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The Demand in Forensic Medicine to Assess the Age of Adolescents and Young Adults in Crime Procedures

Forensic age diagnostics mean multidisciplinary teamwork.
A contribution of the German Academy of Forensic Odonto-Stomatology.

Language: English

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Introduction

In Germany the age thresholds of relevance for criminal proceedings are 14, 18 and 21 years (5). In many other countries the age thresholds which determine criminal liability are similar.
For the purpose of estimating age, the German Study Group on Forensic Age Diagnostics (AGFAD) recommends combining a physical examination of the suspect, a dental examination which records dentition status and evaluates an orthopantomogram, Xray examination of the left hand, and radiographic or computer tomographic survey of the clavicle (9,10).

Objectives

In establishing whether an individual has attained the criminal liability threshold of 21 years, the ossification of the sternal clavicular cartilage is of particular interest, as the other systems on which development analysis is based have usually matured fully by this time. Xrays of the clavicle are important in helping to ascertain whether a suspect was 18 years old at the time of an offence committed some years prior to clinical examination (10).

Material and Methods

Physical, dental and radiological methods differ considerably due to their limits, possibilities and risks (5), i.e. radiological examinations are admitted by medical indication (§ 23ff RöV) or by court order (§ 81a StPO) (Table 1).

Table 1 Age estimation of adolescents and young adults (5):

Reasons	Methods	Legal aspects
Maturity: >14 years of age? (§ 19 StGB)	Radiological assessment of the development of the teeth, of the hand and wrist	X-rays (§§ 23ff RöV) only by court order (§ 81a StPO)
Maturity: >18 resp. 21 years of age? (§§ 1, 105 JGG)	Radiological assessment of the development of the third molars, of the wrist	X-rays (§§ 23ff RöV) only by court order (§ 81a StPO)

Table 1: Age estimation of adolescents and young adults (5).

Proceedings:

The scientific base of age diagnostics means genetic control of ontogenesis. The temporal variability of development stages is limited. By common consent the best usable methods are the physical examination (height, weight, physic, sexual maturity, relevant developmental disturbances due to age; the dental examination including the dental status; photography (Fig. 1); dental x-ray i.e. orthopantomogram (Fig. 2 and 3); x-ray of the left hand and wrist (Fig. 4 to 7) and under special circumstances additional x-ray survey of the clavicle (Fig. 8 and 9).

Photography

Fig. 1: Age: 15, male

Radiography

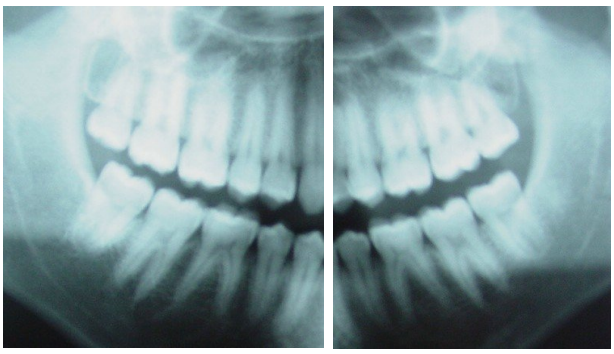

Fig. 2a Fig. 2b

Fig. 2: Age 19, male Stage H (by DEMIRJIAN)

Radiological assessment of the third molars:

The development of the roots of the wisdom teeth is not finished before the age of 18 (2,13) corresponding the stage H (by DEMIRJIAN).
The mineralisation of the teeth is more interesting than the eruption (2). This process is mostly independent facing external factors (1). The classification (by DEMIRJIAN) is most suitable (Fig.3; Table 2 and 3).

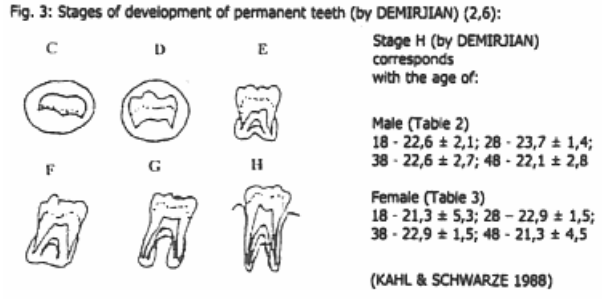

Fig. 3: Age 19, male Stage H (by DEMIRJIAN)

Table 2: Third molars; stages, male (by DEMIRJIAN):
(1. row = medium, 2. row = standard deviation in years)

	KAHL & SCHWARZE (1988)				OLZE et al. (2003)			
Tooth Stage	**18**	**28**	**38**	**48**	**18**	**28**	**38**	**48**
A	10,1	10,3	10,0	10,1	-	-	-	-
	1,0	1,7	2,0	1,5	-	-	-	-
B	10,3	10,6	10,7	10,7	14,4	15,5	13,3	-
	1,3	1,5	1,3	1,8	2,7	3,3	2,1	-
C	11,4	11,2	11,5	11,6	13,6	14,5	14,6	14,5
	1,6	1,6	1,4	1,5	0,7	1,9	1,7	1,5
D	12,7	12,6	12,4	12,5	16,5	16,3	16,3	16,7
	1,7	1,6	1,4	1,4	3,1	3,2	3,1	3,1
E	14,2	14,5	14,8	15,0	16,7	16,6	16,7	16,7
	2,0	1,5	1,4	1,9	2,6	2,3	2,3	2,1
F	16,5	16,5	16,0	16,4	17,8	17,7	18,3	18,2
	1,1	1,5	1,7	1,7	2,0	2,0	2,2	2,1
G	18,6	18,8	18,9	17,8	20,6	20,6	21,3	21,3
	1,2	1,1	1,1	2,3	2,4	2,4	2,0	2,1
H	22,6	23,7	22,6	22,1	22,5	22,6	22,7	22,7
	2,1	1,4	2,7	2,8	1,9	1,9	1,9	1,9

Table 2: Third molars. Stages, male, by DEMIRJIAN.

Table 3: Third molars; stages, female (by DEMIRJIAN):
(2. row = medium, 2. row = standard deviation in years)

	KAHL & SCHWARZE (1988)				OLZE et al. (2003)			
Tooth Stage	**18**	**28**	**38**	**48**	**18**	**28**	**38**	**48**
A	10,3	10,2	10,2	9,9	-	-	-	-
	1,7	1,4	1,4	1,3	-	-	-	-
B	10,2	9,9	9,9	10,3	14,5	12,6	14,0	13,8
	1,6	1,4	1,4	1,4	3,8	0,9	2,9	1,6
C	11,0	11,0	11,0	11,5	14,2	15,1	14,5	14,1
	1,8	1,7	1,7	1,8	1,7	2,3	1,6	1,5
D	12,8	12,6	12,6	13,1	15,7	15,7	15,5	15,7
	2,1	1,8	1,8	1,8	2,8	2,5	2,6	2,6
E	15,6	15,9	15,9	15,9	16,8	17,0	16,8	17,2
	1,9	1,2	1,2	1,2	2,3	2,7	2,3	2,4
F	17,5	16,7	16,7	17,4	18,6	18,7	19,1	19,0
	4,0	3,5	3,5	3,1	2,5	2,5	2,5	2,5
G	20,1	19,8	19,8	19,9	20,7	20,7	21,7	21,7
	2,5	3,7	3,7	2,7	2,6	2,6	2,1	2,1
H	21,3	22,9	22,9	21,3	22,7	22,7	23,0	23,1
	5,3	1,5	1,5	4,5	1,9	1,9	1,8	1,8

Table 3: Third molars. Stages, female, by DEMIRJIAN.

Maturity indicators of individual bones and epiphyses

Fig. 4: Age 15, male
Maturity indicators of individual bones and epiphyses The epiphysis of the radius has capped it's shaft. All carpals have attained their early adult shape. Fusion is under way in the epiphyses of all distal phalanges.

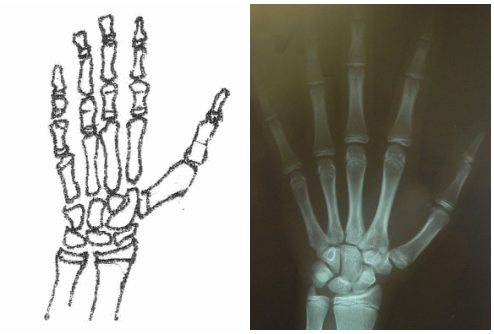

Fig. 5: Age 21, male
The fusion of the radial epiphysis with its shaft completes the skeletal maturation of the hand and wrist.

Radiological assessment of the left hand and wrist:

The skeletal development of the hand and wrist represents the development of the whole skeleton as "pars pro toto" and informs about the skeletal age corresponding with the chronological age (4, 12).

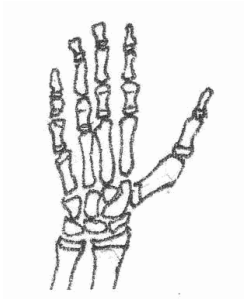

Fig. 6: Age 16, female
Epiphysial lines of ulna and radius still smooth marked. The interstices of ulna and radius mostly ossified, but perceptible. THIEMANN / NITZ and GREULICH / PYLE define the roentgenogram of the left wristbone belonging to a 15-16 years-old female.

Fig. 6a: Age 16, female
Beginning fusion of the distal epiphysis ofthe radius with its shaft. Fusion is completed first in the distal,next in the proximal or distal phalanges.

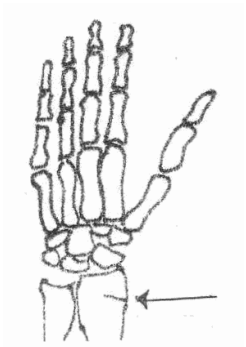

Fig. 7: Age 17, female
In the ulna and in the heads of all fingersthe epiphyseal lines have been almost completely obliterated. In the radius thin terminal lines extend completely across the shaft (see arrow).

Fig. 7a: Age 17, female
Epiphysial lines of ulna and radius still smooth marked. The intersticesof ulna and radius mostly ossified,but perceptible. Fusion is nearly complete.

Radiological assessment of the clavicle:

Fig. 8 Age 27, male
Radiological assessment of the clavicle. The comparison of both sides shows regular structures of the bones. No signs of degenerative or inflammatory alteration. The maturity of both clavicles is finished.

Fig. 9: Age 27, male
12 degrees angled x-ray of the left clavicle. The epiphyseal cartilage shows completely fusion with its shaft. The epiphyseal scar is no longer visible (Stage 5).

Stage	Gender	Min–Max	Mean±SD	Median, LQ, UQ
3	Male	16.7–24.0	20.8±1.7	20.9, 19.9, 22.3
	Female	16.0–26.8	20.0±2.1	19.9, 18.2, 21.5
4	Male	21.3–30.9	26.7±2.3	26.7, 24.8, 28.5
	Female	20.0 30.9	26.7±2.6	26.7, 24.8, 28.9
5	Male	26.0–30.4	28.5±1.5	28.3, 27.1, 29.9
	Female	26.7–30.9	29.0±1.4	29.1, 27.7, 30.5

Min Minimum, *Max* Maximum, *SD* Standard deviation, *LQ* Lower quartile, *UQ* Upper quartile

Table 4: Gender comparison at stages 3, 4, 5. Male and female.

Gender comparison produced significant differences at stage 3 (p=0.006), with the female subjects reaching this stage one year earlier than their male counterparts. In both genders stage 3 first occurred at the age of 16, the maximum age for men being 24 and the maximum for women 27.

There were no statistically significant gender differences at stage 4 and 5. Stage 4 was first observed in male subjects at 21 years and in female subjects at 20 years. In each gender the lowest age for stage 5 was 26.
To assess the degree of ossification of the medial clavicular epiphyseal cartilage, the classification into four stages commonly applied in anatomical and radiological studies was applied as follows:
Stage 1: The ossification centre has not yet ossified
Stage 2: The ossification centre has ossified, the epiphyseal cartilage has not ossified
Stage 3: The epiphyseal cartilage is partially ossified
Stage 4: The epiphyseal cartilage is fully ossified
Stage 5: The epiphyseal cartilage has fused completely and the epiphyseal scar is no longer visible (11).
Stage 5 is characterised by total fusion of the epiphyseal cartilage and the disappearance of the epiphyseal scar.

Plain chest radiographs can essentially provide a basis for assessing clavicular ossification. If overlap in posterior-anterior views impedes evaluation, a lateral view should also be taken to facilitate age estimation. At ossification stage 4 it cannot reliably be ruled out that a female subject is under 21 years old. At ossification stage 5 a minimum age of 26 can be assumed for both genders (10,11).

Results

Radiological assessment of the hand and wrist allows diagnostics up to 18 years of age. The development ends with this age. The mineralisation of the roots of the wisdom teeth is finished at the age of 21. The radiological assessment of the clavicle in both genders shows the lowest age at which stage 5 of was observed was 26 years. Forensic age diagnosis of living subjects in the context of criminal investigations can assume that when this stage of ossification is observed the subject must have attained the age of 21 at least. years prior to the examination and the age of 18 at least 8 years prior to the examination.

Conclusions

Expertness and the combination of physical examination of the suspect, dental examination which records dentition status including orthopantomography, Xray examination of the left hand and wrist and radiographic or computer tomographic survey of the clavicle lead to conclusions regarding the estimated age - a useful support in criminal cases to assess adolescents and young adults due to legal protection in court.
Every year the Study Group proofs the practicability of the methods, points the way to the future and organises lectures regarding the results in research and in practice.

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Abbreviations

RöV: Röntgenverordnung, x-ray degree
StGB: Strafgesetzbuch, penal code
StPO: Strafprozessordnung, code of criminal procedure

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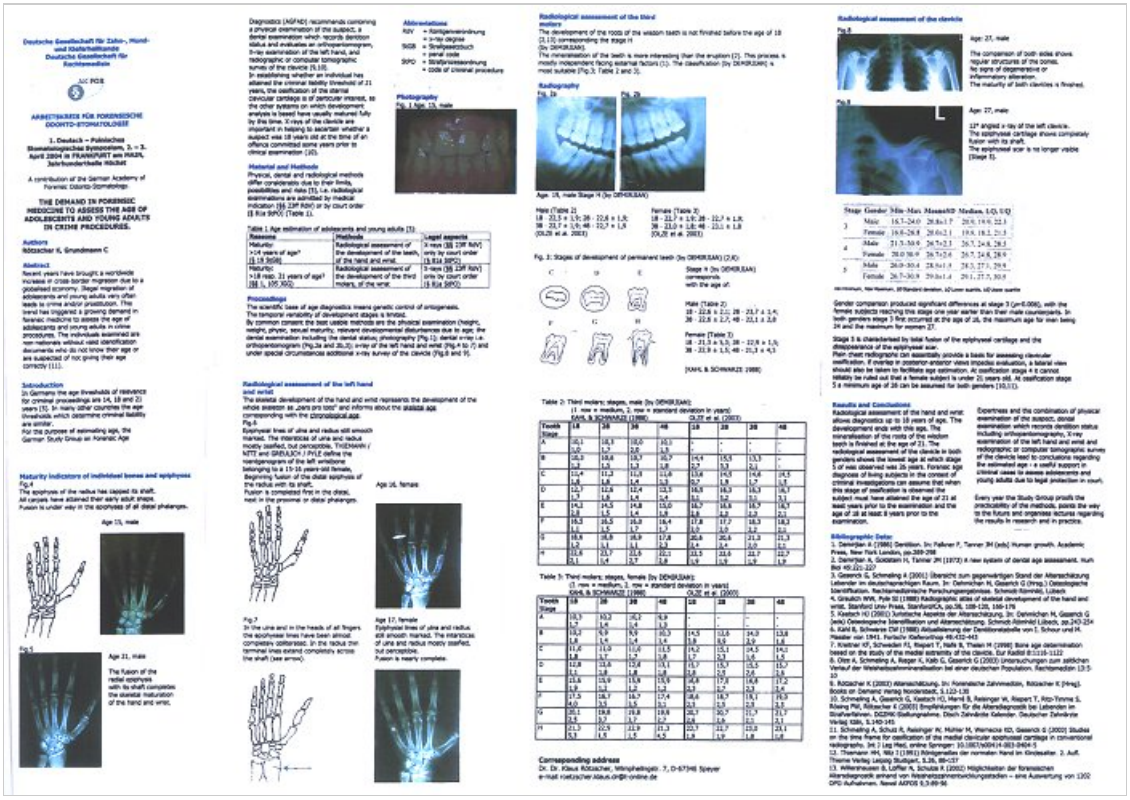
Poster Faksimile:



Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde
Deutsche Gesellschaft für Rechtsmedizin

ARBEITSKREIS FÜR FORENSISCHE ODONTO-STOMATOLOGIE

1. Deutsch – Polnisches Stomatologisches Symposium, 2. – 3. April 2004 in FRANKFURT am MAIN, Jahrhunderthalle Höchst

A contribution of the German Academy of Forensic Odonto-Stomatology:

THE DEMAND IN FORENSIEC MEDICINE TO ASSESS THE AGE OF ADOLESCENTS AND YOUNG ADULTS IN CRIME PROCEDURES.

Authors
Rötzscher K, Grundmann C

Abstract
Recent years have brought a worldwide increase in cross-border migration due to a globalised economy. Illegal migration of adolescents and young adults very often leads to crime and/or prostitution. This trend has triggered a growing demand in forensic medicine to assess the age of adolescents and young adults in crime procedures. The individuals examined are non-nationals without valid identification documents who do not know their age or are suspected of not giving their age correctly [11].

Introduction
In Germany the age thresholds of relevance for criminal proceedings are 14, 18 and 21 years [5]. In many other countries the age thresholds which determine criminal liability are similar.
For the purpose of estimating age, the German Study Group on Forensic Age

Maturity indicators of individual bones and epiphyses
Fig.4
The epiphyses of the radius has capped its shaft.
All carpals have attained their early adult shape.
Fusion is under way in the epiphyses of all distal phalanges.

Age 13, male

Fig.5

Age 21, male

The fusion of the radial epiphysis with its shaft completes the skeletal maturation of the hand and wrist.

Diagnostics (AGFAD) recommends combining a physical examination of the subject, a dental examination which regards dentition status and evaluates an orthopantomogram, X-ray examination of the left hand, and radiographic or computer tomographic survey of the clavicle [5,10].
In establishing whether an individual has attained the criminal liability threshold of 21 years, the ossification of the sternal (sternoclavicular) cartilage is of particular interest, so the other systems on which development analysis is based have usually matured fully by this time. X-rays of the clavicle are important in helping to ascertain whether a suspect was 18 years old at the time of an offence committed some years prior to clinical examination [10].

Material and Methods
Physical, dental and radiological methods differ considerably due to their limits, possibilities and risks [5], i.e. radiological examinations are admitted by medical indication (§§ 23ff RöV) or by court order (§ 81a StPO) (Table 1).

Table 1: Age estimation of adolescents and young adults [5].

Reasons	Methods	Legal aspects
Maturity: >14 years of age? (§ 1 JGG)	Radiological assessment of the development of the teeth, of the hand and wrist	X-rays (§§ 23ff RöV) only by court order (§ 81a StPO)
Maturity: >18 resp. 21 years of age? (§§ 1, 105 JGG)	Radiological assessment of the development of the third molars, of the wrist	X-rays (§§ 23ff RöV) only by court order (§ 81a StPO)

Proceedings
The scientific base of age diagnostics means genetic control of ontogenesis.
The temporal variability of development stages is limited.
By common consent the best usable methods are the physical examination (height, weight, physic, sexual maturity, relevant developmental disturbances due to age; the dental examination including the dental status; photography [Fig.1]; dental x-ray i.e. orthopantomogram [Fig.2a and 2b,3]; x-ray of the left hand and wrist [Fig.4 to 7] and under special circumstances additional x-ray survey of the clavicle [Fig.8 and 9].

Abbreviations
RöV = Röntgenverordnung
= x-ray degree
StGB = Strafgesetzbuch
= penal code
StPO = Strafprozessordnung
= code of criminal procedure

Photography
Fig. 1 Age 13, male

Radiological assessment of the left hand and wrist
The skeletal development of the hand and wrist represents the development of the whole skeleton as „one pro rata" and informs about the skeletal age corresponding with the chronological age.
Fig.6
Epiphyseal lines of ulna and radius still smooth marked. The interdiscal of ulna and radius mostly ossified, but perceptible. THOMANN / MITTI and GRENJACH / PYLE define the roentgenogram of the left wristbone belonging to a 15-16 years-old female.
Beginning fusion of the distal epiphysis of the radius with its shaft.
Fusion is completed first in the distal, next in the proximal or distal phalanges.

Fig.7
In the ulna and in the heads of all fingers the epiphyseal lines have been almost completely obliterated. In the radius the terminal lines extend completely across the shaft (see arrows).

Age 16, female

Age 17, female
Epiphyseal lines of ulna and radius still smooth marked. The interdiscal of ulna and radius mostly ossified, but perceptible.
Fusion is nearly complete.

Radiological assessment of the third molars
The development of the roots of the wisdom teeth is not finished before the age of 18 [2,13] corresponding the stage H (by DEMIRJIAN).
The mineralisation of the teeth is more interesting than the eruption [2]. This process is mostly independent facing external factors [1]. The classification (by DEMIRJIAN) is most suitable [Fig.3; Table 2 and 3].

Radiography
Fig. 2a
Fig. 2b

Age: 18, male Stage H (by DEMIRJIAN)

Male (Table 2)
18 - 22,5 + 1,9; 20 - 22,6 + 1,8;
30 - 23,7 + 1,9; 40 - 22,7 + 1,8
(OLZE et al. 2003)

Female (Table 3)
18 - 21,7 + 1,9; 20 - 22,7 + 1,8;
30 - 23,0 + 1,8; 40 - 23,1 + 1,8
(OLZE et al. 2003)

Fig. 3: Stages of development of permanent teeth (by DEMIRJIAN) (2,6):

Stage H (by DEMIRJIAN) corresponds with the age of:

Male (Table 2)
18 - 22,6 ± 2,1; 20 - 23,7 ± 1,4;
30 - 22,6 ± 2,7; 40 - 23,1 ± 2,0

Female (Table 3)
18 - 21,5 ± 1,5; 30 - 22,6 ± 1,5;
30 - 23,9 ± 1,5; 40 - 21,3 ± 4,3

(KAHL & SCHWARZE 1988)

Table 2: Third molars; stages, male (by DEMIRJIAN):
(1 row = medium, 2. row = standard deviation in years)
KAHL & SCHWARZE (1988) OLZE et al. (2003)

Tooth Stage	18	20	30	40	18	20	30	40
A	18,1	18,3	18,0	18,3	-	-	-	-
	1,0	1,7	2,0	1,8	-	-	-	-
B	18,3	18,6	18,3	20,9	19,4	19,5	19,3	-
	1,2	1,5	1,2	1,8	2,7	3,3	3,1	-
C	11,4	11,3	11,3	11,6	13,8	14,5	14,6	14,5
	1,4	1,6	1,4	1,3	0,7	1,5	1,7	1,5
D	12,7	12,8	12,4	13,5	16,5	16,3	16,3	16,7
	1,7	1,8	1,5	1,5	3,1	3,2	3,1	3,1
E	14,2	14,5	14,8	15,0	18,3	18,6	18,7	18,7
	1,8	1,7	1,4	1,8	3,6	4,2	4,2	4,1
F	15,3	15,5	15,8	16,4	17,8	17,7	18,3	18,3
	1,2	1,5	1,7	1,1	3,0	3,0	3,2	3,0
G	18,9	18,8	18,9	17,8	20,6	20,6	21,3	21,3
	1,2	1,1	1,1	2,3	2,4	2,4	2,0	2,1
H	21,4	21,7	21,6	22,1	23,5	23,6	22,7	22,7
	0,1	1,4	2,7	2,8	1,9	1,8	1,9	1,9

Table 3: Third molars; stages, female (by DEMIRJIAN):
(1 row = medium, 2. row = standard deviation in years)
KAHL & SCHWARZE (1988) OLZE et al. (2003)

Tooth Stage	18	20	30	40	18	20	30	40
A	18,3	18,2	18,2	18,9	-	-	-	-
	1,7	1,6	1,4	1,3	-	-	-	-
B	19,2	19,0	19,1	20,3	19,5	19,6	19,9	19,8
	1,8	1,9	1,4	1,4	3,8	3,5	2,9	1,8
C	11,6	11,9	11,8	11,5	14,2	15,1	14,5	14,2
	1,8	1,7	1,4	1,8	1,7	2,1	1,6	1,5
D	12,8	12,6	12,6	13,1	15,7	15,7	15,5	15,7
	1,1	1,8	1,8	1,8	2,8	2,5	2,6	2,5
E	15,6	15,9	15,8	15,9	18,6	19,8	18,8	17,2
	1,8	1,3	1,2	1,3	2,3	2,7	2,3	2,4
F	17,3	16,7	16,7	17,4	18,6	18,9	19,1	19,9
	4,0	3,5	3,5	3,1	2,1	1,9	2,0	2,5
G	20,1	19,8	19,8	19,8	20,7	20,7	21,3	21,7
	2,5	2,7	2,7	2,7	0,8	1,0	2,1	2,1
H	21,3	22,5	21,9	21,3	23,7	23,7	23,0	23,1
	5,3	1,5	1,5	4,5	1,8	1,9	1,8	1,8

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Radiological assessment of the clavicle
Fig.8

Age: 27, male

The comparison of both sides shows regular structures of the bones. No signs of degenerative or inflammatory alteration.
The maturity of both clavicles is finished.

Fig.9

Age: 27, male

27° angled x-ray of the left clavicle.
The epiphyseal cartilage shows completely fusion with its shaft.
The epiphyseal scar is no longer visible [Stage 5].

Stage	Gender	Min–Max	Mean±SD	Median, 1/Q, 3/Q
3	Male	15.7–24.0	20.8±1.7	20.9, 19.9, 22.1
	Female	18.9–24.8	20.6±2.1	19.9, 18.2, 21.5
4	Male	21.3–30.9	26.7±2.5	26.7, 24.8, 28.5
	Female	20.0–30.9	26.7±2.6	26.7, 24.8, 28.9
5	Male	26.0–30.4	28.6±1.4	28.5, 27.1, 29.9
	Female	26.7–30.9	29.0±1.4	29.1, 27.7, 30.5

min=Minimum, max=Maximum, SD=Standard deviation, 1/Q=Lower quartile, 3/Q=Upper quartile

Gender comparison produced significant differences at stage 3 (p=0.006), with the female subjects reaching this stage one year earlier than their male counterparts. In both genders stage 3 first occurred at the age of 18, the maximum age for men being 24 and the maximum for women 27.

Stage 3 is characterised by total fusion of the epiphyseal cartilage and the disappearance of the epiphyseal scar.
Plain chest radiographs can essentially provide a basis for assessing clavicular ossification. If overlap in posterior-anterior views impedes evaluation, a lateral view should also be taken to facilitate age estimation. At ossification stage 4 it cannot reliably be ruled out that a female subject is under 21 years old. At ossification stage 5 a minimum age of 20 can be assumed for both genders [10,11].

Results and Conclusions
Radiological assessment of the hand and wrist allows diagnostics up to 18 years of age. The development ends with this age. The mineralisation of the roots of the wisdom teeth is finished at the age of 21. The radiological assessment of the clavicle in both genders shows the lowest age at which stage 5 of was observed was 26 years. Forensic age diagnosis of living subjects in the context of criminal investigations can assume that when this stage of ossification is observed the subject must have attained the age of 21 at least years prior to the examination and the age of 18 at least 8 years prior to the examination.

Expertness and the combination of physical examination of the support, dental examination which records dentition status including orthopantomography, X-ray examination of the left hand and wrist and radiographic or computer tomographic survey of the clavicle lead to conclusions regarding the estimated age - a useful support in criminal cases to assess adolescents and young adults due to legal protection in court.

Every year the Study Group proofs the practicability of the methods, points the way to the future and organises lectures regarding the results in research and in practice.

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