INTRA-CRANIAL DEHISCENCES OF THE CAVITIES OF THE EAR AND DEHISCENCES OF THE AQUEDUCT OF FALLOPIUS.

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(A) INTRA-CRANIAL DEHISCENCES OF THE CAVITIES OF THE EAR.

DR. MOURET was charged, at the International Congress of Medicine at Budapest, in 1909, with a report upon the "Paths of Propagation of Infection from the Middle Ear to the Interior of the Cranium," a work which necessitated attention to the paths furnished by dehiscences of the roof of the middle ear. A study of these openings in the works of Bürckner and Flesch, Körner, etc., being unsatisfactory, he has made his own researches, the results of which are contained in the present paper.

These dehiscences are studied here both in the adult and the child, and an endeavour is made to explain their origin by studying the development of the roof of the middle ear in the foetus, from the age of three months, the period at which the petrous is still cartilaginous.

According to Bürckner and Flesch, dehiscences of the roof have their seat of election in the posterior half of the tegmen tympani et antri. They found them relatively frequent in this region—167 times in 765 crania (21·8 per cent.). They attribute their presence to an arrest of closure of the petro-squamosal fissure, due to a double compression of this part of the tympanic roof produced, on the one side, by the pressure of the developing brain, on the other, by the development of the head of the malleus and the body of the incus.

Such explanation is mere hypothesis. If accepted, it is astonishing that dehiscences of this region are not more frequent (although 21·8 per cent. is fairly high), and that they are not the rule even, since the same conditions are met with in all crania. Moreover, it might be objected that, if in the first part of foetal life the malleus and incus are in contact with the vault of the tympanum from the start, they soon leave it by the enlargement of the middle-ear cavity. The ossicles are then no longer in contact with the

¹ From the *Bulletins et Mémoires de la Société Française d'Oto-Rhino-Laryngologie*, tome xxvi, 1910, p. 247.

tegmen, and are attached thereto solely by the mucous reflections serving as suspensory ligaments. From the second part of foetal life they are, therefore, no longer susceptible of impeding the development of the tegmen nor the closure of the petro-squamosal fissure. Moreover, as is shown later, if, in the foetus and the child, this fissure is in relation with the cranial vault, in the adult the petro-squamosal suture is carried further out and is inclined obliquely in the superior wall of the external meatus. This shows that the petrous lamina, which forms the tympanic wall, is developed, in the adult, beyond the tympanum, above the outer attic wall, and consequently beyond the head of the malleus.

In one specimen examined there occurs a linear train of fine dehiscences along the superior wall of the tympanum. Their direction makes it appear as if they were small holes formed at the expense of the petro-squamosal fissure, but more attentive examination shows that the line of the petro-squamous suture is further out, in the neighbourhood of the angle formed by the meeting of the squama with the upper surface of the petrous, that is to say, more than a good centimetre from the line of the dehiscences.

According to Sibenmann, quoted by Bever in his thesis ("Die Fortleitungswege von Mittelohreiterungen in das Gehirn bei der Entstehung von Grosshirnabszessen"), the cause of the dehiscences might be explained by abnormal pneumatization of the tympanic roof. This explanation is, perhaps, more delusive than that quoted above, but the specimen just mentioned showed an exceedingly thin tegmen, absolutely lacking any cellular cavity on its tympanic side. Further, the petro-squamous fissure does not communicate with the cells, as will be shown later.

Körner, in his monograph, "Die Otitischen Erkrankungen des Hirns," found, according to Bever, a percentage of dehiscences of the tympanic roof much inferior to that of Bäckner and Flesch. In 209 crania they were present only 18 times (8.6 per cent.).

In another article on spontaneous dehiscences of the tympanic roof, "Zur Kenntniss der spontanen Deshiszenzen im Dach der Paukenhöhlen" (*Arch. f. Ohrenheilk.*, xxviii, 169), Körner studied them in dolichocephalics and brachycephalics. He distinguished three varieties: (1) Dehiscences of the roof properly speaking, making communication between the cranial cavity and the tympanum; (2) bony fissures which do not lead directly from the cranial cavity into the tympanum, but into "the other" cavities of the petrous; (3) dehiscences leading into the cells of the superior wall of the external meatus. According to Körner, the roof of the

tympanum and auditory meatus is thicker in dolichocephalics than in brachycephalics, and dehiscences of the tegmen will be more frequent in these than in others. Körner thinks this in favour of Bürckner's and Flesch's "wearing of the roof by compression" hypothesis. Dehiscences of the tympanic roof will be, in fact, rare in dolichocephalics. In thirty dolichocephalics Körner found only one case in which a cleft existed, making communication between the cranial cavity, not with the tympanum, but with a cell of the epitympanic system. In ninety-two brachycephalic crania, he found, on the contrary, true roof dehiscences nine times, bilateral in one case. Körner concluded therefrom that median otitis is more dangerous in brachycephalics since tegmental dehiscences are more frequent in them.

Fissures of the superior wall of the tegmen communicating with cavities (cells?), but not with the tympanum itself, have, in their uniformity, appeared to Körner to be more frequent than the dehiscences themselves. In 39 dolichocephalics, 7 showed fissures (2 bilateral), in 92 brachycephalics 16 had them (7 bilateral).

As regards the third variety, Körner stated that he had often seen dehiscences corresponding to the superior wall of the external meatus. These may be sometimes even so numerous as to make the bone appear as if pierced by holes like a sieve, leading to the cells of the superior meatal wall. Körner questioned whether this variety is favoured by the neighbourhood of the angle which "the bottom of the cranial fossa forms with its lateral wall," and said it was not possible to decide. It will be seen later that the cause lies rather in the presence of the petro-squamous suture in the vicinity of the angle in question than in the presence or form of the angle itself.

Dr. Mouret's researches in numerous petrous bones of children and adults have resulted in the discovery of dehiscences of the petrosal cortex in very various situations: (a) Tympanic roof; (b) antral roof; (c) roof of bony Eustachian tube; (d) roof of external auditory meatus; (e) roof of superior petrosal cells; (f) Gasserian fossa; (g) region of the summit of the petrous, in the neighbourhood of the passage of the trigeminal and external oculo-motor nerves; (h) superior semicircular canal; (j) Fallopian canal, in its intra-petrous course.

Some of these dehiscences are punctiform, as in the fossa of the Gasserian ganglion. They lead into the spongy spaces or subjacent cells, are very frequent and variable in numbers, and

may give the Gasserian fossa a cribriform aspect. The bony structure of this region being more often spongy than pneumatic, it may be said that the areola of the spongy tissue opens freely into the cranial cavity at the level of this fossa.

Others are true foramina, generally fairly small, into which dip prolongations and vessels from the dura mater; such are the numerous narrow holes found along the petro-squamous suture in the adult.

Others represent losses of substance in places where the petrous cortex is very thin. Their edges are irregular and more or less serrated. Single or multiple, they simulate "worm-holes." They may be found everywhere, but more particularly in the roof of the tympanum and mastoid antrum, into either of which cavities they may open directly, as well as into the supra-attic, epitympanic cells, when they occur in the tegmen tympani. These "worm-hole" dehiscences may be considered as due to an arrest of ossification in the petrous cortex. It may, however, be suggested that these dehiscences, found in the skeleton, are due to the stripping off of the dura mater during dissection and are non-existent in the living subject. The dura mater is, as a matter of fact, very adherent to the tympanic and antral roof, outside the petro-squamous suture; but, when the tympanic roof is extremely thin, this adhesion, though it may be weak, can cause undoubtedly bony *tears* as the dura mater is stripped off. The dehiscences will not then be simple perforations. If this be so, the resistance of a bony wall, which always allows of its being so easily *torn*, is so slight a matter that, from the practical point of view, parts thus *torn* and *perforated* by the stripping off of the dura mater may be considered as tissues of least resistance predestined to favour the passage of middle-ear suppurations into the cranium. Hence, if the "worm-hole" dehiscences are not, perhaps, true dehiscences *in vivo*, they may, nevertheless, be considered as such. They represent, in fact, "entries closed simply by something as little resistant as a fine spider web," which may be easily accessible to infective germs from the tympanum, unlike the true spontaneous dehiscences such as the petro-squamous fissure, for example, for this is obliterated by thick and resistant prolongations of the dura mater, which may, at least momentarily, play the part of a barrier.

Dehiscences of the superior semicircular canal, which may be bilateral, have also similar significance. In three cases met with by Dr. Mouret the petrous cortex was excessively thin, the proper wall of the bony canal being blended with it without interposition

of spongy tissue. Dehiscence of the canal might well, in such cases, be only a simple *tearing* of the cortex produced in stripping the *dura mater*.

The extreme thinness of the petrous cortex in these cases may be attributed to a disturbance of ossification. The cause itself of this disturbance escapes us, and it does not appear necessary to attribute it to excentric pressures, such as compression by weight of brain mass, or by the head of the ossicles. Besides, double compression cannot be invoked for dehiscences of the superior semicircular canal. Further, dehiscences may also be observed in the bony cortex outside the cranial cavity, without mentioning those already spoken of at the tip of the petrous and in the Gasserian fossa. In one specimen, showing these latter, can be seen an enormous dehiscence of the petrous cortex at the level of the jugular fossa, in the vicinity of the anterior condyloid foramen, making a very large communication between the jugular fossa and the intra-osseous spongy tissue. Only some general disturbance of ossification can amount for such a condition.

Other dehiscences show in the form of large breaches or simple clefts or fissures. The best known of these fissures is that corresponding to the line of the internal petro-squamous suture. There are others which have not yet been described, but which Dr. Mouret has found either at the anterior part of the tympanic roof, or over the bony Eustachian tube. One of the latter, in the form of a very large, blunt-edged oval breach, is seen in one of his specimens in the roof of the Eustachian tube. Another specimen shows two clefts in the same locality.

The origin, seat, and oval or fissured form of the dehiscences, are very well explained by the study of the development of the roof of the middle ear. They more often assume the form of a cleft, because they represent a defect of junction between two neighbouring bony laminae, primarily distinct, but becoming joined in the course of their development. As these osseous laminae are primitively separated by a relatively large space, the dehiscence is large, a little elongated, and of oval form, if arrest of ossification occurs early, but it takes the fissured aspect when the arrest occurs late.

These kinds of dehiscences which are formed in the roof of the middle ear, and are in relation to the development of the tympanic vault, are best studied by observation of the development of the vault itself.

It is known that the antral and tympanic tegmen—that is to say,

the roof of the middle ear itself—is formed by a bony lamella, which is derived from the superior wall of the petrous. In the three months' foetus, this petrous laminae, called by the author the *petro-tympanic lamina*, already exists, although of very small extent, and still cartilaginous. It is detached from the anterior edge of the petrous at the level of the protuberance (as yet little marked) of the superior semicircular canal. Externally, it is applied to the fibrous lamina, which is to become the squama, wherein ossification commences. Between the two parts is found a very fine fissure, the petro-squamous fissure, covered by fibrous tissue, forming the outline of the internal petro-squamosal suture. The petro-tympanic lamina covers the antrum, already sketched out, and the posterior part of the tympanum, forming the roof over the malleus and incus. But in front it does not yet extend over the anterior part of the tympanum, which is simply covered by connective tissue. It does not pass the level of a line drawn perpendicularly to the great axis of the petrous, and passing by the internal auditory meatus. This line is very easy to determine, being marked naturally on the superior surface of the pyramid by a *groove*, which extends from the anterior border of the pyramid to nearly 2 mm. from the internal auditory opening. At this level the groove is formed into a canal, which sinks into the bone to open at the bottom of the internal auditory meatus. The facial nerve is in this *groove*, which is, indeed, nothing but part of the Fallopian canal dehiscence at the superior surface of the petrous during foetal life. To this point further reference will be made. The spot where the petro-tympanic lamina ends, corresponds, therefore, at this age, to the point at which the facial nerve passes from the petrous into the tympanum, above the oval window. This corresponds to the posterior half of the inner tympanic wall; *i. e.* the petro-tympanic lamina only covers as yet the posterior half of the tympanum.

At the age of four months the petro-tympanic lamina is elongated, and passes beyond the Fallopian groove in front. It begins to grow a little over the anterior part of the tympanum; bit by bit it extends thus forward and above, and ends by substituting itself for the fibrous lamina which separates the cranial cavity from the tympanum. This development occurs progressively up to eight or nine months, by which time it is almost complete. But the petro-tympanic lamina, in going to meet the spine of the sphenoid, is extended still more forward beyond the tympanum over the Eustachian tube of which it forms also the bony roof.

The petrous and the squama grow at the same time, and the petro-squamous fissure, which separates them, extends, like the petro-tympanic lamina itself, over the whole middle ear. It corresponds to the external part of the roof. This fissure (into which dips fibrous tissue), which forms the suture between the squama and the petro-tympanic lamina, persists during early infancy—placed close to the external border of the vault of the tympanum, and forming in the child the place of least resistance of the tegmen tympani. It is, therefore, at this age, the spot by which suppuration in the tympanum finds an easy passage to the cranial cavity. It is astonishing that intra-cranial complications in the otitis of childhood are not even more frequent from this cause; it might almost be supposed that they would be the rule rather than the exception. Doubtless, however, the fibrous tissue filling the fissure acts as a sufficiently strong *cork* to prevent the progress of infectious germs in the majority of cases. If a fibrous is certainly less resistant than a bony barrier, its presence is, nevertheless, often sufficient.

Later, the petro-squamous fissure undergoes two important modifications: (a) It is transformed into a suture by junction of its bony edges; (b) it is thrown more outward over the external auditory meatus. This will be referred to later, as, for the present, the petro-tympanic lamina requires further discussion.

In the five or six month fœtus, along the internal (petrous) border of this lamina, and starting from the point where it passes the facial nerve, a cleft is seen, which separates it from the petrous. This Dr. Mouret calls the *principal petro-tympanic cleft*. On the tympanic side it corresponds to the anterior half of the upper border of the inner wall of the tympanum and Eustachian tube. This principal petro-tympanic cleft is closed bit by bit, during fœtal life, by the junction of the petro-tympanic lamina with the petrous. Most often it is closed completely at birth, but it may present small openings (dehiscences) or persist in its whole length and form a long and wide crevice which makes communication between the tympanum and bony Eustachian tube and the cranial cavity (fissured dehiscence of the superior wall of the tube by persistence of the principal tympanic cleft). It is found fairly often in adult crania also.

Beside the principal petro-tympanic cleft and a little outside it, the petro-tympanic lamina very often shows another fissure, sometimes even a third. This starts from the anterior end of the bony lamina and is prolonged forwards, to a greater or less extent, in its

thickness. The author names it the *accessory petro-tympanic cleft*. It is shorter than the principal cleft and corresponds only to the roof of the Eustachian tube, being prolonged but rarely into the tympanic roof. It disappears in the course of development, but it may also persist, and a fissuary dehiscence found by the author in the roof of the Eustachian tube, outside one formed from the principal petro-tympanic cleft, in the cranium of a child of eight to ten years, may be attributed thereto.

In an adult cranium Dr. Mouret found a large oval dehiscence, 4 mm. long by 2 mm. broad, opening into the Eustachian tube, and situated at the extremity of the petro-tympanic lamina. This he also considers as formed at the expense of the accessory petro-tympanic cleft.

Turning now to the dehiscences formed at the expense of the internal petro-squamous fissure, those to which most authors have paid attention, it is pointed out that they are of the highest importance, since they not only put the middle ear in direct communication with the cranial cavity, but because it is by the petro-squamous cleft that the vessels pass which connect the tympanic and intra-cranial circulation.

Part of the venous circulation of the tympanum follows this path to join the meningeal circulation. In the fœtus it is a path of venous origin of the highest importance. There exists above and along the petro-squamous cleft a meningeal vein, the *petro-squamosal sinus*, which receives the veins which leave by the roof of the tympanum. This sinus takes a very great part in the first development of the venous system; as it passes across the lateral cranial wall in the region of the base of the zygomatic apophysis, it carries to the external jugular vein a great part of the intra-cranial venous blood, before the internal jugular system is formed. Later on its importance lessens, and it tends to atrophy. Sometimes it persists in the form of a small venule connecting the branches of the middle meningeal vein with the lateral sinus, and it may also connect the intra-cranial venous system with the extra-cranial system of the external jugular by a perforating branch. But, even if it disappears completely, the tympanic veins which leave by the petro-squamous fissure retain their relations with the intra-cranial venous circulation by the intermediary of anastomotic venules, which join either the branches of the middle meningeal vein or the lateral sinus itself. So that, even after the atrophy of the petro-squamosal sinus, the region of the petro-squamous cleft is always highly important, as much from the

anatomical point of view by the tympano-meningeal vascular relations, as from the pathological standpoint by the possible passage of tympanic suppurations into the interior of the cranium, either by phlebitis of the veins, or by direct extension through the cleft itself, if this be persistent throughout or even partially in the form of dehiscences.

The study of this cleft and its dehiscences must be made in the *fœtus*, the child and the adult, as it undergoes important modifications with age. In the *fœtus* and very young child, the petro-squamous cleft corresponds to the outer part of the tympanic and antral vault. If the petro-tympanic lamina be raised along the petro-squamous fissure in the *fœtus*, the head of the malleus is seen beneath it. But, in the transverse direction, this lamina forms only about four-fifths of the tympanic roof. It is completed externally by a tympana-squamous crest, which is detached from the inferior border of the squama. Both lamina and crest are very thin. The petro-squamous cleft is also of very little depth, and is directed vertically from the cranial cavity towards the tympanum.

In the child, the tympano-squamosal crest and petro-squamous lamina which bound the fissure have become somewhat thicker and the fissure has increased in depth. At the same time it is noticeable that the direction of the depth of the fissure is not vertical but oblique from above down and from without inwards, the superior lip of the petro-tympanic lamina being more prolonged than its lower lip. Nevertheless, the fissure still corresponds to the roof of the tympanum properly speaking. A vertico-transverse section of the cranium of a child from eight to ten years old shows this arrangement well, and makes it plain that the fissure forms a true pathway from the tympanum into the cranial cavity. In the child the petro-squamous fissure still exists in its entirety, save quite behind, where junction has already occurred between the squama and the pars mastoidea of the petrous; it passes over the tympanic and antral roof in its whole length. Supra-attic cells, when they exist, are quite independent of the cleft which opens directly into the tympanum and not into any of such cells.

In the adult the fissure, seen from the cranial cavity, completely disappears behind. The venule representing the vestige of the petro-squamosal sinus is itself enclosed in a fine intra-osseous canal, formed by ossification of this spot in its course to the lateral sinus. In front of the posterior portion the fissure may remain sometimes very apparent in the greatest part of its length. In

one specimen¹ the fissure appears from the cranial aspect clearly open at the level of the petro-squamosal angle, a condition also shown by vertical section. Most of it, however, disappears almost completely, leaving, nevertheless, more or less distinct traces in the anterior three-fourths of its length, sufficient to reveal its situation to attentive examination. These traces are formed either by a slight bony edge representing the edge of the upper (cranial) lip of the petro-tympanic lamina, or by small foramina, opening obliquely in the thickness of the bone. The edge formed by the inner border of the petro-tympanic lamina appears sloped at the level of these foramina. Further, there is often a difference of colour between the squama and the petrous.

Care must be taken to seek the remains of the petro-squamous fissure, not in the tympanic roof itself, but more externally, at the level of the angle made by the cranial base with the inner surface of the squama of the temporal. The petro-squamous fissure of the child has, as a matter of fact, undergone very important modifications: (*a*) the depth of the vertical cranio-tympanic plane, in which the fissure is found, has increased; (*b*) this same vertical plane has inclined outwards; (*c*) the lips of the fissure have joined so as to form the petro-squamous suture.

The first of these modifications is due to the thickening of the bony laminae bounding the fissure. The augmentation of the depth of the fissure is consequent upon the thickening of the petro-tympanic lamina and the tympano-squamous crest, which form the tympanic roof. When these parts are thickened uniformly or even when they are hollowed out by pneumatic cells, the fissure remains independent of them.

The second modification, lateral inclination of the vertical cranio-tympanic plane in which the petro-squamous fissure is found, is explained by the enlargement of the cranial cavity in the course of the development of the superior external meatal wall, and by the tendency of the external border of the petro-tympanic lamina to remain connected with the angle which the cranial base forms with its lateral wall.

In the fœtus the external auditory meatus does not, in fact, exist. It is formed gradually by the enlargement of the tympanic ring and of that part of the inferior border of the squama which closes above the interval left free between the two branches, anterior and posterior, of this ring. This portion forms the outer

¹ The paper is illustrated by photographs of specimens demonstrating all the points referred to.—*Trans.*

wall of the attic and supplies the narrow tympano-squamous crest which, outside the petro-squamous fissure, forms the external part of the tympanic roof. Of these two portions formed by the inferior border of the squama, one, the tympano-squamous crest, develops little; the other, on the contrary, the outer attic wall, is thickened and enlarged externally so as to form the superior wall of the external auditory meatus. In developing thus, this part throws the inner surface of the squama more outwards and removes it further from the superior wall of the tympanum. The petro-squamous fissure comes in consequence to be more and more distant from the angle which is formed between the internal surface of the squama and the cranial surface of the bony lamina which constitutes the superior wall of the external meatus. The line of the petro-squamous suture always remains in the neighbourhood of this angle; it keeps to the way in which the petro-tympanic lamina grows. This may, in fact, be looked at, as in all cranial bones, as an external (inferior and tympanic) lamina and an internal (superior and cranial) lamina. Between these two laminae the supra-attic cells develop. The two laminae lengthen unequally, the tympanic one not increasing any more than the cavity of the tympanum grows, and being stopped by contact with the corresponding border of the tympano-squamous crest. The cranial lamina increases more, glides over the latter, covering it entirely and going even beyond it, above the wall of the external meatus. In thus prolonging the petro-squamosal cleft over this wall it contributes to an increase in its depth, whilst giving it simultaneously a very pronounced lateral inclination. Hence in the adult it is necessary to seek the internal petro-squamous suture over the external meatus, near the lateral angle of the cranial base, and not over the tympanum itself.

Nevertheless, the remains of the petro-squamous fissure do not correspond exactly to this angle in all subjects and may be nearer to the tympanic vault, according as the cranial bony lamella of the petro-tympanic lamina is more or less advanced above the tympano-squamous crest and the wall of the attic.

Nor is the lateral inclination of the plane of the petro-squamous suture the same in all subjects. It is, generally speaking, so much the less pronounced as the bone is thicker and as the petro-tympanic lamina is less outwardly inclined; when the roof of the tympanum and of the external auditory meatus are thin, this inclination may almost approach to the horizontal.

When the petro-squamous suture deepens and inclines outwards

it also tends to disappear by bony union and to be transformed into the petro-squamous suture. The line of suture is effaced on the side of the tympanic cavity, but on the cranial side it sometimes persists, presenting, in the dry bone, a large cleft, sinking more or less into the thickness of the bone. It is, however, almost always closed on this side. Nevertheless, in the great majority of cases its intracranial situation may still be recognised, thanks to the points already mentioned, the more important of which being the foramina which allow of the passage of vessels from tympanum to cranial cavity. These vascular communications, notably the venous relations, persist in the adult despite the fact that the foetal petro-squamosal sinus is atrophied. The veins pass to empty into the branches of the middle meningeal. The presence of veins in the line of the petro-squamous suture results, therefore, in true bony canals, which form passages of communication between the cranial and the tympano-antral cavities. The dura mater sends prolongations around the vessels. It is rare to obtain a vertico-transverse section of the temporal bone which involves one of these canals in its whole length, but their upper and lower ends may be found by comparing various sections, and it is then demonstrable that the widest parts are those which border on the cranial cavity. Chance sections show that these canals may present ampullary dilatations, resembling, in the dry bone, cellular cavities, suggesting that the fissure opens into the cells in the superior wall of the external meatus after being closed on the tympanic side; but a more attentive examination shows that this is only apparent. On the cranial aspect, the openings of the canals are ranged along the line of the petro-squamous suture and sometimes encroach upon one another. They may be sufficiently numerous and clearly enough marked to give the region of the cranio-squamous angle a cribriform aspect (Körner). These are, no doubt, the dehiscences of the superior wall of the external meatus of which Körner speaks, and he remarks also that they open into the bony cells. This opinion, however, is considered by the author to be based upon an erroneous interpretation of such forms as have just been described. The supra-attic cells and the cells of the superior wall of the external meatus border on the fissure and its ampullary dilatation, separated from it by their own bony wall. It may, however, be admitted—although Dr. Mouret has not seen it—that communication may take place between them by bony resorption; in such a case the non-sutured portion of the petro-squamous fissure would be dehiscent into the cells of the superior meatal wall.

To sum up, dehiscences of the cranio-squamous angle in the adult may appear, from the cranial aspect, either as a long, deep cleft, or as more or less rounded, and more or less numerous foramina, arranged side by side. The former is a question of the persistence of the petro-squamous fissure on the surface of the cranial floor; the latter is one of orifices of canals containing vessels emerging from the tympanum.

Returning to the dehiscences of the roof of the middle ear, they may be divided into three groups:

(1) "Worm-hole" dehiscences of the tympanic and antral roof, which are losses of substance due to the excessive thinness of the bony lamina.

(2) Dehiscences of the bony roof of the Eustachian tube, arising more especially from persistence of the principal and accessory tympanic clefts existing in the anterior part of the middle-ear roof in foetal life.

(3) Dehiscences proceeding from the petro-squamous fissure. It is expedient to distinguish these as in the child and in the adult: (a) In the child the *fissure* persists the whole length of the outer part of the tegmen; (b) in the adult the *fissure* becomes a *suture* in its depth, but may remain in the condition of a more or less superficial *fissure* on the cranial aspect, near the cranio-squamous angle; on this level dehiscences are frequently found, arranged along the line of suture, which are merely the orifices of vascular canals putting the tympanum into communication with the cranial cavity.

No attempt has been made to give the percentages of these different dehiscences, as, to make them of any value, hundreds of crania would have to be examined. It is, nevertheless, suggested (a) that in the adult dehiscences of the petro-squamous cranial angle are constant, but more or less obvious and variable in number; (b) that the petro-squamous fissure is constant in the young child; (c) that dehiscences in the roof of the Eustachian tube are fairly frequent and more common than the "worm-hole" dehiscences of the tympanic roof; (d) that dehiscences of the Gasserian fossa are almost constant, but more or less small and more or less numerous; (e) that dehiscences of the petrous cortex, either at the level of the petrous cells or at the level of the spongy tissue of the tip, or at the level of the superior semi-circular canal, are less frequent, but not rare.

All these dehiscences are dangerous, as they facilitate the passage of otitic suppuration into the interior of the cranium. It

is suggested that the most dangerous of all are spontaneous dehiscences of the Eustachian tube. Otitic infection comes almost always from the naso-pharynx, and the tube is infected before the tympanum; dehiscences of its roof are the first offered to an infection, which may pass them even before, perhaps, it can extend to the tympanum itself.

Be this as it may, certain of the dehiscences above mentioned assist the comprehension of certain intra-cranial complications, the mechanism of which has often been discussed. Paralysis of the external motor oculi, in the course of acute otitis—already well explained by the knowledge of the petrous cells, which may be prolonged up to the tip of the petrous—is even better understood if dehiscences exist in the petrous cortex in the neighbourhood of this nerve. It is the same for primary phlebitis of the petrous and cavernous sinuses. Trigeminal neuralgia is also very easily explained by dehiscences of the Gasserian fossa, which favour the passage of bony inflammation to the Gasserian ganglion. Dehiscences of the superior semi-circular canal facilitate the passage of labyrinth suppurations into the cranial cavity, but may even, by an inverse mechanism, make labyrinth infection easy from an extra-dural abscess.

(B) DEHISCENCES OF THE FALLOPIAN AQUEDUCT.

Facial paresis and paralysis, which are sufficiently frequent in the course of acute and chronic otitis, show that suppurations of the ear penetrate fairly often into the aqueduct of Fallopius. Intra-cranial complications, consecutive to the passage of otitic suppuration along this canal, are also pretty frequent. Infective products follow the aqueduct to the bottom of the internal auditory meatus, whence they pass into the cranial cavity; but they can penetrate into the cranium by the hiatus Fallopii as well, following the great and small superficial petrosal nerves, especially when this hiatus, which is widely open in the fœtus, also remains widely dehiscient in the adult. Suppuration often penetrates into the aqueduct in the train of osteitis of the tympanic wall, as much in the course of acute osteitis as of chronic otitis; but it may also, as in the vault of the tympanum, find in this wall *loci resistentiæ minoris*, dehiscences which favour its passage. These are the tympanic and intra-cranial dehiscences of the Fallopiian aqueduct, which are studied here. The results confirm what is known already, and what is mentioned in *l'Embryologie de Kölliker* (French

translation, 1882, p. 767), but which the books on anatomy and otology neglect too much. There is, in addition, a tympanic dehiscence of the aqueduct which has not yet been described.

According to the authors quoted by Kölliker, dehiscences of the aqueduct are especially situated at the level of its passage above the oval window. In the fœtus the Fallopian canal is very short, extending only from the bottom of the auditory meatus to the neighbourhood of the hiatus, and having a length of scarcely 1 mm. (Joseph, Vrolik, Gegenbauer). From the hiatus to the stylo-mastoid foramen the canal does not exist, the facial nerve passing simply in a groove which is marked on the cartilage and merely covered in the tympanum by the tympanic mucosa. Outside the tympanum, in the *pars mastoidea*, the nerve is not even placed in a groove but passes simply over the cartilage. In these two regions (tympanum and mastoid) ossification surrounds the nerve, and forms a bony canal all round it. This canal is, however, almost always incomplete (Hente, Kölliker), and presents a lacuna above the oval window, a lacuna closed merely by the soft parts, periosteum and mucous membrane.

Kölliker makes no mention of the persistence of the fœtal intra-cranial dehiscence of the region of the hiatus in the adult. Nor has a dehiscence of the aqueduct at the level of the superior internal angle of the tympanum been mentioned at the point where the aqueduct makes its first bend to pass the petrous on the inner surface of the tympanum. This dehiscence the author has found three times, and it would peculiarly facilitate the passage of suppuration from the tympanum into the aqueduct and the cranial cavity.

Dehiscences of the Fallopian aqueduct may, therefore, open into the cranial and tympanic cavities. In this they have two seats of predilection: (a) above the oval window, (b) at the level of the bend made by the aqueduct to pass over the inner tympanic wall.

Intra-cranial Dehiscences of the Aqueduct in the Region of the Hiatus Fallopii.—The name "hiatus Fallopii" is given to a small intra-cranial orifice by which the great superficial petrosal nerve passes, coming from the geniculate ganglion of the facial. The hiatus represents the orifice of a small bony canal, the canal of the great superficial petrosal nerve, which is of greater or less length according as the hiatus is more or less close to the place where the facial nerve passes, *i. e.* to the aqueductus Fallopii. Generally this canal is 1 cm. long, but sometimes it is reduced to zero, the hiatus then being even over the Fallopian canal, and the

petrosal nerve enters the cranium immediately on leaving the facial nerve. In this case the small canal is represented simply by a groove in which lies the petrosal nerve, and it may be said that the canal of this nerve is largely dehiscence into the cranium. But in this arrangement the hiatus, which then lies immediately over the aqueduct, may be very large, and instead of forming a small chink destined for the passage of the petrosal nerve, makes a large breach which lays bare a good part of the aqueduct and of the facial nerve. It is then a question of a true dehiscence of the canal of the petrosal nerve and of the external portion of the aqueduct.

In an illustrative specimen the lumen of the canal is seen going on one side towards the internal auditory meatus, and on the other towards the tympanum, forming its first bend where the geniculate ganglion of the facial is found. The arrest of development of the whole canal of the petrosal nerve and of the corresponding part of the aqueduct is seen clearly. The intracranial extremity of the petrosal nerve-canal is simply a deep groove, bounded on either side by a well-marked bony edge forming the outline of its roof. This arrangement, dehiscence of the canal of the petrosal nerve and dehiscence of the intra-petrous portion of the Fallopian canal, reproduces the foetal disposition of the same parts.

In the later periods of foetal life, neither the external part of the intra-petrous course of the facial nor the great superficial petrosal nerve are covered by bone. On either side of the principal petro-tympanic cleft for a distance of 1-2 mm. the bony plane, as much of the petro-tympanic lamina as of the petrous itself, is slightly inclined in the form of a groove, ending behind at the open part of the Fallopian aqueduct. On either side of this groove is seen a bony crest, which is continuous with a similar crest bounding, behind, the open part of the Fallopian canal. The closure of this region is brought about by the raising and lengthening of these three bony crests. They tend to approach one another and to transform the large groove into a canal which contracts bit by bit, and in which are contained the great and small superficial petrosal nerves. Later on, a septum isolates these two nerves from one another. But the covering in of all this region is more particularly effected by the lengthening of the posterior bony crest, which passes above the facial, and is prolonged over the petrosal nerves as it joins with the corresponding border of the lateral crests. It even appears that it is the development of this part which alone ensures the closure of all this region, and

that the lateral crests serve solely to limit it without being able to close it completely. As a matter of fact, crania are found in which, the Fallopian canal being completely covered by the bony lamina, the exit of the superficial petrosal nerves from the petrous occurs very close to the aqueduct. Others, on the contrary, show it at a distance of over 1 cm. from this canal. In the former it may be said that the canal of the petrosal nerves is alone dehiscence. This disposition is met with fairly frequently. But the author has never met with any crania in which the petrosal nerves have been enclosed in a bony canal when the outer part of the intra-petrous portion of the aqueduct was dehiscence; when the latter is the case the canal of the petrosal nerve is dehiscence also. Nevertheless, this can be so without the aqueduct being affected. The canal of the great superficial petrosal nerve appears therefore to exist only if the bony lamina, which arises from the posterior crest of the groove of Fallopius, has first covered the facial, and is prolonged sufficiently between the two lateral crests which bound the fetal groove of the canal of the petrosal nerves.

Dehiscences of the Aqueductus Fallopii above the Oval Window.—In its course on the inner tympanic wall, above the oval window, the Fallopian aqueduct forms a prominence of cylindrical form. Looking at this projection from the side of the oval window, there is often seen a kind of bony cicatrix, in the form of a groove, giving the impression of a scratch. This cicatrix indicates the seat of the dehiscence of the lower border of the aqueduct above the fenestræ oralis. In fact, it is not rare to find, in the adult, the aqueduct there open by an oval orifice, an arrangement still more frequent in the young child. A study of development further shows that it is here a question of arrest of ossification of the tympanic wall of the aqueduct. This wall may also show other foramina in its surface, resembling small holes made with a pin.

Tympanic Dehiscences of the First Bend of the Fallopian Aqueduct.—As its name implies, this dehiscence is seated at the level of the first bend which the facial forms, and corresponds to the point of junction of the superior tympanic wall (petro-tympanic lamina) with its inner (petrous) wall. It occurs in the form of a cleft, the depth of which is measured by the thickness of the superior tympanic wall, and the author has found it only on petrous bones of which this wall was very thin. It is due to a faulty junction of the inner (petrous) border of the petro-tympanic lamina with the extremity of the bony lamina which closes the groove representing the tympanic aqueduct in the foetus.

Study of the development of the Fallopian canal permits the origin of dehiscences in its course on the inner tympanic wall to be properly understood. In the fourth month fœtus the anterior extremity of the petro-tympanic lamina scarcely reaches the level of the facial nerve, which is not yet contained in a bony canal throughout its course through the temporal. A canal exists only in the neighbourhood of the internal auditory meatus; beyond this first interosseous part the nerve passes simply in a *groove* on the surface of the petrous, then it makes its first bend and enters the tympanum, passing along its inner wall in a similar *groove* and simply covered by the tympanic mucous membrane. As it lengthens, the petro-tympanic lamina passes below the facial bend, joining to the two lips of the groove which contains it, and here transforms this into a bony ring in which the nerve passes. The *groove* of the facial is thus found to be divided into an intra-cranial part (large hiatus) and a tympanic part. This closes more rapidly than the first. The intra-cranial portion very often remains open in the eight to nine month fœtus, whilst the canal is already well outlined in its tympanic part in the six month fœtus. Along its course on the inner tympanic wall, ossification starts from the superior lip of the Fallopian groove and covers the facial nerve by joining its lower lip, which is nearest to the oval window. Closure of the aqueduct at the level of the part of the inferior lip of the groove which is immediately above the oval window occurs slowly. Traces of this tardy closure are often very marked here by a depressed line in the form of a scratch, as mentioned above. Ossification is often, nevertheless, not accomplished at this point during the first years, and may even never take place; there is then an oval dehiscence.

In order that the closure of the tympanic portion of the Fallopian aqueduct may be complete, it is necessary not only that the bony lamella should close this part of the canal from the superior border to the inferior border of the groove in which the facial nerve first reposes, but it is also necessary that this lamella, which transforms the groove into an aqueduct, should join by its anterior extremity the corresponding border of the petro-tympanic lamina, which, as has been said, originally forms a bony ring round the first facial bend as it joins the corresponding border of the petrous. If this does not take place, a tympanic dehiscence persists at the superior internal angle of the tympanum and at the first bend of the Fallopian aqueduct, which puts the tympanum into direct communication with the hiatus Fallopii, *i. e.* with the cranial

cavity. This dehiscence may be produced when the tympanic vault is very thin, as if the corresponding border of the petro-tympanic lamina is not sufficiently thickened to be able to meet and join with the extremity of the bony lamina which closes the tympanic portion of the Fallopian aqueduct.

Conclusion. — The different dehiscences of the Fallopian aqueduct have a very great but unequal importance in the propagation of suppuration into the cranial interior. The tympanic dehiscences alone favour the passage of pus from the tympanum into the aqueduct. The intra-cranial dehiscences favour its effusion into the cranium, and conduce more especially to the formation of an extra-dural collection, while, if the pus follows the aqueduct up to the bottom of the internal auditory meatus, it easily sets up meningitis on account of the *culs-de-sac* sent by the arachnoid round the facial and auditory nerves at this part. But, whilst an extra-dural purulent collection is formed on the upper surface of the petrous, proceeding from quite another part of the aqueduct, the hiatus Fallopii and especially the large dehiscence of the intra-petrous part of the facial canal may also serve as a path of derivation, and direct it towards the bottom of the internal auditory meatus in contact with the same arachnoid *culs-de-sac*.

SOCIETIES' PROCEEDINGS.

PROCEEDINGS OF THE AMERICAN LARYNGOLOGICAL, RHINOLOGICAL, AND OTOLOGICAL SOCIETY.

Seventeenth Annual Meeting, Atlantic City, June 1, 2, and 3, 1911.

Report by DR. L. M. INGRAM.

Thursday, June 1, 1911.

DISCUSSION ON DISEASES OF THE SALIVARY GLANDS.

ANATOMY AND PHYSIOLOGY OF THE SALIVARY GLANDS.

By DR. R. JOHNSON HELD (New York City).

A *resumé* was given of the chief anatomical and physiological features of the salivary glands. The subject was discussed under the following heads: (1) The anatomical structure of the parotid, submaxillary, and sub-lingual glands. (2) The histological structure of these glands.