The human incisal suture and premaxillary area studied on archaeologic material

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The purpose of this study was to investigate the extent of the incisal suture, the size of the premaxillary area, and the developmental status of the dentition. Sixty-three medieval crania were examined: 30 from children and 33 from adults, including 5 cases with tooth deviations. All crania were photographed at a 1:1 scale. From the photographs the size of the premaxilla and the length of the incisal suture were measured. In addition, the spatial conditions in the anterior region were recorded. The study showed that the main closure of the suture takes place shortly after the crowns of the permanent incisors have attained their final width size. The mean size of the premaxillary area was larger in individuals with interincisal spacing and smaller in individuals with crowding when comparing with normal spatial conditions. In the cases of tooth agenesis the premaxillary areas were markedly reduced. □ *Agenesis; bone development; dental eruption; maxilla; palate*

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The influence of the human incisal suture on the development of the palate and dentition has hitherto only been studied sporadically (1). It is well known from the literature that the human incisal suture, which is open at birth, undergoes a gradual closure (2, 3). In this connection it is also known that the course of closure of the suture starts laterally and moves medially (2). In the sagittal plane the suture closes from above (4). Different opinions concerning the role of the human incisal suture have been published; some authors consider the suture to be a dividing structure, which means that the upper jaw consists of separate premaxillary and maxillary bones, such as in primates (5–7). Other authors claim that a separate human premaxilla does not exist (8, 9). Recent studies of the development of the palatal transversal sutures (10) have shown that in prenatal life the morphology of the incisal suture differs, both microscopically and macroscopically, from the transpalatal suture. It has recently been proposed that the incisal suture in prenatal life is related to the development of the deciduous incisors (10). Postnatally, it is difficult to locate the incisive suture radiographically in living subjects. A single investigation, based on radiography, indicates the location of the suture but without describing the degree of closure (11). Anthropologic studies are therefore valuable in investigation of the region of the incisal suture. Owing to the nature of the anthropologic material, findings in general must be related to an estimated age of the individual. This estimate is based, for example, on tooth wear, tooth eruption, or the degree of closure of the cranial sutures. The purpose of the present study is to correlate the degree of closure of the incisal suture to the size of the premaxillary area and to the developmental status of the dentition.

From an anthropologic point of view it is interesting to know whether the suture can be used in skeletal age determination or whether local circumstances, such as the development of the dentition, makes it unsuitable for this purpose.

From an orthodontic point of view the

investigation might reveal the relationship between skeletal and dental development in the region.

Materials and methods

Materials

The cranial material included in this study derives from a major archaeologic excavation of a medieval parish cemetery, situated close to the main street of Holbæk, a town located in Zealand, Denmark. The excavation was carried out in 1986 under the leadership of museum curator Else Asmussen, M.A. The archaeologists believe that the monastery was founded around 1200 AD and was thereafter in use for 300 to 400 years. The churchyard covered an area of 450 m^2. The skeletal remains of 673 persons were found (259 children and 414 adults), the excavation accordingly being the largest medieval excavation in Denmark (12). The skeletons represent a 'normal' medieval population, as the graveyard was not associated with a hospital. A systematic anthropologic investigation of the skeletons, including sex determinations performed by J. B. Jørgensen, shows that the persons are of the Nordic type with Cro-Magnon characteristics (13, 14). The study did not show any occurrence of specifically pathologic bone changes but did show arthritic changes, increasing with age, known from other skeletal populations. Similarly, the sex and age distributions are normal for a medieval Scandinavian population (15).

All the skulls in the collection were examined for the purpose of selecting individuals with intact maxillae. Thus 30 child crania were considered suitable for incorporation in the investigation. A similar number of adult crania were taken at random from the central excavation area, so that all the suitable crania between skeletal numbers 200 and 414 were included in the analysis, a total of 33. The sex distribution of the adult individuals was as follows: 53% men, 27% women, and 20% uncertain. The age of these crania was established by means of attrition of the teeth, eruption of the teeth, and sutural closure in the theca cranium.

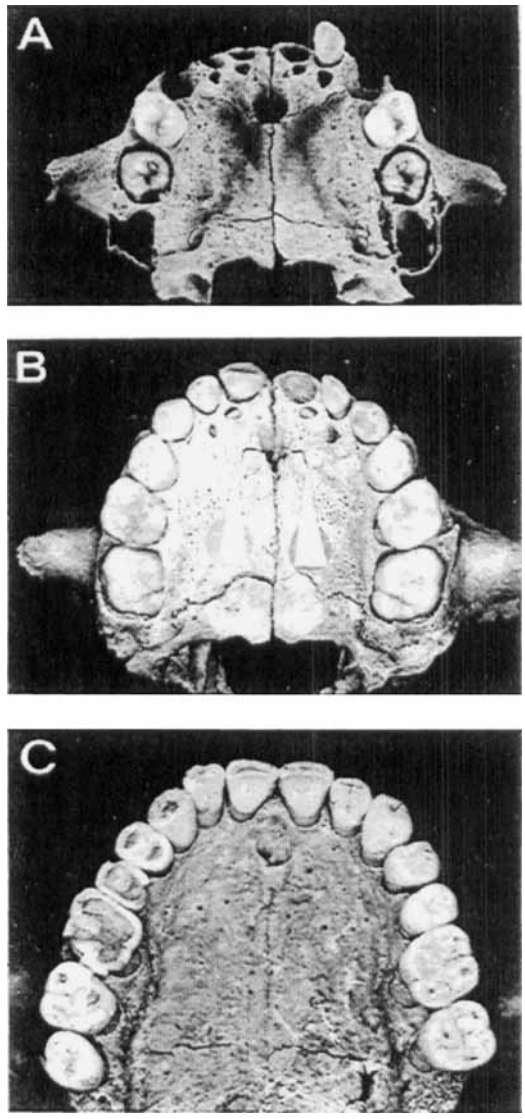

Fig. 1. Examples of the normal anthropologic material included in the study. (Magnification, ×1.) A. Upper jaw from child cranium in DS01. The incisal suture appears open with a bilateral course from the incisive foramen to the empty sockets of the primary canines. B. Upper jaw from child cranium in DS02. The open part of the suture is seen mesially to the marking arrows. Laterally to these a 'trace' is visible, indicating the former course of the suture. C. Upper jaw from adult cranium in DS4M3. The incisal suture cannot be seen.

Methods

For investigation three different methods were used: ordinary anthropologic inspection, photography, and radiography.

Incisal suture. The extent of the incisal suture on the surface of the palate was recorded by ordinary anthropologic inspection. A suture was defined as 'open' when it could be probed; that is, a normal probe could be inserted 0.5 mm or more into the suture itself (Fig. 1A). A suture was defined as 'closed' when the entire suture gap had been replaced by bone. In some instances a superficial 'trace' may persist on the surface of the bone where the suture had been. In depth, however, total obliteration of the suture was seen as previously described by Behrents & Harris (4). In the present study the presence of 'trace' was classified as a closed suture (Fig. 1B).

Size of premaxilla. To perform measurements of the premaxilla and measurements of the extent of the incisal suture, photographs were taken of all the crania. The jaws were placed in sand and orientated with the occlusal plane in the horizontal position. This was done by placing a spirit level above a Plexiglas plate, which rested on the occlusal plane of the jaw. By arrows fixed with Kerr orthodontic tray wax onto the palate itself, the extent of the incisal suture was indicated (Fig. 1B). Thus measurement of the suture could be made directly on the photographs. The photographs were taken with an Olympus OM-2N camera in a fixed position. The film used was Kodak TMX, 100 ASA, routinely processed. Paper prints were made of all the jaw exposures. The following measurements were made on the paper prints, using a slide caliper (0.01–150 mm. Mitutoyo Coprotaion Digimatic) (16).

1. The width of the palate in the region of the canines, defined as the distance between

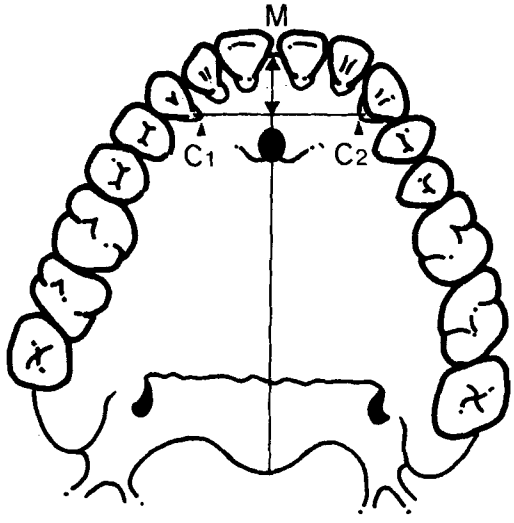

Fig. 2. Sketch of upper jaw indicating permanent teeth and the transverse palatal sutures: the incisal suture and the transverse palatal suture. C1 and C2 indicate the most medial point on the border of the sockets of the canines; M indicates the most anterior point on the alveolar process between the two central incisors. The area of the premaxilla is calculated as the area of the triangle C1–C2–M.

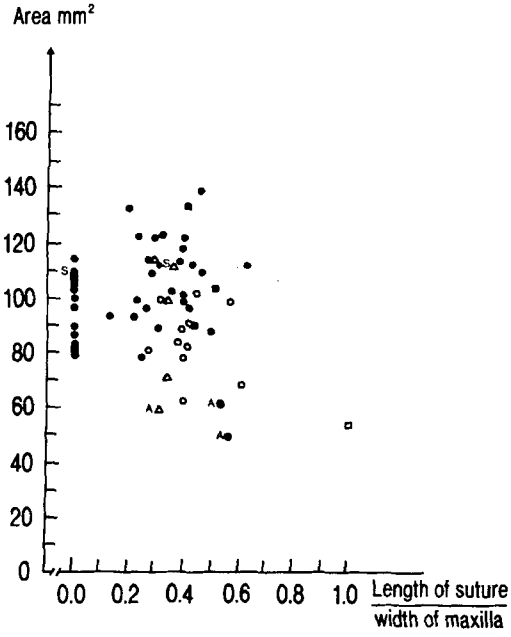

Fig. 3. The area of the premaxilla related to the degree of closure of the incisal suture related to dental stages. White square = DS01; white circle = DS02; white triangle = DS1M1 and DS2M1; black square = DS3M2; and black circle = DS4M2 and DS4M3. Agenesis cases are marked 'A'; cases showing hyperdontia are marked 'S'. The diagram shows that the area of the premaxilla is quite constant during childhood from DS02. Thus the incisal suture seems to be a structure without importance for growth of the jaw.

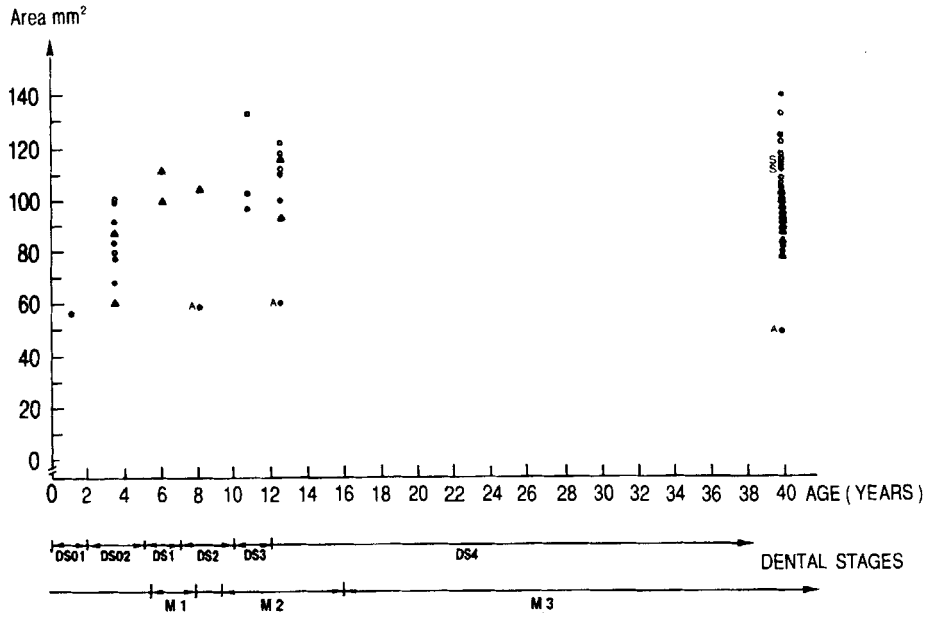

Fig. 4. The area of the premaxilla related to the dental stage in crania with various anterior spatial conditions. Black circle = individuals with normal spatial conditions; white circle = cases with spacing; and black triangle = cases with crowding. Agenesis cases are marked 'A'; cases showing hyperdontia are marked 'S'. In cases with agenesis the area of the premaxilla is observed to be smaller than the normal. The jaws with supernumerary teeth have premaxillary areas close to the normal values.

these teeth. A line was drawn from the most medial point of the right canine alveolus, C1, to the most medial point of the left canine alveolus, C2 (Fig. 2). The extent of this line was measured from C1 to C2.

2. The length of the incisal suture was measured as the distance between the two points of the inserted arrows (Fig. 1B).

3. A median measurement was defined as the shortest distance from the most anterior point on the alveolar process between the central incisors to the 'canine line'. This distance was used as an expression of the length of the premaxilla (Fig. 2).

A conversion factor was calculated for each individual so that the measurements on the photograph corresponded with the actual dimensions of the jaws. On the basis of these corrected measurements the relative length of the suture was calculated as the length of suture over the width of maxilla. In addition, the area of the maxilla was calculated as half the median measurement times the width of the maxilla.

Dental development. The dental stage of each individual was determined by the method defined by Bjørk et al. (17). The definitions based on eruptions are as follows: DS01 = deciduos teeth erupting; DS02 = deciduos teeth completely erupted; DS1 = permanent incisors erupting; DS2 = permanent incisors completely erupted; DS3 = permanent canines and premolars erupting; DS4 = permanent canines and premolars completely erupted; DSM1 = first permanent molar completely erupted; DSM2 = second permanent molar completely erupted; DSM3 = third permanent molar completely erupted. According to Helm & Seidler (18), the average ages for eruption of the permanent teeth are as follows: DS1, 6 years; DS2, 8–8.5 years; DS3, 9–9.5 years; DS4, 12–12.5 years; DSM1, 6 years; and SM2, 13–13.5 years.

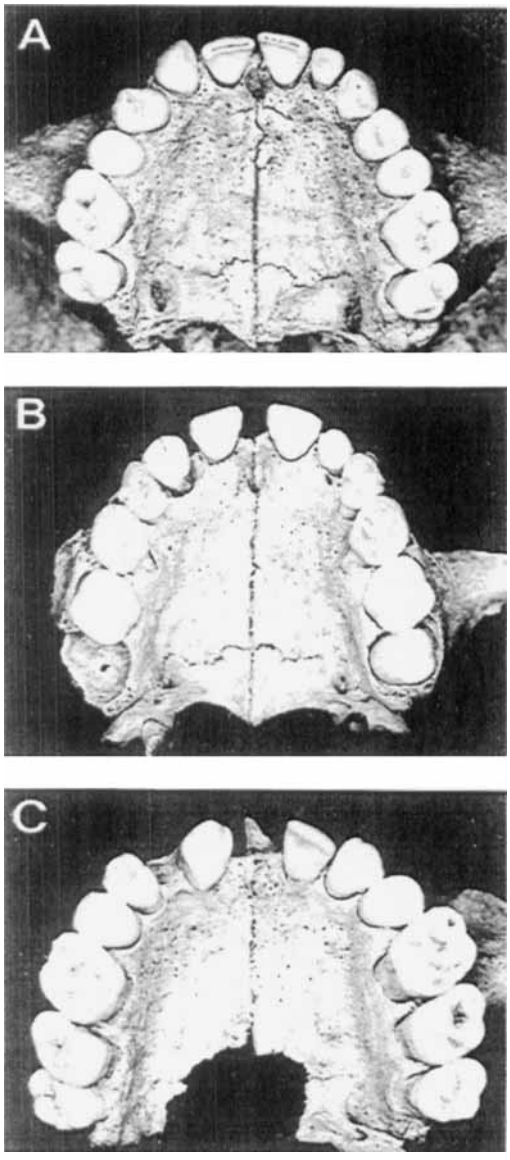

Fig. 5. Anthropologic maxillary material illustrating the occurrence of agenesis of the anterior teeth. (Magnification, ×1.) A. Upper jaw from child cranium in DS4M2. Agenesis of 2+ is registered. B. Upper jaw from child cranium in DS2M1. Agenesis of 2 + 2 is registered. C. Upper jaw from adult cranium. Agenesis of 2.1 + 2.5 is registered. The palatal opening of the incisive foramen is markedly reduced. In all three cases the medial part of the incisal suture is seen.

Sex differences in eruption rates are recorded. Thus girls are 2–5 months in advance of boys.

Roentgenograms were taken of all child craniums to register deviations in the unerupted dentition. The crania showing deviations in the dentition were also examined radiographically, to register unerupted teeth. The radiographs were taken with a Phillips Secondent 65 kVp, 7.5 mA. The film used was Kodak Ekstraspeed film, occlusal, safety E.1, routinely processed.

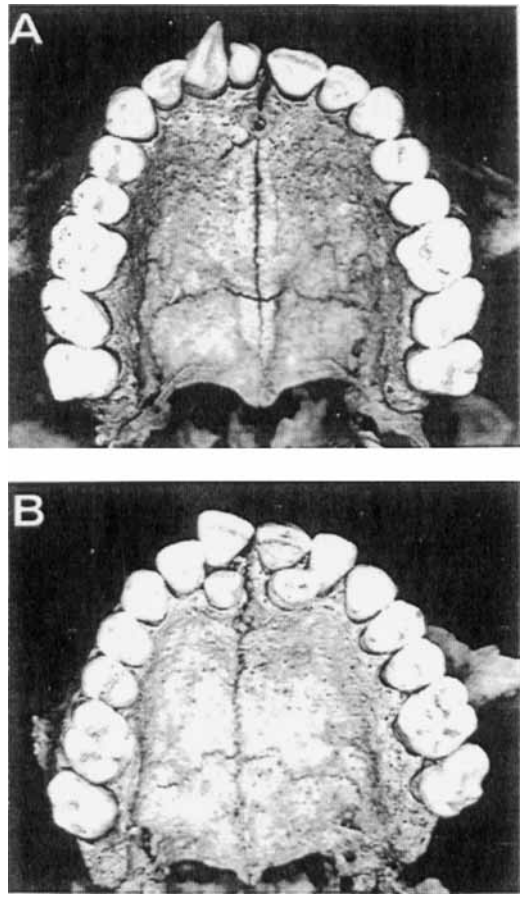

Fig. 6. Anthropologic upper jaw material from adult crania, showing supernumerary central incisors. A. A supernumerary tooth, located between the central incisors. An open incisal suture is observed in the right side of the jaw where the supernumerary tooth is present. This is not seen in the opposite side of the jaw. B. Two supernumerary teeth can be seen, located palatally to 1 + 1. An incisal suture is not seen.

Spatial conditions in the dental arch. The spatial conditions in the anterior region from maxillary canine to maxillary canine were examined anthropologically on all the crania and characterized as 'normal' space conditions when approximal contact between the teeth was recorded, 'crowding' when the teeth were overlapping each other, and 'spreading' if no contact was found between the teeth. Lastly, 'teeth lost post mortem', meaning that a registration of the teeth was impossible, was noted.

Results

The results concerning the appearance of the incisal suture, the size of the premaxilla, the development of the incisors, and the spatial conditions in the front are as follows.

Suture closure and premaxillary area

The area of the premaxilla was related to the degree of closure of the incisal suture. No direct relationship could be demonstrated between the premaxillary area and the degree of closure at any given dental stage (Fig. 3).

Some cases of dental deviations were examined; the premaxillary areas of these jaws were considerably smaller than normal (Figs. 4 and 5). The three agenesis cases had a more open suture than normal individuals at the same dental stage.

In the two jaws with supernumerary teeth the size of the premaxillary area did not differ markedly from the normal (Figs. 4 and 6).

Development of the dentition and relation to suture closure

Dental stages from DS01 to DS4M3 were recorded. A reduction in the length of the suture occurred between DS01 and DS4M3 (Fig. 7). It is remarkable that the main changed occurred between DS01 and DS02. In jaws with deviations in the dentition the pattern of suture closure was different. In the three cases with agenesis the suture was more open, and in the cases with super-

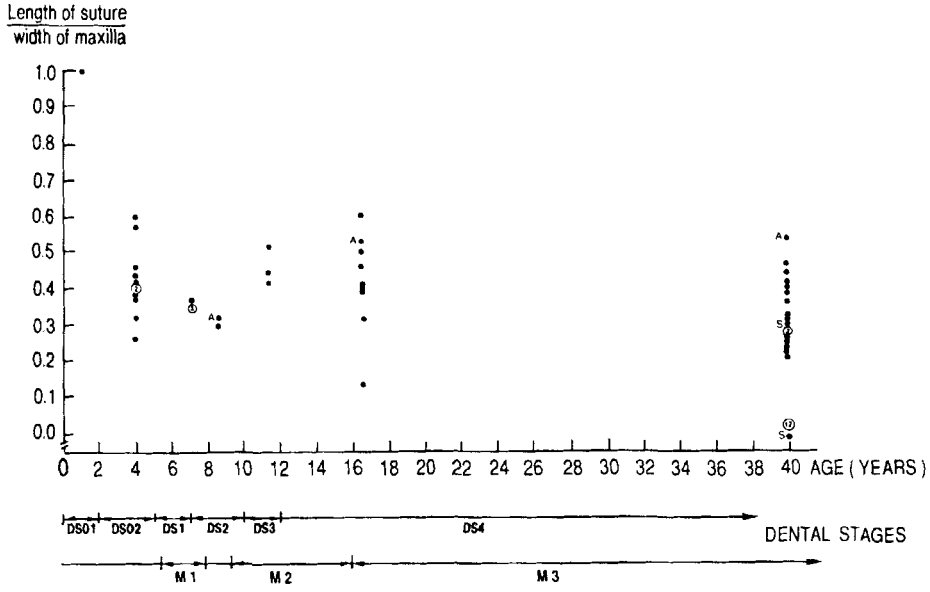

Fig. 7. The degree of closure of the incisal suture in relation to the dental stages. Black circle = normal cases. Agenesis cases are marked 'A'; cases showing hyperdontia are marked 'S'. A reduction in the length of the suture takes place between DS01 and DS4M3. It is remarkable that the main change takes place between DS01 and DS02.

numerary teeth the suture pattern did not differ convincingly from the normal appearance. In 2 of the 30 child crania examined (DS01–DS4M2) dental anomalies were found in the anterior region: one case with agenesis of the upper left lateral incisor and one case with agenesis of both upper lateral incisors. Of the 33 adult crania included in the study (DS4M3) three different dental deviations were found; one cranium showed multiple anterior agenesis, one cranium had a single supernumerary tooth, and one had two supernumerary teeth (Figs. 5 and 6). The normal material accordingly comprised 28 children and 30 adults.

The radiographic investigation of the anterior part showed that unerupted front teeth were all normal in relation to the stage of development.

Size of the premaxillary area and spatial conditions

The area of the premaxilla was calculated and related to the dental stage of eruption. The size of the premaxillary area was larger in the cases representing the later dental maturity stages. On the basis of spatial conditions the normal material was further divided into three groups (Fig. 4): group 1 = normal anterior space; group 2 = anterior crowding; and group 3 = anterior spreading.

In DS4M3 (completely developed jaws) the mean premaxillary area was 93.5 mm^2 in cases with crowding, 107.8 mm^2 in cases showing normal spatial conditions, and 111.9 mm^2 in cases with spreading. In the three individuals with agenesis of teeth the areas were considerably smaller than in the normal material: 49.7 mm^2, 59.0 mm^2, and 61.1 mm^2, respectively. The two crania with supernumerary teeth had premaxilla areas close to the normal values (Fig. 4).

In 5 of the child crania and 4 of the 33 adult crania the teeth were lost post-mortem. Accordingly, it was not possible to record the spatial conditions in these cases.

Discussion

In the present study the question of the function of the incisal suture is raised. Is the suture related to palatal growth and hence to be regarded as an ordinary growth suture, in which the rate and intensity of growth follow the child's ordinary growth rate, or does the suture have a function related to the local incisor development such as development of tooth germs or to the eruption of the incisors?

Bjørk & Skieller (19) have shown that the median palatal suture closes in connection with puberty, earlier in girls than in boys, and that it is consequently a palatal suture with an ordinary growth function. Njio & Kjær (10) have shown that early in the prenatal period the incisal suture differs markedly from the transpalatal suture. This difference is observable both macroscopically and microscopically. The conclusion is that prenatally the function of the suture is related to early tooth development such as alterations in size and location of tooth germs and not to the growth of the palate. If this relationship also applies postnatally, closure of the incisal suture should begin when the mesiodistal width of the crowns of the permanent teeth has reached its maximum. Opinions are divided in the literature concerning the closure of the incisal suture in relation to age. Ashley-Montagu (5) found that 26% of all crania included in the study in question still showed a visible suture after 6 years of age. Mann et al. (2) found that the lowest age for total closure of the incisal suture was 25 years. In an investigation undertaken by Behrens & Harris (4), the suture persisted for 4–5 mm medially on the surface of the palate in half of the adult crania examined.

The present study shows that the main closure of the suture takes place early in development, before eruption of the permanent incisors. At the same time this study confirms Behrens & Harris's investigations (4) on the persistence of the medial part of the suture in adult persons. The closure of the suture hence appears to follow a two-phased course with a possible occasional persistence of the most medial part. The degree of closure of the suture thus seems unsuitable in anthropologic age determination. The medieval material is, because of its

considerable size, considered to be representative of the period and the population concerned.

In the present study the size of the premaxilla was calculated in connection with spacing and crowding. Under normal growth conditions the maxilla is modeled in several ways. When the teeth erupt, the alveolar process becomes elongated in the vertical plane as a result of appositional growth on the alveolar process (20). It has been reported that the dimension of the premaxilla increases in accordance with the growth of the maxilla in the median palatal suture. The growth posteriorly in the medial palatal suture is more pronounced than anteriorly (19). As space is gained in the incisor area by the mesial drifting of the teeth after the growth in the median suture, skeletal growth contributes not only to the size of the premaxillary area but also to dental crowding and spacing. Traditionally, only interdental spatial conditions have been related to the size of the teeth. The area of the premaxilla has not previously been related to the interdental spatial conditions. The present study suggests that in the event of crowding the mean area of the premaxilla is smaller than the area in a premaxilla with normal spatial conditions. In cases with spacing the mean value is above the value found in crania with normal spatial conditions in the maxilla.

In the three crania in which agenesis was registered, the area of the premaxilla was considerably less than the mean value for the premaxillary area in individuals with normal spatial conditions. In these cases reduced amounts of both tooth and bone substance were observed. Kjær (21) has previously described a close relationship between prenatal outgrowth of peripheral nerve tissue and early maxillary bone formation. Deficient nerve supply in a certain area of the jaw might perhaps result in tooth agenesis and in reduction of skeletal tissues, as proposed by Jakobsen et al. (22). The case presented in Fig. 6C is remarkable in this context. It is striking that, on the one hand, three incisors are missing and, on the other hand, a premaxillary area that is almost pathologically underdeveloped is seen. Again these findings are seen in conjunction with a severely reduced incisive foramen, possibly indicating lack of nerve supply. The foramen appears asymmetric, especially with an undeveloped diminutive canal entrance in the right half of the jaw, where both incisors are missing. The possibility that this condition might be caused by an early trauma is contradicted by the fact that in the maxilla and mandible in question, agenesis is also seen, in accordance with the well-known agenesis pattern: the second premolar in the upper jaw and a central incisor in the lower jaw. This individual cranium has, in addition, a reverse maxillary overjet, which also supports the presumption of a congenitally deficient maxillary development, possibly caused by reduction in nerve supply.

Conclusion

To summarize, the present study has shown a connection between the extent of the incisal suture and tooth maturation and a connection between the incisal suture and the size of the premaxillary area and the interdental spatial conditions. In cases of dental deviations these different variables are affected to various extents. For more reliable conclusions in this context, further investigation of other anthropologic material with dental anomalies is necessary. The present work indicates that both postnatally and prenatally the function of the incisal suture most likely is linked to the maturation of tooth germs. Thus the investigation has created some new perspectives and restrictions for the use of the suture in the fields of anthropology and in addition for the understanding in orthodontics of the relation between early dental and skeletal maturation.

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References

1. Delaire J. Considerations sur l'acrossement du premaxillaire chez l'homme. Rev Stomatol 1974;75: 951–70.

2. Mann RW, Symes SA, Bass WM. Maxillary suture obliteration: aging the human skeleton based on intact or fragmentary maxilla. Forensic Sci 1987; 32:148–57.
3. Sperber GH. Craniofacial embryology. Bristol: John Wright & Sons Ltd, 1981:28–50.
4. Behrens RG, Harris FH. The premaxillary-maxillary suture and orthodontic mecanoherapy. Am J Orthoped Dentofac Orthoped 1991;99:1–6.
5. Ashley-Montagu MF. The premaxilla in the primates. Q Rev Biol 1935;10:181–208.
6. Woo JK. Ossification and growth of the human maxilla, premaxilla and palatal bone. Anat Rec 1949;105:735–53.
7. Bollobas E. Fissures canals and syndesmoses in the fetal maxilla. Acta Morf Hung 1984;32:231–43.
8. Wood NK, Wragg LE, Stuteville OH. The premaxilla: embryological evidence it does not exist in man. Anat Rec 1967;158:485–59.
9. Wood NK, Wragg LE, Stuteville OH, Oglesby RJ. Osteogenesis of the human upper jaw: proof of the non-existence of a separate pre-maxillary center. Arch Oral Biol 1969;14:1331–41.
10. Njio BJ, Kjær I. The development and morphology of the incisive fissure and the transverse palatine suture in the human fetal palate. J Craniofac Gen Dev Biol 1993. In press.
11. Haskell BS, Farman AG. Exploitation of the residual premaxillary-maxillary suture site in maxillary protraction: an hypothesis. Angle Orthod 1985;55:108–19.
12. Koch HD. Udgravningen i Ahlgade 15–17. In: Museet for Holbæk og omegn. Årsberetning. 1986:59–66.
13. Brøste K, Jørgensen JB, Becker CD, Brøndsted J. Prehistoric man in Denmark: a study in physical anthropology. Copenhagen: Einar Munksgaard Publishers, 1956.
14. Sellevold BJ, Hansen UL, Jørgensen JB. Iron age man in Denmark. Prehistoric man in Denmark. Vol III. Copenhagen: Det Kongelige Nordiske Oldskriftselskab, 1984.
15. Sagne S. The jaws and teeth of a medieval population in southern Sweden. An anthropological study of a skull material with special reference to attrition, size of jaws and teeth, and third molar impaction. Ossa 1976;3 Suppl 1.
16. Lynnerup N, Lynnerup O. Automatic data acquisition of anthropological measurements. Comput Biol Med 1993. In press.
17. Bjørk A, Krebs Aa, Solow B. A method for epidemiological registration of malocclusion. Acta Odontol Scand 1964;22:27–41.
18. Helm S, Seidler B. Timing of permanent tooth emergence in Danish children. Community Dent Oral Epidemiol 1974;2:122–9.
19. Bjørk A, Skieller V. Growth of the maxilla in three dimensions as revealed radiographically by the implant method. Br J Orthod 1975;4:53–64.
20. Bjørk A, Skieller V. Growth in width of the maxilla studied by the implant method. Scand J Plast Reconstr Surg Hand Surg 1974;8:26–33.
21. Kjær I. Correlated appearance of ossification and nerve tissue in human fetal jaws. J Craniofac Genet Dev Biol 1990;10:329–36.
22. Jakobsen J, Jørgensen JB, Kjær I. Tooth and bone development in a Danish medieval mandible with unilateral absence of the mandibular canal. Am J Phys Anthrop 1991;85:15–23.

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