From: The Department of Anatomy (Head: Professor, Dr. Med. *Per Heier*), Dental Faculty, University of Oslo.

THE COURSE OF THE PREMAXILLARY NERVES AND BLOOD VESSELS

by

ARNE BØHN

THE PROBLEMS: INTRODUCTION AND ORIENTATION

The human premaxilla presents a number of problems which have occupied research workers for a long time. Although it has been agreed for about one hundred years now that humans do, in fact, have a premaxilla, nevertheless, there is still no general agreement regarding its precise limits, the different aspects of its phylogeny and ontogeny, nor its relation to the primary facial processes during embryogenesis. The role of the premaxilla in congenital clefts of the palate and the alveolar process is also not clear. These problems have given rise to many conflicting theories.

Despite the fact that considerable interest in the premaxilla has made this bone one of the best known and most discussed in the human skeleton, a perusal of standard and established text books shows that the difference of opinion and lack of clarity which prevail are not only of academic interest. Since they represent basic anatomical descriptions to be used by dentists, this, in itself, is unsatisfactory. From a practical clinical consideration there would be a decided advantage in having more detailed knowledge regarding the structure of this bone. Moreover, greater knowledge in this field might prove to bring new impetus into the above-mentioned discussion.

The present work draws attention to two points in the anato-

mical descriptions; first, the median suture as a division between nerves and vessels in the right and left premaxillae, and second, the course of the artery in the incisive canal.

Next, there is a consideration of what limited material can yield on these points. Finally, an appraisal of the findings is given.

Below are listed the nerves and vessels with which the investigation was especially concerned. Corresponding designations which are used in quotations from other workers are added in parentheses.

N. alveolaris superior anterior [(frontal part of) plexus dentalis]
N. nasopalatinus (n. Scarpae, le nerf sphéno-palatin)
N. palatinus anterior
A. alveolaris superior anterior
A. nasalis posterior septi [(the posterior septal nasal branch of) the spheno-palatine artery, l'artère sphéno-palatin intérieure]
A. nasopalatina (a. incisiva)
A. palatina major (the terminal branch of the a. palatina descendens, the greater palatine artery, l'artère palatine).

The Premaxillary Median Suture as Division between Nerves and Vessels of the Right and Left Sides

On the question of whether the right and left nerves and vessels of the premaxilla communicate over the midline, the usual anatomical reference works give either an incomplete answer or none at all. *Wetzel* (1922), *Gray* (1942), *Cunningham* (1951) and *Rauber-Kopsch* (1955) say that n. nasopalatinus has anastomoses over the midline, and that is all. And yet the question has been a subject of discussion for many years.

Questions regarding the nerves of the premaxilla were asked most frequently about half a century ago, when the development of the injection technique with modern local anaesthetics began, following the introduction of novocaine. Throughout that time, articles and textbooks were written in large numbers and, as usual, the views were strongly divergent.

The majority of authors are agreed that unilateral infraorbital block which cuts off n. alveolaris superior anterior is in many

cases not sufficient for full anaesthetization of the central and lateral incisor. Four different opinions prevail regarding the anatomical features of this region. These may be summarized as follows: (1) there are anastomoses over the midline of n. alveolaris; (2) accessory innervation of the teeth from n. nasopalatinus; (3) both these features exist together; (4) the central and lateral incisors are innervated by n. nasopalatinus alone.

Each of these standpoints is based upon experience from injection experiments and/or findings from dissection material. Occasionally, conclusions are also drawn from what seems to be known about the normal and abnormal embryogenesis of the face.

The following representative quotations illustrate the differences of opinion:

(1) *Raab* (1950) (concerning infraorbital anaesthesia): "Es ist dabei zu bedenken, dass wegen des Übertretens von Nervenfasern aus dem Plexus dentalis der anderen Kieferhälfte diese Anästhesie noch durch eine örtliche Injection knapp an der Mittellinie ergänzt werden soll."

Monheim (1957): "While the block of the anterior and middle alveolar nerve anesthetizes the five anterior teeth, it is necessary to allow for midline or overlapping innervation by infiltrating over the apex of the opposite central incisor." And further, "It has been claimed that the occasional failure to obtain pulpal anesthesia by the supra-periosteal method is due to innervation from the nasopalatine nerve, and that injection into the incisive canal should be used to supplement this injection in such cases. However, during the last five years I have given the infra-orbital injection in all instances when the supra-periosteal has failed, and each time, complete pulpal anesthesia has been the result. Since it is impossible for the nasopalatine nerve to be influenced by this injection, the theory of the innervation of the incisors from the nasopalatine nerve would appear to be ruled out by this observation."

(2) *Sicher* (1952) (also on infraorbital anesthesia): "The anesthetic zone frequently does not reach to the midline, and pulp and periodontal membrane of the central incisor are not

anesthetized, or are only partly anesthetized. It has been claimed that this is caused by a crossing of the alveolar nerves over the midline of the face from one side to the other. Although such an overlapping nerve supply is true for the skin, it could be proved that the anterior superior alveolar nerves are entirely restricted to one side of the upper jaw. The paramedian defect of the infraorbital anesthesia is, in fact, caused by the participation of fibers of the nasopalatine nerve in supplying this area. The nasopalatine nerve and the superior alveolar plexus exchange nerve fibers just below the nasal floor." The author does not discuss more closely the proof referred to of the absence of anastomosis between the alveolar nerves of the two sides.

(3) *Fisher* (1925): "Von besonderer Wichtigkeit ist ein Zweig des II. Astes der N. nasopalatinus, der am vorderen Gaumendach ausmündet und kurz vor seiner Endausbreitung feine Aste zu den Pulpen der Schneidezähne abgibt." Further concerning infraorbital anaesthesia: "Wegen der Anastomose der Gegenseite wird man gut tun, in der Spina nas. ant. der *anderen* Seite eine bestimmte Menge (1 ccm.) der Lösung zu injizieren, wenn man nicht vorzieht, beide Infraorbital-nerven mit N.S.L. zu tränken."

Seldin (1942): "The maxillary or second divisional nerve of any one side with the associated sphenopalatine ganglion represents the sensory nerve supply of all the structures of the upper jaw. Theoretically, therefore, when the trunk of the nerve is blocked (in fossa spheno-palatina), all the terminal ramifications depending upon the main nerve, including the inner and outer nerve loops, should equally be desensitized — as far as the median line. Practically, however, we discover that the anesthesia is secured up to the cuspid only; the anterior region is only partly anesthetized, if at all. That this incomplete anesthesia may be attributed to accessory innervation by overlapping branches from the maxillary or second division of the other side of the head is proved by the fact that the bilateral blocking of both maxillary nerves temporarily suspends sensation from the entire upper jaw."

What *Seldin* calls "inner and outer loops" includes, according to his preceding explanation, n. nasopalatinus and n. alveolaris superior anterior, respectively.

(4) *Phillips & Maxmen* (1941) obtain full anaesthesia of the incisors by injection in the incisive canal. They give a picture of the development of the face on the usual lines, and conclude, "A rational assumption based on this knowledge leads us to believe that the nasopalatine nerve which develops along with the median nasal process innervates the incisors which are also developed in this process. Further proof of this theory may be seen in cases of double cleft lip and palate." *Cook* (1949) supports this view.

Disregarding the literature on injection methods, the subject of the nerve and blood supply of this area has especially attracted the attention of one writer, viz. *Veau* (1926). He treated the problem out of a desire to elucidate the innervation of the teeth and jawbone, and the blood supply, by the jaw clefts. His conclusions are different again from all the above quotations. Admittedly, he asks in one place: "Qui connaît les nerfs de l'os intermaxillaire?" But on the basis of his clinical observations and experience, together with macroscopic and microscopic discoveries in dissection material, he maintains that the midline is an absolute division between nerves and vessels of the right and left sides of the premaxilla. Nevertheless, he must have found some signs that this does not apply unreservedly: "Sur le foetus coupé en serie, j'ai vu souvent que le nerf sphénopalatin donne un petit filet qui aborde l'os sur la ligne médiane audessus et en arrière de l'ébauche de l'incisive médiane. Il me semble prouvé qu'une partie au moins de l'intermaxillaire a une innervation axiale." And in another place: "Une seule fois nous avons pu suiver un petit filet nerveux absolument insignifiant qui franchissait la ligne médiane et se dirrigeait vers l'apex de l'incisive médiane". No importance, however, is attributed to these findings: "..., les deux moities de l'os incisif restent toujours distinctes".

Sicher and *Veau* drew attention to the fact that the conditions are completely opposite in the soft tissues which cover the premaxilla. No midline exists as a division, either for muscles, nerves or vessels.

There are two more authors who should be mentioned as having reported observations of interest in this connection. *Bellairs*

(1951) investigated the contents of the incisive canal. He produces, as a subsidiary finding, a photograph of a horizontal section which shows anastomosis between arteries accompanying the right and left n. nasopalatinus around the middle of the canal. In a horizontal section he draws attention to an unpaired artery, cut transversely and lying centrally located in the connective tissue of the median suture, somewhat in front of the incisive canal. *Bruni* (1913) also mentioned this artery, and both authors hold that it is most frequently present, but neither of them investigated its course closely.

A summary of this information shows that we have before us the following answers to the question whether nerves and vessels anastomose over the midline:

Nerve or vessel	Anastomoses across midline	
	Yes	No
n. alveolaris sup. ant.	*Raab, Monheim, Fisher, Seldin*	*Sicher, Phillips & Maxmen, Veau*
n. nasopalatinus	*Wetzel, Rauber-Kopsch Gray, Cunningham*	*Veau*
a. alveolaris sup. ant.		*Veau*
a. nasopalatina	*Bellairs*	*Veau*

Further, *Wetzel* and *Rauber-Kopsch* have reported an indirect connection over the midline for n. alveolaris superior anterior. Apart from the above-mentioned anastomosis between both nn. nasopalatini, they report that a branch of n. nasopalatinus in the floor of the nasal cavity anastomoses with a ramus nasalis from the alveolar nerve. Thus we get: r. nasalis and n. nasopalatinus ⟷ n. nasopalatinus and r. nasalis.

Finally, it is mentioned in the literature that in the midline itself there is found a nerve *(Veau)* and an artery *(Bellairs, Bruni)*. Their courses are not described or illustrated which in itself is a good reason for further investigation.

These incomplete and, to a certain extent, conflicting descriptions clearly show the need for new investigations and a com-

plete and conclusive survey, supplemented by detailed information. Perhaps, too, an explanation might be given for the divergences which have arisen.

The Course of the Artery in the Incisive Canal

From all descriptions of the premaxillary nerves and vessels, it is evident that an artery runs through the incisive canal, parallel to n. nasopalatinus. It is sometimes given a name of its own, a. nasopalatina or a. incisiva, but at least as often, it is described merely as a terminal branch of a. nasalis posterior septi, or as a terminal branch of a. palatina major. This reveals a difference of opinion with regard to the direction of the bloodstream in the canal. The question is whether the blood flows from the nose towards the palate or *vice versa*. A natural consequence of this is that when a junction of the nasal and the palatal artery is described, the location of this junction is given differently, either at the lower or at the upper end of the canal. Some textbooks avoid this difficulty by merely mentioning that the two arteries anastomose, without saying where this occurs, or by simply saying that there is an anastomosis in the incisive canal.

Examples of these different opinions are given below:

Downward direction:

Wetzel (1922) depicts a. nasalis posterior septi as an accompanying artery to n. nasopalatinus down through the incisive canal, and explains in the text that this artery in the foramen incisivum anastomoses with a. palatina major.

Upward direction:

Veau (1926): "Il nous semble que chez le foetus la circulation dans le canal palatin antérieure se fait du palais vers le nez. ... quand on incise la muqueuse palatin à sa partie antérieure, l'hemmoragie se fait en jet *par la lèvre posterieure.*"

Gray (1942): "The terminal branch of the artery (palatina descendens) passes upwards through this canal (can. incisivus) to anastomose with the sphenopalatine artery."

Sicher (1952) and *Pernkopf* (1954) express the same: a. nasopalatina goes as a terminal branch of a. palatina major up

through the canal, and anastomoses at the upper end of the canal with a. nasalis posterior septi.

Direction not defined:

Rauber-Kopsch (1921) only says that the palatal and the nasal artery anastomose.

Spalteholz (7th edition) has a picture of aa. nasales posteriores septi which shows "anastomosis with the a. palatina major in the canalis incisivus".

Schreiner (1921): ". . . art. nasalis posterior septi goes together with n. nasopalatinus in a groove in Vomer and anastomoses in the incisive canal with a. palatina major."

From this it is not clear whether a. posterior septi is only an artery for the mucous membrane of the nose, with supplementation from a. palatina major, or whether both arteries have common terminal branches in the gingiva and the mucous membrane of the palate.

This provides ample reason for carrying out research to determine whether a. nasopalatina always flows exclusively in one of the directions mentioned, and if so, which direction. Perhaps the bloodstream varies from one individual to another. Perhaps, also, it may change in the same individual according to a certain law, or by chance.

THE AUTHOR'S STUDIES

Material and Methods

For this study, nine human upper jaws were used.

The specimens, all formalin-fixed, were taken out as blocks, ½—1½ cm in width, on each side of the midline. In length, they extended from the fore-edge of the upper jaw to a little behind the papilla incisiva, and in height from the under-edge of the alveolar process to a little way up on the nose partition.

The preparations were decalcified, dehydrated and embedded in paraffin wax. After sectioning, complete series were mounted and stained with haematoxylin-eosin, van Gieson and Goldner stain. The section thickness was 5—6 μ.

"Camera Lucida" was used to a great extent to obtain a general view of the sections.

Preparation	Assumed Age*	Direction of Section
1	about 430 days	vertical at 30° to the sagittal plane.
2	„ 285 „	sagittal
3	„ 210 „	horizontal
4	„ 225 „	„
5	„ 240 „	„
6	„ 280 „	„
7	„ 180 „	frontal
8	„ 250 „	„
9	„ 255 „	„

* Days after fertilization, calculated from the hospital's records.

Some of the results obtained from the histological material made it desirable to examine macroscopically the medial bone-wall of the premaxilla. This was done on 55 cranial fragments where the medial wall was exposed and mostly undamaged.

Histological Findings

In the following synopsis, greater significance has been accorded to those features which could be observed in all or most of the sectional series. It proved to be convenient to divide the description into four divisions. These are (a) the premaxillary median suture, (b) the incisive canal, (c) the arteries, (d) the nerves.

Figures 1, 2, and 3 have reference in all four divisions. Reference to the other figures is made incidentally in the text.

The premaxillary median suture

The anlage of i_1, the deciduous central incisor, is surrounded by an incomplete hood of premaxillary bone. Apart from being open orally, the hood has openings against the neighbouring anlage (i_2, the deciduous lateral incisor), causing it to be incomplete. The permanent incisor, I_1, which is found in the bell stage, falls within the same hood. However, there is an incomplete partition of bone between the anlages of the temporary and of the permanent tooth. The medial wall of the bony hood is also the

Fig. 1. From preparation no. 6.

Horizontal section showing the median artery with accompanying nerve in its horizontal part, just under septum nasi. On the left side is seen n. alveolaris superior anterior with a number of branches over the apical part of the anlage of the permanent medial incisor. Similarly, on the left side is seen one and on the right side three branches of this alveolar nerve on its way into the midline. Ductus nasopalatinus with accompanying artery etc. is seen in front of and lateral to n. nasopalatinus. Connective tissue links the canal branches with each other and across the midline.

Fig. 2. From preparation no. 6.
Horizontal section approximately in the middle of the incisive canal. The canal branches, with clearer demarcation in the bone. On the left side a new branch of plexus dentalis has come out in the midline. The other branches have a downward direction on the medial side of the follicle of the permanent incisor. The canals and the median artery have approached each other more closely.

Key to abbreviations in Figures 1, 2, 3, 6, and 8:

a.j. = arterial junction in foramen incisivum
a.n.p. = a. nasopalatina
a.p. = the median artery (a. praemaxillaris mediana)
a.p.m. = a. palatina major
c.i. = canalis incisivus
c.p.s. = cartilago paraseptale
c.s. = cartilago septale
d.n.p. = ductus nasopalatinus
f.i. = foramen incisivum
n.a. = n. alveolaris superior anterior
n.n.p. = n. nasopalatinus
n.p. = the median nerve (n. praemaxillaris medianus)
r.n. = ramus nasalis of n. alveolaris superior anterior
s.i. = sutura incisiva

Fig. 3. From preparation no. 4.

Horizontal section in foramen incisivum. The two nn. nasopalatini have reached very close to each other and the median artery has come inside the same connective tissue capsule. In this case a. nasopalatina on the left side runs backward and laterally to join up directly to a. palatina major. Still further down, both aa. palatinae majores will join the median artery. The right ductus canal here only contains a diminutive artery, two veins and two fine nerve fibres.

medial limit of the premaxilla. It extends anteriorly from spina nasalis anterior and the inferior of the alveolar process backwards to the upper and the lower opening of the incisive canal.

The cleft between the medial walls of the premaxillae of the two sides is filled with the connective tissue which forms the premaxillary median suture.

The two medial walls are slightly convex towards the midline. They are not completely in contact at any point, but come relatively near each other in the frontal half, corresponding to the greatest curvature of the crowns of both deciduous central incisors. From here forward, the cleft broadens out slightly, until the medial wall progresses with an even curve into the frontal wall. Behind, the cleft also broadens out somewhat, to again become narrower between the two incisive canals.

The median suture essentially consists of connective tissue of a periosteal nature. From the frontal wall on both sides, one can follow the periosteum into the cleft opening, where the two strata fibrosae lie close to each other. Their long horizontal parallel fibres running in the sagittal direction soon become interlaced across the midline, and this network is reinforced by a few fibres which run crosswise, approximately vertically to the median plane. Further inwards the sagittal fibre groups gradually come to an end, and essentially transverse fibres may be noted. In the lace work there are also fibres with an almost vertical course.

From openings in the medial walls, relatively large blood vessels directed towards the midline may be noted, especially in the upper part of the median suture. These vessels, which must be assumed to come from the supply region of a. alveolaris, can usually be followed for a short distance only. Occasionally, they may be seen extending further and will sometimes be found connecting with a main median vessel. This is described more closely in the section on the arteries. A clear and conspicuous anastomosis across the midline is seen in Fig. 4. This finding, however, is restricted to this one case. The connective tissue of the suture is otherwise permeated by numerous capillaries which, on the whole, follow the direction of the fibres, and which can very often be followed from one side of the midline to the other.

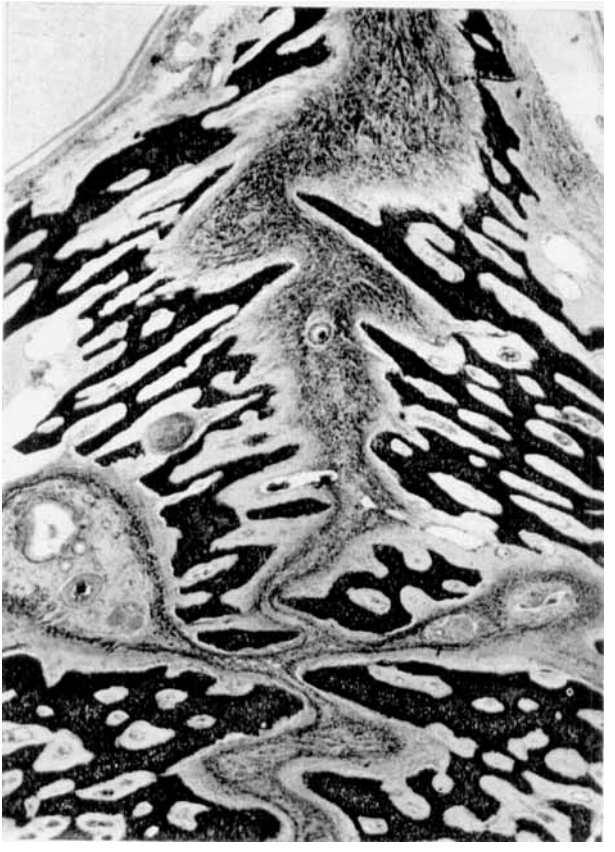


Fig. 4. From preparation no. 4.
Horizontal section with blood vessel across the midline.

In this area are also found a number of nerve fibres which appear to come partly from plexus dentalis and partly from n. nasopalatinus. A description of these nerve fibres is given in the section on nerves.

The Incisive Canal

The right and left incisive canals (can. Stensoni) open into the nasal floor, one on each side of the septum of the nose, medially and just behind the crowns of the anlages of the medial permanent incisors. On their way through the bone, the canals

are bounded in front and on both sides by the premaxillary bone, and posteriorly by the frontal edge of the hard palate. In this area the sutura incisiva is a clear boundary between the maxilla and the premaxilla.

The canals run downwards, slightly forward and medially, and finally converge and open on the palatal side in the foramen incisivum. Nowhere is a canal completely surrounded by bone, or completely separated from the other by a continuous wall. Even at the top, where the canals lie furthest away from each other, a horizontal section shows the connection of the fibrous tissue through a winding bony cleft on each side of, and across, the midline.

Each of the canals is again divided into two parts, an anterior or lateral part and a medial part. *In the anterior part,* a longer or shorter ductus nasopalatinus, which leads from the nasal cavity down in the direction of the papilla, may be noted. Inside it is covered with a continuation of the nasal mucous membrane. Together with the duct an artery, one or two thin nerve branches, a fair number of mucous glands with outlets to the duct, epithelial masses and cystic cavities may be seen. *In the medial part, slightly posteriorly,* n. nasopalatinus, in one or, more often, several branches, runs together with an artery.

Moreover, there is found in both parts of the canal a connective tissue, which is partly arranged in a loosely knit lacework and partly in tighter fibre groups surrounding the various regions of the canal and connecting them to each other. Finally, a number of veins are found.

The above-mentioned tissue elements, which constitute the contents of the canals, vary quite considerably from one specimen to another and are also frequently different on the right and left sides. The connective tissue, the nerves and the veins, however, are rather constantly found in the places mentioned.

The Arteries

In all the preparations, anastomoses are found between vessels of the incisive canals of the right and left sides.

All the arteries of the two above-mentioned regions of the canals may be identified as continuations or branches of a. nasalis posterior septi. Often they gradually become smaller and

have almost disappeared before they reach the foramen incisivum. One or two of them may show a direct connection with a. palatina major in or near foramen incisivum, which is a conspicuous junction.

An attempt has been made to reconstruct the course of these arteries on the basis of the horizontally cut preparations (Fig. 5). The superimposed arrows show the direction in which the lumen of the arteries appears to diminish. The illustrations also show that from the junction in the foramen incisivum some new arterial branches extend. Of these vessels, those which appear rather constantly are; two or three small branches which follow n. nasopalatinus in its terminal ramifications forward and downward into papilla incisiva; one unpaired branch which, from the *frontal part of foramen incisivum, has its course entirely in the* median plane, centrally in the connective tissue of the suture. It runs, as a rule, in a big curve, first approximately vertically, then almost horizontally under the septum, and continues its course forwards and a little downwards to the soft tissue just under spina nasalis anterior, where its terminal branches are to be found. Fig. 6 a shows the course of this artery in its entirety, from preparation no. 2.

This last mentioned artery is called *the median artery.*

Occasionally, especially where the stems of a. palatina major do not reach the foramen incisivum, either on the right or on the

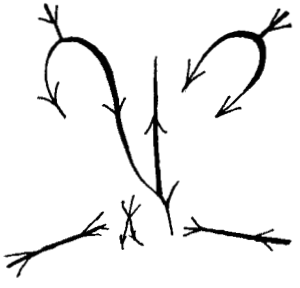
---

Fig. 5.

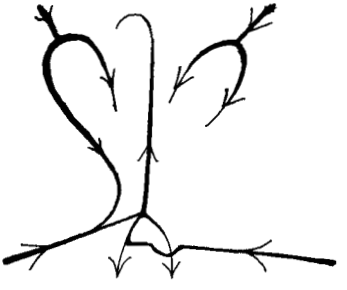
Schematic reconstructions of the artery course in the incisive canal in the four horizontally cut preparations. In the centre, a schematic overall view with the following designations:

a.d.n. = artery which follows ductus nasopalatinus
a.n.n. = artery which follows n. nasopalatinus
a.p. = the median artery (a. praemaxillaris mediana)
a.p.m. = a. palatina major
a.p.s. = a. nasalis posterior septi

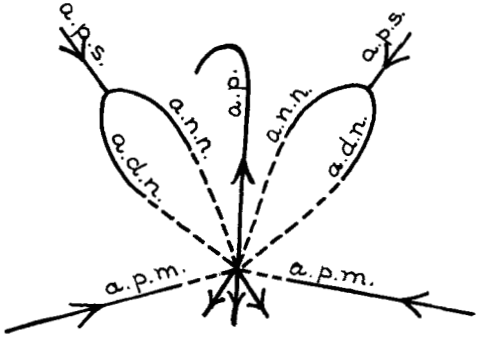
The arrows show the direction of the course of the arteries. A. palatina major does not always go as far as the foramen incisivum, and the median artery sometimes lacks the last, curved part of its course.



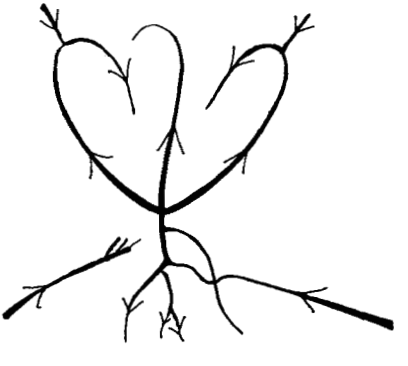
Specimen 3



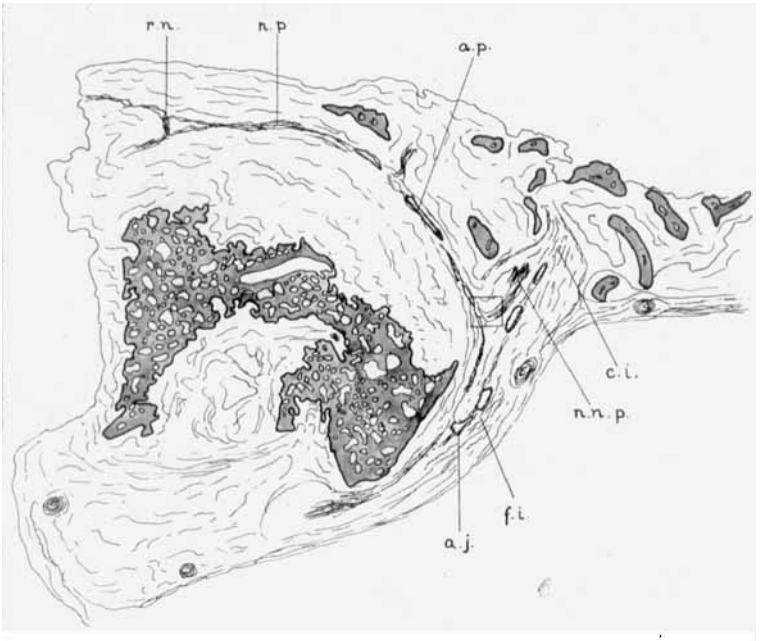
Specimen 4



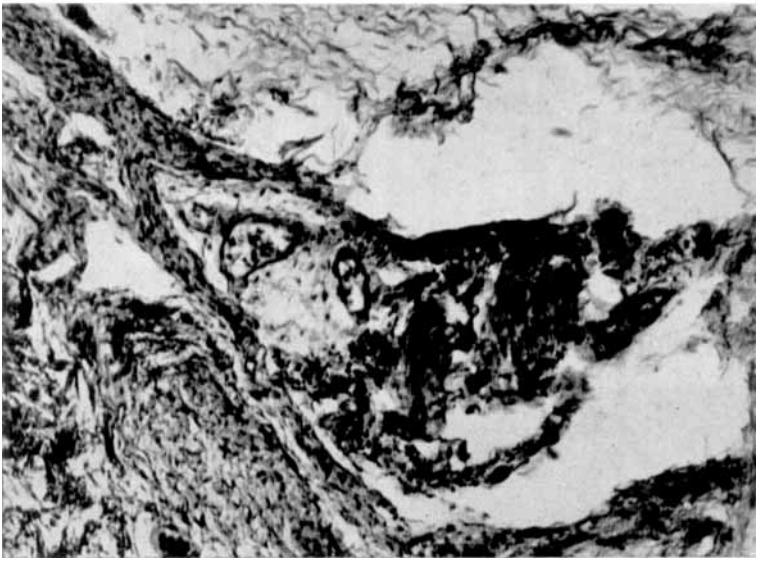
Specimen 5



Specimen 6



a.



b.

Fig. 6.

left side, the median artery is small, and can be followed only in its vertical course. In other preparations, however, it is conspicuous and relatively large.

The Nerves

Fig. 7 shows schematically the relation, described below, between the premaxillary nerves of the two sides as they appear from this study.

Before n. nasopalatinus leaves the septum and enters the canal, it divides a few times, sending branches forward into the mucous membrane. It also sends one or two small branches which follow the ductus nasopalatinus (or its canal branch where the duct is missing) down to the palatal mucous membrane. The main stem, with one, two, or three branches which lie close together, passes through the posterior, medial part of the incisive canal, and sends, en route, more or less horizontal threads towards the midline. These threads converge from the right and left sides into *a median nerve* which continues forward with the median artery. Fig. 6 a shows the median nerve together with the median artery. The course of the median nerve is the same, even in those cases where the median artery seems to be lacking its horizontal part.

The nn. nasopalatini of the two sides approach each other on their course through the respective canals, and in foramen incisivum they lie closely grouped around the median artery near its point of origin. Here also they may be found to anastomose. Then the nerve branches appear to diverge somewhat and run forward and downward into the papilla incisiva and the region just in front of the papilla.

N. alveolaris superior anterior, in its premaxillary course, consists of a number of branches. The uppermost, i.e. the foremost

---

Fig. 6. From preparation no. 2.

a. Sagittal section showing the median artery and the median nerve through the whole of their course.

The artery originates in foramen incisivum, which is also a meeting point for other artery branches. Fibres from the two nn. nasopalatini here join the median artery above its source. A good way forward is seen the point of junction with r. nasalis.

b. Greater enlargement of the source of the median nerve.

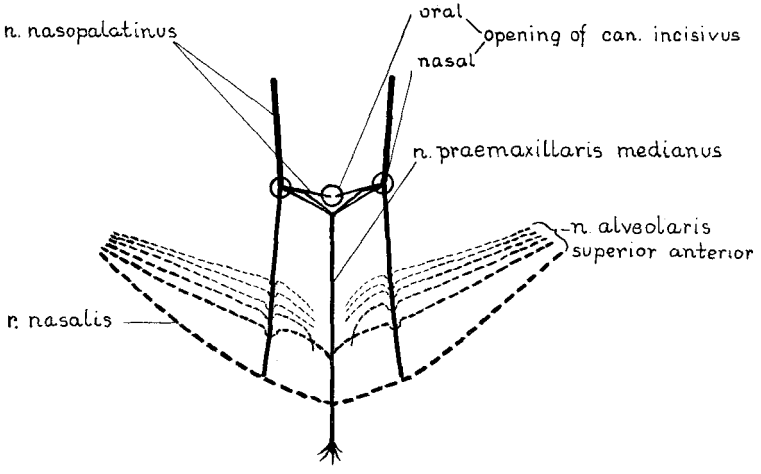


Fig. 7.

Diagram of the course of the nerves, seen from above.

N. nasopalatinus and the median nerve are drawn with unbroken line. N. alveolaris superior anterior is drawn with broken line which becomes thinner in the downward direction.

branch, goes to the mucous membrane in the frontal, medial part of the nasal floor. There it joins the threads from the first mentioned ramifications of n. nasopalatinus. Together they form a small branch which passes by way of a duct through the bone under the septum some distance forward, and from there down to the median suture, where they join the median nerve (Fig. 8).

At least one or two other branches of n. alveolaris superior anterior also go through the medial wall of the bony crypt of the tooth follicle and are thrust out in the premaxillary connective tissue of the median suture. Here they either join the median nerve, or turn forward and go under and parallel to it. It has not been possible to demonstrate with certainty any direct connec-

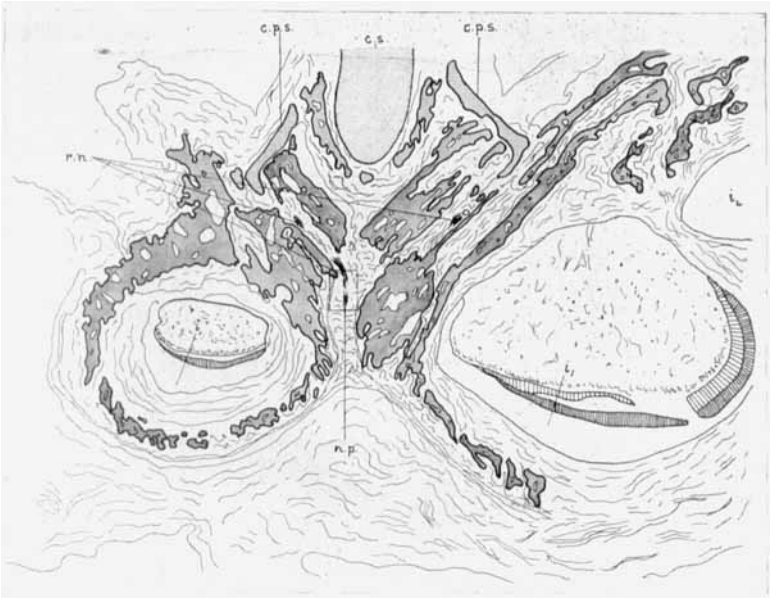
---

Fig. 8. From preparation no. 8.

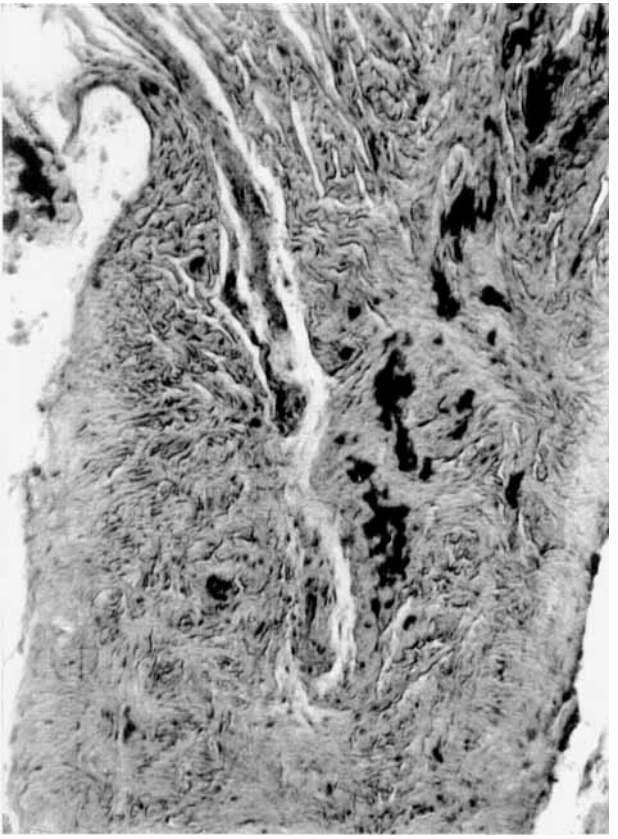
a. Frontal section far forward.

The junction of r. nasalis of the right side and the median nerve is seen in approximately the centre of the picture. The junction for the r. nasalis of the left side is found about 300 μ further back. The median artery appears to lack its most anterior part in this preparation.

b. High magnification of r. nasalis and the median nerve at the junction.



a.



b.

Fig. 8.

Fig. 9.

Left upper jaw of child approximately four years old. The medial wall of the premaxilla with the curved furrow for the median artery and its accompanying nerve.

tion between such nerve branches across the midline, but they often approach each other very closely.

The rest of the branches from n. alveolaris superior anterior, perhaps 8—10, run just over and behind the apical region of the teeth. Thence they turn downwards, along the medial periphery of the follicle of the permanent central incisor, finally giving up their terminal ramifications to the gingiva on the lowest part of the alveolar process around the midline, partly in the same region where the branches of the n. nasopalatinus end.

N. palatinus anterior has a number of very small branches that follow the palatal artery to the foramen incisivum and further forward into the gingiva. Occasionally, some of these fine branches seem to follow the arterial branches up through the foramen and onward with the median artery.

Analysis of Gross Skeletal Material

The 55 halves of upper jaws were divided by age groups as follows:

3	approx. new born
1	" 3 years
3	" 4—5 "
1	" 7 "
11	8—20 years
36	older

In the first four groups, which include specimens up to and including seven years of age, all showed in the medial wall of the premaxilla, a clear, curved furrow from the foramen incisivum, going first upwards, then forwards and finally downwards. This is in conformity with the histological observations (Figs. 6 & 9).

Fig. 10.

Left upper jaw from an approximately 15-year-old. The medial wall of the premaxilla shows a number of deep vertical furrows, but no clear curved furrow.

Fig. 11.
Right upper jaw from an approximately 20-year-old. The same strong vertical furrowing as in Fig. 10, but also clear curved furrow.

The bony wall was relatively smooth in all these small crania, with some small foramina for vessels and nerves, especially in the uppermost part near the highest portion of the curved furrow, as well as in the frontal edge.

In the older crania, the bony wall has assumed a more disintegrated appearance, with vertical grooves and bony crests (Fig. 10). Nevertheless, it was possible to find the curved furrow in six of the eleven specimens in the 8—20 year age group (Fig. 11), and in eighteen of the thirty-six from the older individuals (Fig. 11). The furrow was very clear in the cranium which was obviously from the oldest individual.

DISCUSSION AND CONCLUSIONS

This investigation has brought forward so many new features for the elucidation of the anatomical conditions in the premaxilla, that it is now possible to get a clearer picture than that which, by way of introduction, was mentioned concerning communica-

tion of nerves and blood vessels across the midline, and concerning the course of the artery in the incisive canal. This picture will, however, to a certain extent be dependent upon the significance one attributes to the median artery and nerve, i.e. the findings which in previous works have been quite insufficiently discussed.

The median artery always originates from the junction in the foramen incisivum, and as a rule can be followed, possibly with a diminishing lumen, throughout its curve upward and forward, until it comes to an end in the soft tissue under the spina nasalis anterior.

The artery was found in all preparations, and both *Bruni* and *Bellairs* say that it is seen so often that it must be regarded as normal; however, neither of these writers has followed it through its entire course. *Bellairs* believes that it is this artery, and not a nerve, that runs in the median nerve duct which *Scarpa,* in his time, described as the duct for the left n. nasopalatinus. *Le Double* (1906), who has probed the duct in numerous crania, says that it is usually a dead-end duct, only for the supply vessels. *Bellairs,* however, produces a picture of a preparation which shows the medial wall of the premaxilla of a child of nine months, and draws attention to a curviform groove from the foramen incisivum, going upwards and forwards until it ends under the spina. Without placing this in connection with the median artery which he has referred to earlier, he says that the same curve is observed in other cases, but comments: "Its significance is obscure."

The curved furrow in *Bellairs'* preparation corresponds in all essentials to the curve of the artery-nerve on the median section in Fig. 6. It has proved easy to establish that the curviform bone duct in the medial wall of the premaxilla is very common, especially in crania of infants, and there can hardly be any doubt that it contains the median artery.

Judging from the present investigations, the median artery is a normal, commonly occurring vessel. Within its limited area, it is quite a dominant feature from several months before birth and for at least some years thereafter, and often up to higher ages.

In some preparations the artery appears to be more poorly developed than in others. In such cases it is found only in the

vertical part of its course. We do not know whether it would have appeared relatively more strongly developed at a later stage in the same individual, or whether it would have remained weak. The crania of older persons, however, show that the development of the median artery in a good many cases is too weak to make an impression in the medial wall during the growth and development of the premaxilla after the earliest periods of childhood.

The median nerve has, in all preparations, been as constant a finding as has the median artery; indeed, it may be observed in its entirety even where the horizontal part of the artery's course is lost. Its origin seems always to be from the converging branches of the right and left nn. nasopalatini, joining the course of the median artery at various points, either near its source in the foramen incisivum or higher up. In all the preparations it communicates with branches of n. alveolaris superior anterior.

The median nerve was observed by *Veau*, but otherwise no mention of it is found in the literature. It is not improbable, however, that just this nerve might have been the basis of *Scarpa*'s assumption, which still persists in certain anatomical textbooks.

Although the observations made in this study did not reveal how long the median nerve may be seen postnatally, it appears likely that this structure is present as long as the curved duct makes an impression on the medial wall.

Seen in relation to many other nerves and vessels, the median nerve and artery are insignificant in size and extent, even when they appear most highly developed. Despite this, they are very noticeable when one examines the median suture, and the fact that they appear so regularly signifies that they both have a definite function, at least at one stage in the development of the premaxilla. They may also be special generic features.

Studies of more extensive and varied material, from both animals and humans, however, seem to be necessary to approach the question of a definite ontogenetic and phylogenetic significance of the median artery and nerve.

The present investigation seems, however, sufficient to establish that with this unpaired branching of artery and nerve there is a distinct communication across the midline at a certain age level. This age level coincides with an immensely important

period in the development of the jaws and teeth. The condition probably continues for a longer or shorter time.

There is every reason to give concise anatomical names to the median artery and the median nerve, viz. *a. praemaxillaris mediana* and *n. praemaxillaris medianus,* respectively.

We can now return to the two unclarified points mentioned in the introduction; the premaxillary median suture as a division between the nerves and vessels of the right and left sides, and the course of the artery in the incisive canal.

The Premaxillary Median Suture

As a result of this study, the question of anastomosis across the midline is now easier to answer. This is especially so where n. nasopalatinus and a. nasopalatina are concerned. All the preparations show that such communication occurs not just once, but a number of times, for both the nerves and the vessels.

A number of textbooks have long ago alleged anastomoses for nn. nasopalatini. As far as that goes, there is nothing surprising in having the accompanying arteries also showing anastomoses.

For the blood and nerve supplies which come from the original processus maxillaris, the answer must be more qualified.

In only one case is there a vessel of some size, which goes from the supply region of a. alveolaris superior anterior directly across to the other side, unequivocally demonstrated. Communication from the side to the median artery can be found. Moreover, there are a number of capillary anastomoses over the midline.

In the case of n. alveolaris superior anterior, no direct anastomosis over the midline has been demonstrated with certainty. The ramus nasalis of the nerve communicates, however, with a branch of n. nasopalatinus of the same side, and can be followed onwards to the terminal fibres of the median nerve. Other terminal branches of the alveolar nerve can also be followed to the median nerve, and yet others for a short distance in the connective tissue of the median suture. These branches from the two sides come very close to each other and the possibility of direct anastomoses over the midline through fine fibres cannot be dismissed, even though they have not been found in this study.

The nerve fibres and, much more rarely, blood vessels, which arise in the maxillae and which supply the bone and teeth of the premaxilla, show a number of junctions in the median nerve and artery. Even though in many specimens those junctions may be regarded as a transitional stage associated with early growth, nevertheless, their existence does mean that there are a number of possibilities for the development of direct anastomoses.

With regard to the purely practical questions which have arisen in connection with injection technique, it can safely be said that no finding in this investigation makes it reasonable to believe that n. nasopalatinus alone, in general, innervates the incisors. But there appears to be many other possible causes for the inadequate effect on the incisors of injection in the foramen infraorbitale.

These causes are:

(1) Communication between alveolar nerves of the right and left sides via the median nerve;
(2) Other possible, as yet unproved, direct connection between a few branches of the alveolar nerves of the two sides;
(3) Supplementary innervation from n. nasopalatinus via the median nerve;
(4) Supplementary innervation from n. nasopalatinus via r. nasalis;
(5) A combination of (1)—(4).

In conclusion, an answer to the first main question, i.e., that the premaxillary suture forms a barrier between the right and left sides, may now be attempted:

The midline forms no absolute division between the nerves and vessels of the two premaxillae. The connections are, however, clearly both rarer and more special than is the case for the soft tissues which cover the bone. Especially characteristic of the premaxillary median suture are the n. praemaxillaris medianus and the a. praemaxillaris mediana (here charted), which serve as links in the connection between the maxillary supplies of the two sides.

The Course of the Artery in the Incisive Canal

The proposed reconstructions of the course of the arteries in the incisive canal show a surprising number of variations from

one preparation to another. This may be the reason for the divergence in the descriptions of those anatomical features.

In only two of four cases has a. palatina major from each side been found to reach all the way to the junction in the foramen incisivum. In one case this has been shown from the one side only, and in one case not at all. On the other hand, a. nasalis posterior septi can always be followed down into the incisive canal from the nose, with branches in both parts of the canal on the right and left sides. One or two of these branches will communicate with a. palatina major where this reaches as far as to the foramen incisivum. When this occurs, such a connecting branch becomes relatively voluminous, and the direction of the bloodstream then goes, as a rule, upwards. This, in the histological sections, is determined by the direction in which the lumen of the artery diminishes. It appears that when the palatal artery participates in the blood supply to the incisive canal, it will govern the direction of the course of an a. nasopalatina. If the increase from the palatal artery is absent here, the direction of the arterial bloodstream in the canal will be determined only by the nasal artery and flow downwards.

The question naturally arises whether the situation which is present in each single preparation will necessarily continue unchanged in the growing individual. In respect to development, it is probable that a. posterior septi has attained its terminal branches earlier than a. palatina. The possibility that somewhat later the palatal artery would have gone ahead and developed more fully, and thereby would have changed the situation, is certainly not excluded; cf. preparation 3, which is from one of the youngest individuals. All in all, however, one readily accepts that the palatal artery is not so certain a participant in the blood supply to the premaxilla as is the nasal artery. That, in a number of cases, the median artery is little developed could possibly be connected with the fact that there is no supplementation from the palatal artery.

In conclusion, it may be said that the course of the artery in the incisive canal is dependent upon the different possibilities of combinations among the supply vessels; a. nasalis posterior septi, which always participates, and a. palatina major, whose participation is more irregular. The direction of the bloodstream in the

canal is upwards, in relatively large branches which show connections both to the palatal and to the nasal artery. The bloodstream goes downwards in all branches with connection only to the nasal artery.

It is possible that the supply arteries' relative influence upon the direction of the bloodstream in the canal may change with increase in age.

SUMMARY

Excisions of the anterior, central part of the upper jaw from nine human specimens of 180—430 days of age were examined microscopically in order to study whether the nerves and vessels of the premaxilla communicate across the midline, and, at the same time, whether a. nasopalatina runs from the nose towards the palate or *vice versa*. This study yielded the following findings:

(1) Nerves and vessels in the incisive canal communicate over the midline, and especially in the foramen incisivum.

(2) From an arterial junction in the foramen incisivum there extends an unpaired arterial branch which has not previously been charted. It has its course upwards, centrally in the median suture, and can very often be followed further, in a curve forward and downward, until it terminates under the spina nasalis anterior. The present author has called it *a. premaxillaris mediana,* or simply the median artery.

(3) The right and left n. nasopalatinus give off fibres which form a single, unpaired nerve branch with essentially the same course as the median artery. This is called *n. premaxillaris medianus* or the median nerve.

(4) N. alveolaris superior anterior gives off, as its uppermost and foremost terminal branch a ramus nasalis, which anastomoses a long way forward in the floor of the nasal cavity with a branch from n. nasopalatinus. Thereupon, r. nasalis continues to the median suture, where it joins the median nerve. A few other terminal branches of the alveolar nerve also lead out in the median suture, where they either join the median nerve or take a forward course, under and parallel with the latter.

(5) From the supply region for a. alveolaris superior anterior, vessels may occasionally be found in communication with the median artery. A direct course of similar vessels across the midline, apart from the median artery, was observed once.
(6) Capillaries cross the midline.
(7) The size and course of the arteries in the incisive canal vary greatly from one preparation to another, and, as often between the right and left sides. A. nasalis posterior septi is always found to contribute branches to the artery supply in the canal. A. palatina major also often contributes, i.e., when on the one side or on both sides it reaches the arterial junction in the foramen incisivum. When this is the case, an a. nasopalatina, on the one side or on both sides, will, as a rule, run upward as a connecting branch between the palatal and the nasal artery. When a. palatina major does not reach the foramen incisivum, the artery's course in the incisive canal is identified only with the nasal artery, and goes downward.

A supplementary investigation utilized 55 fragments of human skulls, where the medial wall of the premaxilla was exposed. Eight were from children of various ages up to seven years, and they all showed a curved furrow for the median artery. The rest came from older individuals, eight years of age or more. On half of these, the same furrow was found.

RÉSUMÉ

LE COURS DES NERFS ET DES ARTÈRES PRÉMAXILLAIRES

L'auteur a fait des recherches microscopiques sur les sections centrales antérieures de la mâchoire supérieure de spécimens humains âgés de 180 à 430 jours pour constater si les nerfs et les artères prémaxillaires communiquent sur la ligne médiane et, aussi, pour examiner si l'artère naso-palatine court du nez vers le palais ou du palais vers le nez. Les séries de sections ont donné les résultats suivants:

1. Les nerfs et les artères du canal incisif communiquent sur la ligne médiane et surtout dans le foramen incisivum.

2. D'un point de jonction artériel dans le foramen incisivum sort une ramification artérielle qui n'a pas été décrite auparavant. Elle monte au centre de la suture médiane et, dans la plupart des cas, elle peut être suivie en un arc qui avance et descend pour aboutir sous la spina nasalis antérieure. L'auteur lui a donné le nom de *a. praemaxillaris mediana* ou seulement artère médiane.
3. Les nerfs naso-palatins de droite et de gauche cèdent des filaments qui forment une ramification nerveuse commune et non-accouplée qui suit à peu près le cours de l'artère médiane. Il a été appelé *n. praemaxillaris medianus,* ou le nerf médian.
4. Le nerf alvéolaire supérieur antérieur donne comme sa ramification finale supérieure et antérieure un ramus nasalis, qui, sur le devant du fond de la cavité nasale s'anastomose avec une ramification du nerf naso-palatinus. De ce point le r. nasalis continue jusqu'à la suture médiane où il se conjoint avec le nerf médian. Quelques autres ramifications finales du nerf alvéolaire conduisent aussi à la suture médiane où elles se joignent au nerf médian, où bien elles procèdent sous ce nerf en direction parallèle.
5. Dans la région desservie par l'a. alveolaris superior anterior on peut quelquefois trouver des artères qui sont en communication avec l'artère médiane. Dans un cas on a trouvé un cours direct de pareilles artères à travers la ligne médiane, en dehors de l'artère médiane.
6. Des capillaires croisent la ligne médiane.
7. Les dimensions et le cours des artères dans le canalis incisivus varient sensiblement de préparation à préparation, souvent même le côté droit et le côté gauche diffèrent. On a constaté que l'a. alveolaris posterior septi contribue toujours avec ses ramifications à l'approvisionnement artériel du canal. L'a. palatina major y contribue aussi souvent, notamment quand elle parvient de l'un ou des deux côtés au noeud artériel dans le foramen incisivum. Quand cela est le cas une artère nasopalatine, de l'un ou des deux côtés, monte, comme règle, d'en bas vers le haut comme ramification de jonction entre l'artère palatine et l'artère nasale. Quand l'a. palatina

major n'arrive pas jusqu'au foramen incisivum, le parcours de l'artère dans le canal incisif est déterminé exclusivement par l'artère nasale et elle descend du haut vers le bas.

Des recherches supplémentaires comprennent 55 fragments d'os humains du visage où la parois médiane de la praemaxilla était mise à découvert. Dans 8 cas, concernant enfants âgés de 0 à 7 ans on a trouvé un sillon en forme d'arc pour l'artère médiane. Le reste du matériel provenait d'individus plus âgés (supérieurs à 7 ans). Dans la moitié des cas on a ici aussi retrouvé le même sillon artériel.

ZUSAMMENFASSUNG

VERLAUF DER PRAEMAXILLÄREN NERVEN UND ARTERIEN

Von 9 Präparaten menschlicher Oberkiefer im Alter von 180—430 Tagen, wurde der vorderste, zentrale Teil mikroskopisch untersucht um festzustellen ob die praemaxillären Nerven und Arterien über die Mittelinie kommunizieren, und ob die a. nasopalatina von der Nase aus gegen den Gaumen oder vom Gaumen gegen die Nase verläuft. Die Untersuchungen der Schnittserien ergaben folgendes:

1. Die Nerven und Arterien in canales incisivi treffen über der Mittellinie zusammen, besonders im foramen incisivum.
2. Von einem arteriellen Knotenpunkt aus im foramen incisivum wurde ein ungepaarter Arterienzweig festgestellt, dessen Verlauf früher nicht nachgewiesen wurde. Er verläuft aufwärts zentral in die Mediannaht und kann sehr oft in einem Bogen nach vorne verfolgt werden, bis er unter die spina nasalis anterior mündet. Der Verfasser dieser Arbeit gab diesem Arterienzweig den Namen *a. praemaxillaris mediana* oder Medianarterie.
3. Der rechte und linke n. nasopalatinus weist zarte Fäden auf, welche einen gemeinsamen ungepaarten Nervenzweig mit im Wesentlichen dem gleichen Verlauf wie die Medianarterie bilden. Er wird *n. praemaxillaris medianus* oder Mediannerv genannt.

4. N. alveolaris superior anterior bildet wie sein oberster und vorderster Endzweig, ein ramus nasalis, welcher weit vorne im Nasenhöhlenboden mit einem Zweig vom n. nasopalatinus anastomosiert. Von hier setzt der ramus nasalis zur Mediannaht fort, in dem er sich mit dem Mediannerv vereinigt. Auch andere einzelne Endzweige des alveolaren Nerves führen in die Mediannaht, um sich mit dem Mediannerv zu vereinigen, oder sie verlaufen nach vorne, untenhin und parallel mit demselben.
5. Vom Bereich der a. alveolaris superior anterior findet man hin und wieder Blutgefässe die mit der Medianarterie kommunizierend. Ein direkter Verlauf von ähnlichen Blutgefässen quer über der Mittellinie und ausserhalb der Medianarterie ist nur einmal nachgewiesen worden.
6. Kapillaren kreuzen die Mittellinie.
7. Die Grösse und der Verlauf der Arterien im canalis incisivus variiert von Präparat zu Präparat sehr stark. Auf der rechten und linken Seite des einzelnen Präparates sind sie auch häufig ungleich. Die Zweige der a. nasalis posterior septi tragen, wie schon immer festgestellt, zur Arterienversorgung in den Kanal bei. Auch die a. palatina major tut in dieser Hinsicht sehr oft dasselbe, nämlich wenn sie auf der einen oder auf beiden Seiten zum arteriellen Knotenpunkt in das foramen incisivum vorreicht. Ist dies der Fall, verläuft eine a. nasopalatina auf der einen oder auf beiden Seiten in der Regel von unten nach aufwärts, als Verbindungszweig zwischen der palatinalen und der nasalen Arterie. Wenn die a. palatina major zum foramen incisivum nicht vorreicht, wird der Arterienverlauf im canalis incisivus nur von nasaler Arterie bestimmt, welche von oben nach abwärts führt.

Das weitere Untersuchungsmaterial umfasst Knochen von 55 Gesichtsknochen des Menschen, Fragmenten bei denen die praemaxillare Mittelwand freigelegt war. Von diesen waren 8 Fälle im Alter von neugeboren bis zu 7 Jahren. Hier konnte man bei jedem eine bogenförmige Furche der Medianarterie feststellen. Die übrigen Fälle stammen von Individuen im Alter von 8 Jahren und aufwärts. Die Hälfte dieser letzteren Fälle erwiesen die gleiche bogenförmige Arterienfurche.

REFERENCES

Bellairs, A. d'A.: Observations on the incisive canaliculi and nasopalatine ducts. Brit. dent. J., *91*, 1951, 281—291.

Bruni, A. C.: Svilupo della regione intermascellare nell uomo. Mem. R. Accad. Torino, *63*, 1913, 19—58.

Cook, W. A.: The nerve supply to the maxillary incisors. J. oral Surg., 7, 1949, 149—154.

Cunningham's Textbook of Anatomy, ninth edition. Oxford, 1951.

Fisher: G.: Die örtliche Betäubung in der Zahnheilkunde. Berlin, 1925.

Gray, H.: Anatomy of the Human Body. Philadelphia. 1942.

Le Double, A. F.: Traité des variations des os de la face de l'homme. Paris, 1906.

Monheim, L. M.: Local Anesthesia and Pain Control in Dental Practice. St. Louis, 1957.

Pernkopf, E.: Die Zahn-, Mund- und Kieferheilkunde. München—Berlin, 1954.

Phillips, W. H. & H. Maxmen: The nasopalatine block injection as an aid in operative procedures for maxillary incisors. Amer. J. Orth. 27, 1941, 426—434.

Rauber-Kopsch: Lehrbuch und Atlas der Anatomie des Menschen. Leipzig 1955.

Raab, H.: Die örtliche Schmerzbetäubung (Plexus- und Stammanästhesie) in der modernen Zahnheilkunde. Wien 1950.

Schreiner, K. E.: Menneskeorganismen. Kristiania 1921.

Seldin, H. M.: Practical Anesthesia for Dental and Oral Surgery. Philadelphia 1942.

Sicher, H.: Oral Anatomy. St. Louis 1952.

Spalteholz, W.: Hand Atlas of Human Anatomy. Seventh edition in English. Philadelphia 1940.

Veau, V.: Le rôle du tubercule médian dans la constitution de la face. Les vaisseaux et nerfs du tubercule médian dans le bec-de-lièvre. Artères et nerfs sphéno-palatins chez le foetus. Ann. Anat. path. méd.-chir. 3, 1926. 305—348, 515—516, 516—518.

Wetzel, G.: Lehrbuch der Anatomie für Zahnärzte. Jena 1922.

Address: *The Dental Faculty*
University of Oslo
Geitmyrsvegen 69
Oslo, Norway