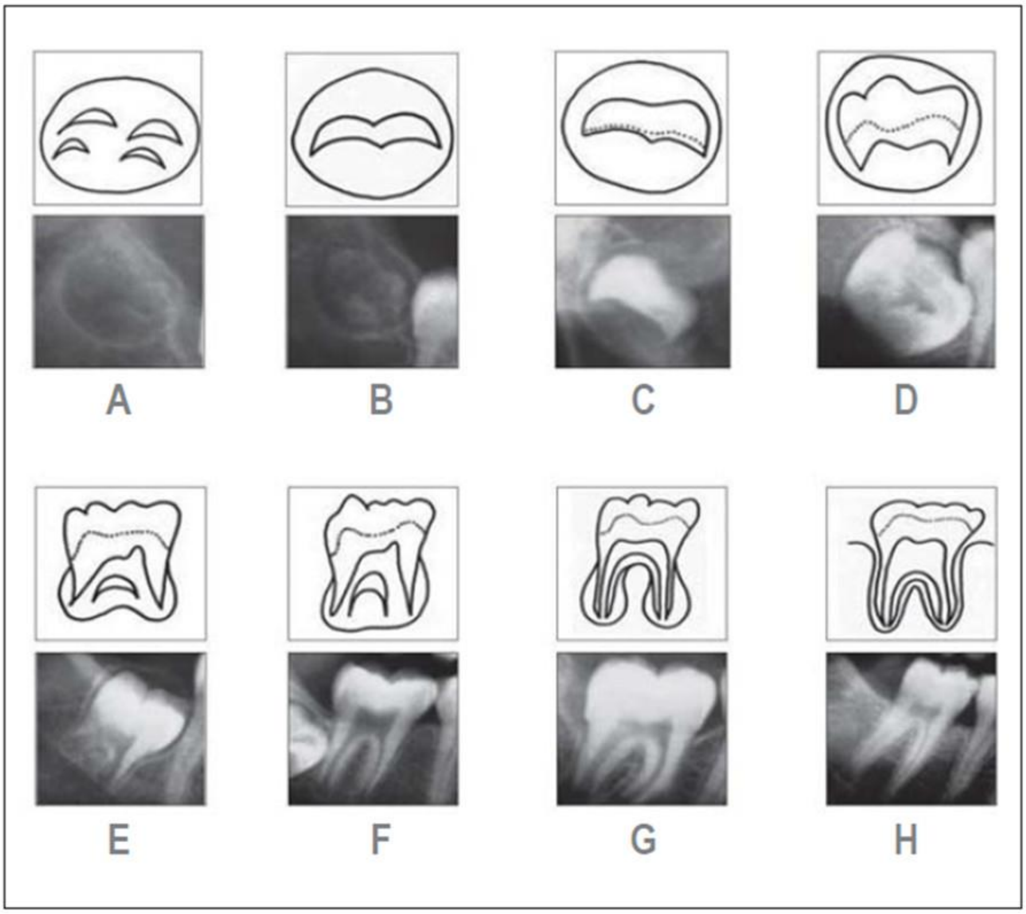



*Figure 10: Mineralisation phases of third molar[26]*

Data on these stages show large differences, regardless of the classification scheme. Values are very often reported as mean values (plus "standard deviation") even though the phase length (for an individual) may last well more than one year. Also, ethnicity plays an important role when a certain phase is reached (see section 2.3).

| Phase | Min age | Max age |
|---|---|---|
| D | 10,29 years | 15,20 years |
| E | 12,14 years | 18,46 years |
| F | 12,83 years | 23,43 years |
| G | 15,77 years | 25,17 years |
| H | 17,38 years | n/a |

*Table 4: Age phases according to Demirjian concerning not impacted mandibular 3rd molars of black male Africans[27]*

[26] Source: Dtsch Arztebl Int 113: 44-50

As an example on available data, Table 4 displays results of a study on 437 black male Africans [14], aged 10-26 years. According to these results, minority cannot even be excluded from the final stage H. On the contrary, only stage D would safely exclude majority.

### 2.2.4 Knee

The considered age markers are here the epiphyses of the knee joint (see Figure 11) that involves three bones: femur, tibia and fibula. The main reference is an atlas of relevant X-rays published by Pyle and Hoerr [26] that has been gradually improved over time [27]. There exist a number of approaches to distinguish between phases, including studies that provided the corresponding data. The method is actually more rarely used [2] and thus not further discussed here. The scientific literature also suggests that there is a significant number of cases where the knee joint is complete below the age of 18 for both sexes. Thus, the knee is not sufficient to safely exclude minority.

*Figure 11: Two different phases of epiphysis development*

## 2.3 Impact of ethnicity and nutrition

Whilst gender dependence was always taken into account, the impact of ethnicity and nutrition appears rarely in studies. However, there are also comparative studies that concentrate exactly on the impact of ethnicity and nutrition [40].

For example, regarding ethnicity, a study from 2008 [17] on hand age markers came to the following conclusion that *"ethnic and racial differences in growth patterns exist at certain ages; (…) the Greulich and Pyle atlas does not recognize this fact.* [28] *Assessment of bone age in children with use of the Greulich and Pyle atlas can be improved by considering the subject's ethnicity."*

[27] Data of non-retarded third molars only [14]
[28] cf. section 2.2.1

Another study from 2002 on teeth development [19] stated that *"when compared to the French-Canadian sample of Demirjian [18], Brazilian males and females were 0,681 years and 0,616 years, respectively, more advanced in dental maturity."* Similar studies exist as well.

However, there are indications that the problem of ethnicity is mainly limited to teeth development. Already in 2000, a relevant study [46] concluded that, *"(t)ime-related differences in passing through these stages of skeletal maturation were obviously not affected by ethnicity in the relevant age group. (…) The rate of ossification is primarily affected by the socio-economic development of the population concerned."* In other words, statistical correlation of bone development with ethnicity could have been confused with socio-economic status. **Thus, scientific studies on age markers should be reviewed with a focus on resolving that confusion before any indiscriminate use.**

With respect to nutrition, the relevant potential impact can be twofold: First, the physical development could be delayed in case of malnutrition. Second, the tooth development (relevant for third molar assessment as explained in section 2.2.3) could be influenced by certain type of nutrition. Regarding malnutrition, the impact is less critical for age estimation. As physical development would be delayed, the estimated age would be at most an underestimation of the chronological age (e.g. a malnourished child of chronological age 14 would normally result younger in terms of its estimated age).

Regarding the impact of nutrition on tooth development, Timme et al. [45] have noted that certain habits in the choice of food and in dental care can have a significant influence on the chronological development of the third molars age markers.

## 2.4 Combining age markers

Different age markers (and their phases) cover different parts of the age scale. A particular age marker may therefore not deliver a useful result to decide whether a person's chronological age is below or above a certain threshold. For that reason, the usage of more than one age marker has become a wide-spread practice.

Figure 12 below illustrates how multiple age markers can be used in a reasonable way. Suppose we have 2 age markers. The acquired medical images of the person in question relate to individual phases, denoted as "data marker 1" and "data marker 2". These are the age windows for the relevant phases as depicted in Figure 5.

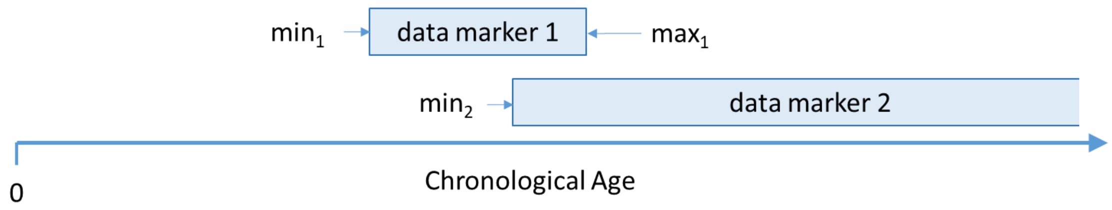



*Figure 12: Combination of two age markers*

$min_1$ and $max_1$ denotes the minimum and maximum, resp., of the data for age marker 1, $min_2$ the minimum value of the data for age marker 2 (that does not have an upper limit). From a purely logical point of view, the person must be at least as old as $min_2$ because younger ages have not been observed for that phase of age marker 2. On the other hand, the person cannot be older than $max_1$ because there was no observation of an older person for the relevant phase of age marker 1. Thus, in the simple example of Figure 12, we would gain an age interval for the estimation of the chronological age between $min_2$ and $max_1$.

This approach can be easily generalised to any number of age markers: **always take the largest minimum value of all observed age windows as the estimation of**

**Minimum Age; always take the lowest maximum value of all observed age windows as the estimation for the Maximum Age.**

**Only in case Maximum Age < 18, majority can be excluded.**

**Only in case Minimum Age > 18, minority can be excluded.**

In all other cases, no specific conclusion about minority or majority can be drawn. **If the "benefit of doubt" is applied, this must result in assuming minority.**

## 2.5 Ethical and health implications of using age markers

As said earlier, the focus of this report is on the scientific feasibility of age marker-based conclusions. However, this section will summarise various considerations that can help to understand more-in-depth the ethical and health issues involved in this type of age assessment.

### 2.5.1 Ethical issues

Ethical issues related to age assessment, and in particular medical age assessment, have been intensively discussed in the past [34]. For example, the "Advocacy and Ethics Group" of the European Academy of Paediatrics announced in 2015 [16]:

> *The European Academy of Paediatrics strongly recommends all paediatricians in Europe not to participate in the process of age determinations in minor asylum seekers stating they are minors. It also recommends all paediatricians to convey this opinion to all other physicians. All physicians should let the representatives in their countries know that they oppose the Asylum Procedures Directive (2005/85/EC) according to which the member states may use medical examinations to determine age in relation to the procedure of an asylum application.*

Similar recommendations exist from other medical associations in Europe. These are mainly based on the argument that persons undergoing an age assessment are not patients. Interventions of medical doctors may be seen as conflicting with the Hippocratic Oath.

It is therefore interesting to see what experts in medical ethics have elaborated on this subject. The following conclusions on the ethical aspects of age assessment have been derived by a Swedish research group, led by Prof. Lars Sandman. The study was funded by the Swedish Agency for Public Health and Social Affairs (Socialstyrelse), triggered by plans to use examination of the knee and the third molars as age markers[29] (cf. section 2.2). The following main conclusions are cited from [28] (an extended conclusion can also be found in [41]):[30]

- *Given there are age limits in the migration legislation, it can be considered reasonable to use age assessments to fulfil demands for equality and rule of law. It should be as accurate as possible and medical age assessments seems to fulfil this the best.*
- *Particular attention needs to be put on an emerging culture of distrust, i.e. a general suspicion against the claims of asylum seekers within all services involved in age assessment.*
- *It is not compliant with the principles of non-discrimination and legal certainty that the concerned services tend to use their own intuitive age assessment. This allows for arbitrariness by the authorities.*
- *Socialstyrelse's proposal to examine the knee cannot be considered as a violation of a person's physical integrity. However, as integrity has different cultural and religious definitions, one has to consider each case individually.*

[29] https://www.migrationsverket.se/English/Private-individuals/Protection-and-asylum-in-Sweden/Children-seeking-asylum/Without-parents/Application-for-asylum/Age-assessment.html

[30] The cited conclusions do not necessarily reflect the opinion of the authors of the present report.

- *If there is insecurity in the assessment, the strong norm about protecting children should rather assess the asylum seeker as the youngest possible age within the range of the assessment.*
- *[Resistance of professionals involved in age assessment] can be acceptable if focused on questioning the evidence-base. Otherwise, the support for this seems weaker.*

In summary, the Swedish experts concluded that medical age assessment could prevent arbitrariness, provided its implementation respects a sufficient level of proportionality. The usage of knee and wisdom teeth X-rays was balanced against potential arbitrariness in using other means. Still, there was no final conclusion addressing the remaining ethical concerns of the medical doctors involved.

Even though the assessment of the Swedish case cannot be generalized to other applications of medical age assessment, it suggests that it is worth assessing the ethical issues on a case-by-case basis The Socialstyrelsen example illustrates that the introduction of particular principles or aspects in the entire process leading to age estimation could successfully balance concerns. In this decision process, human rights standards, including relevant rulings of the European Court of Human Rights (ECHR) can be an important reference, even though the ECHR has not yet given explicit guidance as to age assessment procedures and their impact on fundamental rights.[31]

### 2.5.2 Health issues

The only real health issue related to medical age assessment is the exposure to X-Rays. Other imaging techniques (ultrasound, magnetic resonance) are not considered equally critical as ionizing radiation. On the other hand, X-ray images are most widely used in the analysis of age markers, mainly due to their cost efficiency, the broad availability of relevant devices and the large amount of reference material based upon them.

With respect to the associated risks of X-Rays, one needs to refer to EU Directive 2013/59 (Euratom) with regard to radiation hazard. There, due justification for any non-medical application of X-rays is required. In its Annex V on the "indicative list of practices involving non-medical imaging exposure, "Radiological Age Assessment" appears as one of these practices[32].

Radiation itself is measured in units of Sievert (Sv) and provides an indication on the health effect of low levels of ionizing radiation on the human body. To give an idea about the amount of radiation for various exposures, the following list has been extracted from various sources:

| | |
|---|---|
| X-ray of hand | 0,1 μSv[33] |
| X-ray of other limbs | 10-100 μSv |
| One set of dental radiograph | 5-30 μSv |
| CT of sternoclavicular joints [34], [47] | 400-800 μSv |
| Annual dose for flight attendants | 1500-1700 μSv |
| Natural radiation at earth level (annual exposure) | 1000-5000 μSv |
| Annual allowed dose for workers in nuclear facility [37] | 50000 μSv |

[31] See, for example, Darboe and Camara v Italy (Appl.no.5797/17) - Third Party Intervention: The AIRE Centre, Dutch Council for Refugees and ECRE 5 July 2017, para 9, available at: http://www.asylumlawdatabase.eu/sites/www.asylumlawdatabase.eu/files/aldfiles/Darboe%20Camara%205072017%20final%20INTERVENTION%20ONLY%20as%20sent.pdf
Further references to pending cases before the UN Committee on the Rights of the Child can also be found here:
https://www.ohchr.org/Documents/HRBodies/CRC/TablePendingCases.pdf

[32] Obviously, the Directive does not use the same terminology as in this report where the term "medical age assessment" includes the usage of X-rays. The Directive groups "radiological age assessment" under "non-medical" applications because it would not be used for medical diagnostics or therapeutical purposes.

[33] 1 μSv = 0,000001 Sv (one millionth Sievert)

Similar to the considerations of section 2.5.1, the criticality of any X-ray exposure needs to be evaluated case by case. However, the list above suggests that in particular computed tomography (CT) entails a level of exposure that is already in the order of magnitude of half the annual exposure to (unavoidable) natural radiation. In contrast, imaging processes for hand, knee and third molars involve radiation of up to twice the amount of a daily dose of natural radiation.

With respect to radiation hazard in general, the International Commission of Radiological Protection (ICRP) has published in 2007 the essential reference document [37]. According to it, *"the assumption (is) that at doses below about 100 mSv[34] a given increment in dose will produce a directly proportionate increment in the probability of incurring cancer or heritable effects attributable to radiation. This dose-response model is generally known as 'linear-non-threshold'".* In other words, the risk of cancer or other harmful impact on human DNA as a consequence of radiation is assumed to grow linearly with dose, with no "safe threshold value". However, the ICPR also stated that it is unlikely to expect relevant studies to underpin this hypothesis. Moreover, *"because of this uncertainty on health effects at low doses, the (ICPR) judges that it is not appropriate, for the purposes of public health planning, to calculate the hypothetical number of cases of cancer or heritable disease that might be associated with very small radiation doses received by large numbers of people over very long periods of time"* [37].

Despite the admitted uncertainty, this statement of the ICPR (including the complete lack of "safe thresholds") has led many to the conclusion to better avoid any exposure to X-Rays. Nevertheless, the existence of natural radiation at significant order of magnitude suggests that risks associated to the radiation cannot be brought to zero. Rather, risk needs to be seen in its relation with other aspects involved. For the estimation of risk, the ICPR provides a quantification of 5% per Sievert as the approximated overall fatal risk coefficient [37]. According to this coefficient, the risk of radiation-caused death would increase by 0,004% for a CT of clavicle at 800 µSv. The risk can be halved with modern CTs at 400 µSv.

These probabilities do not reflect an individual risk. A more correct statement about these reference values would be: Consider two (large) groups of persons. The first group would, person by person, undergo a CT of clavicle, but no one of the second group. Then, one could observe, after several years, a 0,004% (or 0,002%, resp.) higher number of radiation-caused death in the first group compared to the second group. This equals to 1 out 25000 (or 50000, resp.), an estimate that was approximately confirmed by a US study conducted in 2009 on real patients data of CT examinations [42].[35]

Nevertheless, these figures have to be treated with care for a number of reasons. For example, they do not distinguish between the parts of the body that are actually examined.

The uncertainty about the real risk of X-Ray exposure has already motivated a number of studies to explore alternative imaging concepts, with **Magnetic Resonance Imaging (MRI) being the most promising alternative** [32]. Still, the level of available reference material for MRI, in particular reference images, is far below the one for computed tomography imaging and this limits its usefulness for age-assessment at present. Furthermore, whilst capturing of a clavicle CT takes some seconds, an alternative MRI takes some minutes in which the person needs to remain stock-still. If there was too much movement, the MRI has to be completely redone. Thus, MRI can be more stressful than CT.

On the other hand, radiation risk of CT imaging for age diagnostics can be further reduced as explained in the next section.

[34] Equals 100000 µSv (one hundred thousand micro Sievert)

[35] The study revealed, among others, the probability of 1 out of 7350 male patients to develop cancer when exposed at age 20 to a CT of head at 3 mSv. This dose is roughly 3,75 times the amount of a CT of clavicle. 3,75 x 7350 ≈ 27500

## 2.6 Managing risks in medical age assessment

Following the discussion about the principles of age marker-based age assessment and the corresponding issues, Table 5 summarises some first conclusions about the associated risks as listed in Table 1. Risk 1 and 2 can be addressed in the same way as they share the same risk factors.

Table 5 also gives for each risk factor a level of "criticality" that should describe the potential impact, ranging from "low" to "high":

| | |
|---|---|
| "low" | the factor may have at most a limited influence on the associated risk |
| "medium" | the factor has a significant impact but is likely to be addressed properly |
| "high" | the factor requires particular attention because it has high impact and is likely to be underestimated. |

| Risk | Risk Factors | Criticality | Proposed risk handling |
|---|---|---|---|
| **Risk 1:** A child could be falsely assessed as being an adult.<br>**Risk 2:** The indicative age assigned to a child could be too high. | Wrong identification of the particular phase of an age marker (Table 2). | High | • Only appropriately trained experts should do the assignment of phases.<br>• At least two experts should do an independent assessment; in case of disagreement, a third one should be involved.<br>• In case of doubt which of the two phases should be assigned, the earlier one should be chosen |
| | Usage of average values within the observed time period of a phase (Table 2). | High | • Use of averages should not be allowed; generally, the understanding of medical age assessment as a classification problem needs to be revised<br>• Minimum and maximum values of observed age periods should be used instead. |
| | Inappropriate definition of distinguishable phases (Table 2, Figure 6) | low | Phase length (in particular that of sub-stages) should be carefully revisited in order to find a good balance between proper recognition and significance. |
| | Outliers could exist that have not been observed so far (Table 2). | Medium | • Review of sample size of relevant studies, including its statistical foundation.<br>• Review to what extent ethnical differences have been taken into account. |
| | Abnormal physical development could prevent proper age marker-based conclusions (Table 2). | Medium | Abnormal developments need to be documented and be part of the training of experts |

| Risk | Risk Factors | Criticality | Proposed risk handling |
|---|---|---|---|
| **Risk 3:** The person undergoing age assessment could experience inhuman and degrading practices. | As far as age marker based assessment is concerned, "humiliation" refers to the question of ethical proportionality in the case of migration related assessment (section 2.5.1). | medium | Relevant human rights standards, including case law from the European Court of Human Rights, need to respected and taken into account at all stages of an age assessment procedure, especially when deciding on the way medical age assessments are implemented and applied. In any case, the examination process must be done under full respect of the person's dignity. |
| **Risk 4:** Radiation could be harmful for the person undergoing age assessment. | While X-rays of hand and teeth imply only low radiation, computed tomography scans of clavicle create significant radiation (section 2.5.2). | low to medium | • Assessment should start with hand and teeth where radiation is low. Only if these markers do not provide the necessary clarity (or they suggest majority), markers involving computed tomography should be considered.<br>• More studies should be conducted with MRI instead of computed tomography in order to increase the available knowledge base |

*Table 5: Medical Age Assessment Risk Management*

# 3 Towards a Child-Safe Age Markers Assessment Scheme

According to the discussion in chapter 2, in particular the discussion on how to best control risk in section 2.6, there is a responsible way to use age markers for the estimation of a person's chronological age, implemented in an ethical and least unambiguous way. Furthermore, and most importantly, the risk of a child being falsely considered as an adult can be reasonably minimized.

In the following, an age markers-based approach is outlined that is founded on four pillars:

- The establishment of a comprehensive, scientifically sound and agreed **catalogue of age markers** that is also regularly updated. This catalogue would provide for each age marker the reference images of its individual phases and the corresponding statistics about observed ages in those phases. Without such a common reference, each expert involved in medical age assessment would use an individual selection of references from scientific literature. This could possibly lead to different assessments of the same case.
- The development of an **Age Marker Assessment Protocol** that describes how from a set of images on the status of the age markers a decision shall be inferred about the minimum and maximum age of the person, in particular whether minority or majority can be excluded without reasonable doubt. The existence of the protocol would guarantee that decisions are obtained following exactly the same rationale.
- The establishment of **Age Marker Training** capabilities in order to systematically disseminate the knowledge on age markers and qualify suitable experts.
- Optionally, a centralized **Age Marker Diagnostics Centre** that hosts a number of permanently available experts in age diagnostics of juveniles. Such a centre would first, guarantee full availability of the relevant expertise across Europe and, second, would save costs for the participating Member States. Furthermore, uniform treatment of all cases is facilitated if the same group of experts is involved in performing the assessments.

With the establishment of the mentioned pillars, medical age assessment could be made available to all Member States while at the same time guaranteeing its uniform application.

## 3.1 Catalogue of Age Markers

The current knowledge about age markers is spread over a large number of scientific publications, with their different focus and reference population. This makes it difficult even for experts to retrieve the necessary information that is needed for individual cases. There is also the risk that existing knowledge is overlooked.

It is therefore advantageous to compile the relevant knowledge and data of these publications into age marker specific catalogues or one catalogue combining all age markers. Such a catalogue would consist of a number of reference images that illustrate the various phases of a marker and the corresponding data on observed age ranges. The catalogue would also include particular information on known abnormalities and other aspects that could complicate the proper assignment of phases. Table 6 summarises all elements of the catalogue that have to be elaborated for each and every age marker to be considered for inclusion.

There is also the need for covering existing data gaps. It could happen that the data available for a certain age marker phase is not sufficient, either with respect to its significance in the sensitive range around the age of 18, or with respect to an unacceptable likelihood of outliers, or with respect to coverage of certain ethnicities. In such cases, additional studies should be initiated to close this data gap. An indicative list of foreseeable studies is provided in Table 7.

| Element | Challenge |
|---|---|
| Selection of age markers and corresponding phases and classification schemes | The first and most important step towards the catalogue would be to decide which age markers are the most useful ones. To that end the existing recommendations of the international and interdisciplinary 'Study Group on Forensic Age Diagnostics' can be utilized (see section 3.3). Then, the selection of the classification scheme has to follow in cases where there are several schemes in use. |
| Visual reference of age marker phases | Collection of images that can serve as unambiguous reference for the identification of each phase (see Figure 13 as an example). Each image must be accompanied by additional explanations on main characteristics and how to best identify these in a given image of the age marker. |
| Collection of data (ages) to age marker phases | The fragmented repository of relevant studies needs to be reviewed and the data fused into one set of data per marker and phase. This requires a detailed analysis of the statistical significance of each study (sample size, population characteristics, ethnicity, ground truth, etc.). The result would be an agreed set of age boundaries for each age marker phase. |
| Accompanying information about the data | The final statistical significance and any restriction must be clearly expressed in the catalogue. This also requires the calculation of the probability that a person could fall outside the set of already observed data. |
| Description and illustration of abnormalities | Any known abnormality needs to be documented with relevant image material. Practitioners must be in a position to identify such abnormalities and to suspend further age marker –based age assessment in such cases. |

*Table 6: Elements of the Age Marker Catalogue*

## 3.2 Age Marker Assessment Protocol

Equally important for the applicability of medical age assessment is the process of how age estimation is derived. Once the proper age marker phase is identified, the corresponding age indication needs to be used to draw conclusions about the age. This is essentially the question of **whether minority can be excluded**, but also includes the question about an **indicative age**. The latter can be decisive for the time until minority status is granted.

Thus, the process of age estimation described in this report requires the development of a clear protocol on how the assessment shall be established, given the two inputs:

- The Catalogue of Age Markers with reference images and associated data
- The newly acquired images from the person in question.

In its simplest form, while not showing other procedural aspects (like the involvement of guardians etc.), the protocol would be as in Figure 14. Note that in some cases MAX may be "infinity" meaning that it relates to the final phase of an age marker.

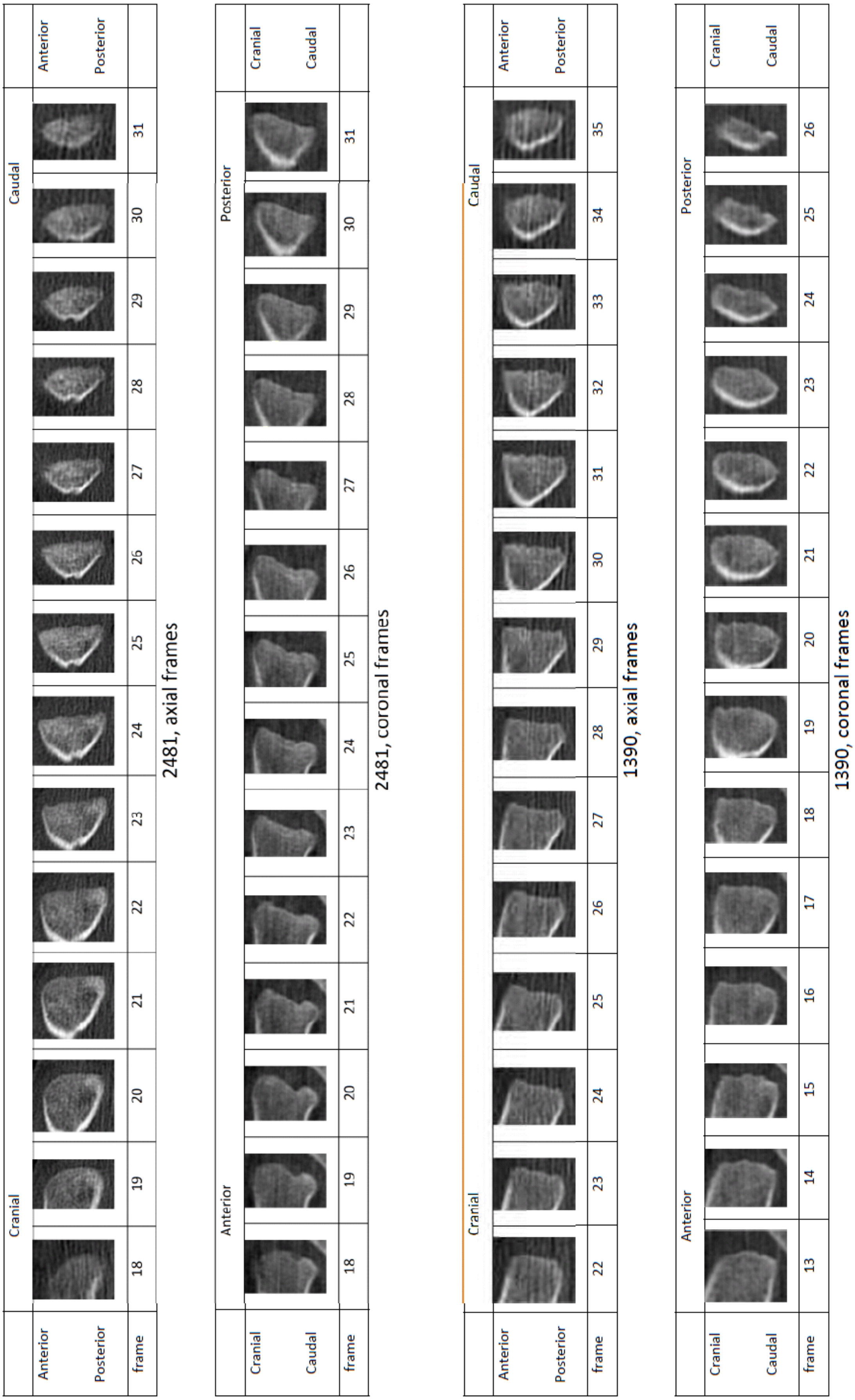



*Figure 13: Example reference CT image series for clavicle*

**(Basic) Age Marker Assessment Protocol**

1. Provide an anamnesis of the person in question and make sure the person does not suffer from any serious disease. Otherwise, STOP age assessment.
2. Start acquiring images for all age markers that do not require computed tomography imaging.
3. Assign for all acquired images of age markers the corresponding phase according to the Catalogue of Age Markers. If there is doubt between two phases, choose the lower one.
4. Make sure that any abnormality can be excluded. Otherwise, STOP further age assessment
5. Look up in the Catalogue for each identified phase the minimum and maximum value (the latter may not exist)
6. Take from all minimum values the largest value and denote it with MIN
7. Take from all maximum values the smallest value and denote it with MAX
8. Repeat steps 3. – 7. with another independent examiner. If MIN and MAX are the same for both examiner, continue with these values. Otherwise, involve a third examiner and use voting from the three examiners for MIN and MAX.
9. Result: The person is at least MIN years old and at most MAX years without reasonable doubt.
10. Report: if MIN is below 18, minority cannot be excluded;<br>if MIN is above 18, minority can be excluded;<br>if MAX is below 18, majority can be excluded;<br>indicative age: MIN years
11. If neither majority nor minority can be safely excluded, acquire images of those age markers that require CT and continue with steps 3.-10.

*Figure 14: Age Marker Assessment Protocol*

Step 2 of the protocol would involve, as a recommendation, X-Rays of hand and third molars. Only if step 11 is required, a CT of clavicular would be considered.

The protocol has several moments where a suspension of the medical age assessment is triggered ("STOP age assessment"). This would happen if any abnormality is encountered.

The protocol as such is already used in Austria where the methodology has reached legislative status.[36] It is therefore also interesting to note some practical experience in the usage of this method. The Annex offers some examples of results of age assessment for illustration.

In the period 2014-2016, some 4700 age assessments of this type were performed in Austria in the context of unaccompanied minors. Some 46% of cases resulted in the exclusion of minority "without reasonable doubt". Depending on the point of view, the age claim of every second person of that group has been falsely doubted, or – the other way round – the age claim of every second person has been proven to be false. It is also interesting to know that the reported costs were around 1200 EUR per age assessment.[37]

[36] "Multifaktorielle Untersuchungsmethodik" according to § 2 Abs. 25 AsylG 2005 (Austria) and the corresponding (not public) implementation guidelines (https://www.ris.bka.gv.at/GeltendeFassung/Bundesnormen/20004240/AsylG%202005%2c%20Fassung%20vom%2006.06.2018.pdf

[37] Information according to Written Request Austrian Parliament 11814/J of 06.02.2017 and answer 11324/AB of 28.03.2017:

## 3.3 Age Markers Training

As mentioned already in section 2.1 ("Phase Identification" of Table 2), dealing with age markers requires special knowledge. It is not even enough to be acquainted with the relevant reference images. Also, knowledge about abnormalities is essential in order not to risk misinterpretation ("Abnormalities" in Table 2).

Such a special expert profile requires the establishment of dedicated training capabilities. Currently, only the German Society for Legal Medicine, with its working group on forensic age diagnostics (AGFAD[38]), offers a forum for the exchange and training of relevant experts in the field. The working group has more than one hundred members from 11 European Member States (Germany, Austria, France, Great Britain, The Netherlands, Belgium, Spain, Denmark, Portugal, Greece, Italy) as well as from Norway, Switzerland, Israel, USA, and Azerbaijan. As such, the AGFAD could form the core of a relevant initiative at European level to develop training capacities on age markers, including a certification scheme.

## 3.4 Age Markers Diagnostics Centre

Optionally, relevant expertise in the interpretation of acquired age marker images could be concerted within an Age Markers Diagnostics Centre. This Centre would host a few well trained specialists that would provide the interpretation of images. European authorities could have access to this service, thus limiting their own investment to the less complex medical and radiological part of the age marker evaluation process.

Operationally, the acquired images would be transmitted in a secure manner to the Age Markers Diagnostics Centre that evaluates the transmitted information on the basis of the Catalogue of Age Markers. The evaluation will then be sent back to the authorities involved for further processing.

Communication with the Age Diagnostics Competence Centre requires the establishment of a security policy that prevents the mismatching of cases, that verifies the identity of the involved actors and that protects all sensitive data. Once the age assessment is established and properly recorded, the underlying medical data (age marker images) could be deleted.

Such a service could be established at a place in Europe that can offer suitable conditions to attract well-trained experts for a longer-term engagement.

## 3.5 Required and Desired Additional Studies

The implementation of the Age Marker Catalogue and Assessment Protocol (sections 3.1 and 3.2) requires more than just the collection and review of already existing material. For example, with the desire to move away from CT imaging towards MRI, there is also the need for relevant studies to acquire reference images and phase data.

Table 7 summarises the required new knowledge that have been mentioned at various points in this report. It also gives an expected time frame needed by the relevant studies.

With respect to studies on MRI-based age estimation the proposal is limited to clavicle ossification because of the significantly higher exposure to radiation for the CT-based alternative. However, a complete transition to MRI-based imaging for all age markers would be desirable, at least in the longer term.

[38] AGFAD is the abbreviation for "Arbeitsgemeinschaft für Forensische Altersdiagnostik", founded in 2000 https://www.dgrm.de/arbeitsgemeinschaften/forensische-altersdiagnostik/

| **Required Study** | **Expected Time Frame** |
|---|---|
| **Study on MRI classification of clavicle ossification:** Based on a number of already existing studies to that subject [32] [44], both the image basis and the corresponding age distribution for individual phases shall be elaborated in order to achieve similar significance as with computed tomography. | 1 year |
| **Statistical analysis of outliers:** The study shall investigate and quantify the probability of outliers for the existing age ranges of age markers for hand, third molar and clavicle. In contrast to the scholastic approach to consider age assessment as a classification problem, this study shall focus on the statistical significance of the currently available age limits for individual markers (minimum and maximum age). | 1 year |
| **Study on ethnical and nutrition caused differences of dental age markers:** The study shall analyse systematically the impact of ethnicity on the localisation of age periods for third molars stages according to Demirjian. Furthermore, the effect of nutrition practices on certain anomalies of dental development shall be investigated. The result should be translated to relevant ethnical correction factors that shall be applied with the Age Marker Assessment Protocol. | 3 years |
| **Study on continuous age marker assessment:** Following the approach of Remy et al. [48] to use what is called "biometric techniques", current age markers data should be analysed about the feasibility to distinguish between infinite many stages (rather than only a few). In [48], this was applied to hand bone development with promising results. Computer assisted methods (similar to those used in biometrics) could then help to decouple age assessment from subjective assignment of development phases (as outlined in section 2.1) and to reduce the margin of error when distinguishing only a few phases. For the current practice, the margin of error can never be smaller than the length of the time period of each phase. In the approach of [48], the margin of error could be significantly smaller. | 3 years |

*Table 7: Indicative list of required studies to complement the Catalogue of Age Markers*

# 4 Conclusions

This report addressed medical age assessment based on age markers from the perspective of the person undergoing such a procedure, in particular with respect to the associated risks. We identified 4 main risks and some factors that actually create these risks.

The conclusion is that an appropriate medical age assessment practice can reduce these risks to a potentially acceptable level, while more work is necessary to address some of the data gaps (cf. section 2.6). In chapter 3, a proposal is made on how such improvements could be gradually achieved.

Table 8 summarises these conclusions on medical age assessment for each of the identified risks individually.

<table>
<tr><th>Risk</th><th>Conclusion</th></tr>
<tr><td>A child could be falsely assessed as being an adult.</td><td rowspan="2">The main risk factors are the proper phase identification, the wrong usage of “averages”, the ignorance of abnormalities and the potential existence of “outliers”. All these risk factors can be tackled with the proposed improvements of chapter 3. In particular, the knowledge base would be increased and a centralised assessment centre could guarantee a uniform treatment of all cases.</td></tr>
<tr><td>The indicative age assigned to a child could be too high.</td></tr>
<tr><td>The person undergoing age assessment could experience inhuman or degrading practices.</td><td>This risk concerns the question whether age assessment raises ethical questions. The conclusion here is that fundamental rights must be guaranteed throughout the process. It is important to provide decisions balancing the ethical viability of a procedure on a case-by-case basis, balancing well the pros and the cons as illustrated in section 2.5.1.</td></tr>
<tr><td>Radiation could be harmful for the person undergoing age assessment.</td><td>Radiation is an issue, in particular for computed tomography (CT) imaging. The fostering of magnetic resonance (MRI) imaging, combined with significant further research in this direction, could reduce this risk to an acceptable or absolute minimum (section 2.5.2).</td></tr>
</table>

*Table 8: Conclusions about risks in medical age assessment*

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## List of abbreviations and definitions

| | |
|---|---|
| AA | Age Assessment |
| AGFAD | Arbeitsgemeinschaft für Forensische Altersdiagnostik |
| AMDC | Age Markers Diagnostics Centre |
| BIA | Best Interest Assessment |
| BIC | Best Interests of the Child |
| CBSS | Council of Baltic Sea States |
| CEAS | Common European Asylum System |
| CRC | Convention on the Rights of the Child |
| CT | Computed Tomography |
| EASO | European Asylum Support Office |
| ECHR | European Court of Human Rights |
| GCR | Global Compact on Refugees |
| GCM | Global Compact on Migration |
| ICPR | International Commission of Radiological Protection |
| MAA | Medical Age Assessment |
| MRI | Magnetic Resonance Imaging |
| RC | Refugee Convention |
| Sv | Sievert (unit of ionizing radiation) |
| UN | United Nations |
| UNHCR | United Nations High Commissioner for Refugees (UN Refugee Agency) |
| UNICEF | United Nations International Children’s Emergency Fund |

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## Annex: Examples from Medical Age Assessment

The following 19 anonymised examples from practice illustrate how the proposed age assessment protocol (section 3.2) would work. Examples were chosen in order to illustrate the variety of possibilities and not to be representative with regard to results. For each example, the supposed country of origin is mentioned, the gender and the observed phase of third molar, wrist, and collar bone development (see section 2.2).

Age limits are calculated back to the date of asylum application. Therefore, the displayed age limits for the same observed phase may differ from case to case. Note that cases 16-19 reflect situations where CT of clavicle is not required to derive conclusion.

The used abbreviations mean:

YoI = Year of life; utr = utriusque; age assert. = age assertion; PHX = Preliminary hand-X-ray; GP = Greulich/Pyle; Clav = Clavicula(e), right side (R) and left side (L); WT = "wisdom teeth";

**Case 1:** Guinea, male: GP 31, WT H, Clav 2a utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) PHX GP 31 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | 14,4 | 14,4 |
| **AGE-ASSERT.** | 15 | **15,23** | | | | |
| | 16 | | 16,16 | | | |
| **Overall min** | 17 | | | **17,38** | | |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20 | 20 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 2:** Afghanistan, Hazara, male: GP 31, WT H, Clav 2b & 2c

| **Summary of age ranges per age marker to date of the investigation** | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | Yol (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) PHX GP 31 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT.** | 16 | **16** | 16,18 | | 16,1 | |
| **Overall min** | 17 | | | **17,6** | | 17,1 |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20,4 | 20,2 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 3:** Gambia, male: GP 31, WT H, Clav 2c utr

| Summary of age ranges per age marker<br>to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min → max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range)<br>PHX GP 31 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| | 16 | | 16,13 | | | |
| **AGE-ASSERT. > Overall min** | 17 | **17,54** | | **17,38** | 17,1 | 17,1 |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20,2 | 20,2 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 4:** Afghanistan, Hazara, male: GP 31, WT H, Clav 3a utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) | | | |
| | | | PHX GP 31 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT.** | 16 | **16,29** | 16,15 | | 16,4 | 16,4 |
| **Overall min** | 17 | | | **17,6** | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| **Overall max** | 22 | | | | 22,3 | 22,3 |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 5:** Nigeria, male: GP 31, WT H, Clav 3b utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range)<br>PHX GP 31 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT.** | 16 | **16,66** | 16,15 | | | |
| **Overall min** | 17 | | | 17,38 | **17,6** | **17,6** |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 6:** Nigeria, male: GP 31, WT H, Clav 3c utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) PHX GP 31 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| | 16 | | 16,17 | | | |
| **AGE-ASSERT.** | 17 | **17,46** | | 17,38 | | |
| | 18 | | | | | |
| **Overall min** | 19 | | | | **19** | **19** |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority excluded

**Case 7:** Nigeria, male: GP 31, WT H, Clav 4 utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min  max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) | | | |
| | | | PHX GP 31 | WT_H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT.** | 16 | **16,73** | 16,15 | | | |
| | 17 | | | 17,38 | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| **Overall min** | 21 | | | | **21,6** | **21,6** |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority excluded

**Case 8:** Libya, male: GP 31, WT G, Clav 2b utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) PHX GP 31 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| **AGE-ASSERT.** | 15 | **15,97** | | | | |
| **Overall min** | 16 | | **16,19** | 16 | 16,1 | 16,1 |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20,4 | 20,4 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | 25 | | |

Conclusion: Age minority not excluded

**Case 9:** Afghanistan, Tadjik, male: WT F & G, Clav 2b & 3a

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | Yol (a) | AGE-ASSERT. | Merkmale und assoz. MA-Werte | | | |
| | | | PHX GP 31 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| **AGE-ASSERT.** | 14 | **14** | | | | |
| | 15 | | | | | |
| **Overall min** | 16 | | 16,17 | 16 | 16,1 | **16,4** |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20,4 | |
| | 21 | | | | | |
| | 22 | | | | | 22,3 |
| | 23 | | | 23 | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 10:** Afghanistan, Pashtu, male: GP 31, WT G, Clav 2c utr

| **Summary of age ranges per age marker to date of the investigation** | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min max) | Yol (a) | AGE-ASSERT. | Merkmale und assoz. MA-Werte | | | |
| | | | PHX GP 31 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT.** | 16 | **16** | 16,21 | 16 | | |
| **Overall min** | 17 | | | | **17,1** | **17,1** |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20,2 | 20,2 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | 25 | | |

Conclusion: Age minority not excluded

**Case 11:** Somalia, male; GP 31, WT G, Clav 3a utr

| Summary of age ranges per age marker<br>to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | YoI (a) | AGE-ASSERT. | Merkmale und assoz. MA-Werte | | | |
| | | | PHX GP 31 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| **AGE-ASSERT.** | 15 | **15,84** | | 15,77 | | |
| **Overall min** | 16 | | **16,4** | | **16,4** | **16,4** |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| **Overall max** | 22 | | | | 22,3 | 22,3 |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | 25 | | |

Conclusion: Age minority not excluded

**Case 12:** Afganistan, Tadjik, female: GP 26, WT G, Clav 3c utr

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) | | | |
| | | | PHX GP 26 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT.** | 16 | **16,94** | 16,23 | 16 | | |
| | 17 | | | | | |
| | 18 | | | | | |
| **Overall min** | 19 | | | | **19,4** | **19,4** |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| **Overall max** | 25 | | | 25 | | |

Conclusion: Age minority excluded

**Case 13:** Afghanistan, Pashtu, male: GP 31, WT E, Clav 1 utr

| Summary of age ranges per age marker<br>to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | YoI (a) | AGE-ASSERT. | Merkmale und assoz. MA-Werte | | | |
| | | | PHX GP 31 | WT-E | Clav R | Clav L |
| | 13 | | | 13 | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT. ≈ Overall min** | 16 | **16** | **16,19** | | | |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| **Overall max** | 22 | | | | 22 | 22 |
| | 23 | | | 23 | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 14:** Afghanistan, Tadjik, male: GP 31, WT E, Clav 2a utr

| **Summary of age ranges per age marker to date of the investigation** | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ▯ max) | Yol (a) | AGE-ASSERT. | Merkmale und assoz. MA-Werte | | | |
| | | | PHX GP 31 | WT-E | Clav R | Clav L |
| | 13 | | | 13 | | |
| | 14 | | | | 14,4 | 14,4 |
| **AGE-ASSERT.** | 15 | **15** | | | | |
| **Overall min** | 16 | | **16,1** | | | |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | 20 | 20 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | 23 | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 15:** Afghanistan, Pashtu, male: GP 31, WT E, Clav 2b left (right side = not assessable)

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | YoI (a) | AGE-ASSERT. | Merkmale und assoz. MA-Werte PHX GP 31 | WT-E | Clav R | Clav L |
| | 13 | | | 13 | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT. ≈ Overall min** | 16 | **16** | **16,15** | | | 16,1 |
| | 17 | | | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| **Overall max** | 20 | | | | | 20,4 |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | 23 | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 16:** Somalia, male: GP 30, WT H

| **Summary of age ranges per age marker to date of the investigation** | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ⍰ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) PHX GP 30 | WT-H | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| | 16 | | | | | |
| **AGE-ASSERT. ≈ Overall min** | 17 | **17,57** | **17,88** | 17,38 | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| **Overall max** | 22 | | 22,28 | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

**Case 17:** Nigeria, male: GP 30, WT G

| Summary of age ranges per age marker<br>to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range)<br>PHX GP 30 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| **AGE-ASSERT.** | 14 | **14,48** | | | | |
| **Overall min** | 15 | | **15,92** | 15,77 | | |
| | 16 | | | | | |
| | 17 | | | | | |
| **Alias Age** | 18 | **18,87** | | | | |
| **Overall max** | 19 | | 19,68 | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | 25 | | |

Conclusion: Age minority not excluded

**Case 18:** Afghanistan, Tadjik, male: GP 29, WT G ret

| **Summary of age ranges per age marker to date of the investigation** | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min ▯ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) | | | |
| | | | PHX GP 29 | WT-G | Clav R | Clav L |
| | 13 | | | | | |
| | 14 | | | | | |
| | 15 | | | | | |
| **AGE-ASSERT. > Overall min** | 16 | **17,09** | 16,75 | **16,8** | | |
| | 17 | | | | | |
| | 18 | | | | | |
| **Overall max** | 19 | | 19,65 | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | | | |
| | 24 | | | | | |
| | 25 | | | 25 | | |

Conclusion: Age minority not excluded

**Case 19:** Afghanistan, Pashtu, male: GP 29, WT F

| Summary of age ranges per age marker to date of the investigation | | | | | | |
|---|---|---|---|---|---|---|
| Relation of age-assert. to range of possible age (= min □ max) | YoI (a) | AGE-ASSERT. | Age traits & assoc. min/max (= poss. age range) | | | |
| | | | PHX GP 29 | WT-F | Clav R | Clav L |
| | 13 | | | | | |
| **Overall min** | 14 | | **14,9** | 14 | | |
| **AGE-ASSERT.** | 15 | **15,21** | | | | |
| | 16 | | | | | |
| **Overall max** | 17 | | 17,8 | | | |
| | 18 | | | | | |
| | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | | | |
| | 23 | | | 23 | | |
| | 24 | | | | | |
| | 25 | | | | | |

Conclusion: Age minority not excluded

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