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The Lenticular Process of the Incus

Evan M. Graboyes, AB, Timothy E. Hullar, MD, and Richard A. Chole, MD, PhD

Department of Otolaryngology, Washington University in St. Louis, Carl & Fay Simons Center of the Central Institute for the Deaf at Washington University St. Louis, Missouri, USA

Abstract

17th century anatomists, including Franciscus Sylvius, identified a small bony structure between the distal end of the incus and the stapes that they believed was a separate and thus additional ossicle. The existence of the ossicle at the distal portion of the long process of the incus was controversial for the next two hundred years. In the 19th century, anatomists including Johann Friedrich Blumenbach, Henry Jones Shrapnell, Eduard Hagenbach, and Joseph Hyrtl provided numerous arguments to demonstrate why the so-called additional ossicle was actually attached to the incus by a thin strut, and thus not a separate bone. Since then, the ovoid end of the incus has been referred to as the “lenticular process” of the incus. The best nomenclature for the bony connection between the lenticular process and the rest of the incus remains uncertain, but the term “lenticular process” should not include its connecting pedicle.

Keywords

lenticular process; fourth ossicle; os orbiculare; Sylvian ossicle; history of otology; history of the middle ear

Beginning in the early 1600s, anatomists reported that they had identified additional auditory ossicles. One was a small bone located at the distal end of the long process of the incus. Although no description of the ossicle can be found in his *Opera Medica* (1,2), the Dutch scientist and anatomist Franciscus Sylvius (a Latinized form of his name Franz de le Boë), many of his contemporary and subsequent anatomists gave him credit for its discovery (3–7). As a result, this ossicle has occasionally been named in his honor as the “*os lenticulare s. Sylvii*” (6), “*ossiculum Sylvii*” (8), “*Ossiculum lenticulare Sylvii*” (8), and the “*processus lenticularis (ossiculum lenticulare Sylvii)*” (9).

As anatomists continued to write about the additional auditory ossicle at the distal portion of the long process of the incus, they described and named it based on its spherical, oval, or lens shape. These appellations included the “*os lenticulaire*” (10–12), “*os orbiculare*” (3,13,14), “*os orbiculaire*” (15), the “*os semilunare*” (4), and the “*ossiculum subrotundum*” (5). The French anatomist Jean Mery, writing in the late 17th century, may have been the first to apply the name “lenticular ossicle” (10). Mery described and illustrated a lenticular bone at the end of the long process of the incus that forms an articulation with the stapes (“A l’extrémité de la plus longue apophyse de l’enclume, il a une tres-petite cavité, dans laquelle une des faces du petit os lenticulaire, est attachée par un cartilage, qui fait la simphise de ces deux os; & par l’autre face, il est à la pointe de l’étrier, avec laquelle il est articulé par artrodie”) (Figure 1). This name was also used by Mery’s contemporary Guillaume Lamy, who explained that the newly discovered fourth ossicle was appropriately named lenticular

because of its round and flat shape (“Les modernes ont découvert un quatrième osselet beaucoup plus petit que les autres, qu’on peut appeler lenticulaire à cause de sa figure ronde & plate”) (11). Saint-Hilaire Geoffroy also described the bone as lenticular in 1778 (12).

In his 1704 work *De Aure Humana Tractatus*, Valsalva illustrated an “Os Orbiculare” which he described as a very small bone at the end of the long process of the incus that was said to have a spherical shape (“In longioris Processus Incudis extremitate...Ossiculum omnium minimum observabile est, à formâ Orbiculare inepté dictum”) (3) (Figure 2). His margin notes indicate that he thought the ossicle was in fact oval in shape (“non est orbiculare; sed ovale”). In 1717, James Drake described and illustrated the “*Os Orbiculare*” as “a round thin Bone; Concave on one side, and Convex on the other. On the Concave side it receives the Head of the *Stapes*, and the Convex is receiv’d by the Process of the *Incus*” (13). In 1734, Johann Friedrich Cassebohm wrote of the “*ossiculum orbiculare*” (14). Claude Nicolas Le Cat described the bone as the “*l’os Orbiculaire*” in 1742 (15).

Hermann Friedrich Teichmeyer noted that in his 1727 thesis dedicated to the auditory ossicles that even though the ossicle at the distal end of the long process of the incus was called “orbiculare” by others, he believed that a better description and name was “semilunare” (“communissime salutatur orbiculare, a me vero semilunare, propter figuram, quam possidet, vocatur”) (4). In 1763, Albrecht von Haller entitled the section of his text about this ossicle “*Ossiculum subrotundum*,” although he acknowledged that many other anatomists has described its shape with other adjectives (5). All of these anatomists, unaware of the existence of a bony connection between the so-called lenticular ossicle and the incus, used their respective terms to indicate what we now know to be the distal portion of the long process of the incus.

This bone has also been known as the fourth ossicle at various points (6,8,10,11,14,16-20). In his 1683 text *Traité de l’organe de l’ouïe*, Guichard-Joseph Du Verney described this “fourth ossicle” as being of inconsiderable thickness, slightly convex on the side facing the stapes, and a little concave on the side that articulates with the tip of the incus (“le quatrième osselet n’a presque point d’épaisseur; il est un peu convexe du costé qui regarde la teste de l’étrier, & tant soit peu cave du costé qui s’articule avec le bec de l’enclume”) (17) (Figure 3). References to the “os lenticulaire” as the “fourth ossicle” have created confusion in historical accounts of the lenticular process because anatomists such as Johannes Vesling, Nicolas Fontano, Thomas Bartholin, Caecilius Folius, Günther Christoph Schelhammer, and Hermann Friedrich Teichmeyer described and illustrated different anatomic structure in the stapes tendon that they called the “fourth ossicle” (4,21–26) (Figure 4).

The existence of the lenticular ossicle at the distal end of the long process of the incus has been debated since it was first described (6,8,16,18,19,27). Claude Perrault, in the 1680 edition of *Essais de Physique*, suggested that even though modern anatomists had added a fourth ossicle that is round and very small, what he found was really a portion broken off from the incus (“Les Anatomistes modernes ont adjouté un quatrième osselet qu’ils dissent estre rond & tres-petit. Mais on le trouve rarement, & il y a lieu de croire quand on le rencontre que c’est le petit noeud du bout de la jambe par laquelle l’enclume est attachée a l’étrier qui a esté rompu”) (16).

A lengthy line of argumentation from the late 18th and early 19th century eventually convinced the scientific and medical community that the putative lenticular ossicle at the distal end of the long process of the incus was in fact not a separate ossicle. In 1786, Johann Friedrich Blumenbach argued that the os orbiculare was an epiphysis of the incus and thus not a separate bone (28). He pointed out that the os orbiculare and incus “can only be separated by the employment of some force” (18). He also undertook careful microscopic

examination and noted that in cases in which the lenticular bone was separated from the incus, the surfaces of the lenticular bone showed evidence of jagged fractures (28).

In 1832, Henry Jones Shrapnell found that he was unable to separate the “incus” from the “os lenticulare” though maceration and concluded that there was a bony connection between the os lenticulare and the incus (19). He wrote, “the appearance of the connexion of the reputed os lenticulare to the incus is that of a distinct neck or process of bone... this process thus spreads out into an oval plate, which forms the articulation with the head of the stapes.” He proposed that “the os lenticulare is to be struck out of the list of the bones, and should be considered merely a process--namely, the processus lenticularis of the os incus” united with the long process of the incus through a “connexion.” His accompanying figures depict the os lenticulare fractured from its supporting connection and a caption explaining that the “lenticular portion” is “named the os lenticulare” (Figure 5).

Despite the works of Blumenbach and Shrapnell showing that the lenticular ossicle was not a separate additional ossicle, apparently not all were convinced. In 1835, Eduard Hagenbach, who was aware of Shrapnell’s work, felt it necessary to list several reasons why the lenticular ossicle was actually part of the incus (6). First, he noted that the lenticular bone generally remained attached to the incus when he separated the ossicles, in fresh and dried specimens, and in embryonic and adult forms. Second, it required a significant effort to separate the lenticular ossicle from the incus. Third, the face of the lenticular process resembled the face of a true joint. Fourth, when the lenticular ossicle and incus were found independently, he observed irregular splintered edges on the lenticular ossicle which unmistakably indicated that a forceful separation had occurred. Fifth, he was never able to observe a true joint in the area between the incus and the lenticular ossicle. Sixth, the lenticular bone formed early in development in combination with the incus itself and did not start as a distinct bone that then grow to join the incus at a later point in time.

The question of the lenticular ossicle as an independent bone was addressed again in 1845 by the eminent anatomist Joseph Hyrtl (8). He analyzed the ossicles of many mammalian species and again arrived at the conclusion that the ossiculum lenticulare is connected by a thin column to the long process of the incus, and therefore not a separate bone. He was aware of the work of Shrapnell and Hagenbach, and used many of the same arguments to support this conclusion. Like Shrapnell and Hagenbach, Hyrtl also found that when he separated the lenticular ossicle from the incus, there was a fracture on the side facing the incus. In agreement with Hagenbach, Hyrtl also believed that there was no separate developmental site for the lenticular bone, but rather it grew out of the incus.

Despite the work of Blumenbach, Shrapnell, Hagenbach, and Hyrtl, controversy about the existence of a lenticular ossicle has persisted into the 20th century (20,29–31). Gaudin, in a 1969 article about biophysical properties of the middle ear, wrote that “the lenticular process is the smallest bone in the human anatomy” and that it could “be considered as the fourth auditory ossicle” because of its independent structure and function (31). In a 1997 article, a histological investigation by Pal’chun and Magomedov concluded that the “lenticular process is a separate bone” (30). A response by Chien et al. addresses possible explanations for Pal’chun’s conclusion (32). Asherson, in 1978, argued that “the past existence of a fourth ossicle must be accepted” because it had been described by so many anatomists, but he could not explain why it was no longer observed in modern times (20).

One reason for the ongoing uncertainty regarding the presence of a separate lenticular ossicle may be the lack of well-accepted nomenclature describing the attachment of the lenticular process to the distal long process of the incus. Several terms for this attachment been used in the past. In his 1806 work *Abbildungen des Menschlichen Hoerorganes*,

Samuel Thomas Soemmerring referred to the lenticular ossicle as a knob (not a separate ossicle), and used the term “Hälschen” (small neck) to describe the narrow connection to the long process of the incus (33) (Figure 6). Eysell also illustrated the connection between the lenticular process and the incus in 1870, naming it the stalk of the lenticular process, or “Stiel des Os lenticulare” (27) (Figure 7). Funnell et al., in their description of the anatomy of the incudo-stapedial joint in the cat, simply referred to it as a “connection between the long process and the lenticular process of the incus” (34). Recently, Chien et al. have written that the lenticular process constituted both the “proximal narrow pedicle and a distal flattened plate” (32).

The inclusion of the connecting strut as part of the lenticular process proper is inconsistent with the earlier usage by Shrapnell and others to delimit the term lenticular process to solely the distal lens-shaped portion of the incus and to the exclusion of its connecting strut (9,19,27). It is also inconsistent with the etymology of the word “lenticular” and its use in other areas of science (35). It is used in several contexts to convey information about a particular biconvex shaped object. It is used in astronomy (lenticular galaxies appear as bi-convex disks when viewed on-edge), neuroanatomy (the lenticular nucleus was named for its resemblance to a bi-convex lens), and meteorology (lenticular clouds are stationary lens shaped clouds that form at high altitude) (Figure 8). With permission, we have adapted the Chien et al. figure to indicate that the lenticular process does not include the connecting piece and suggest that this figure is more consistent with historical precedent, etymology, and other uses of the word lenticular (Figure 9).

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Figure 1.

An illustration of the incus and lenticular ossicle from the figure L of the 1681 edition of Mery's text *Description exacte de l'oreille de l'homme*. The lenticular ossicle ("l'os lenticulaire") (e) is depicted at the distal tip of the long process of the incus. Mery is thought to have been the first to use the appellation "l'os lenticulaire."

Figure 2.

The incus and “Os Orbiculare” reproduced from figure VI of Valsalva’s 1704 work *De Aure Humana Tractatus*. The lenticular ossicle is termed the “Os Orbiculare” by Valsalva (N) and is shown separate from the long process of the incus (M). Valsalva thought that the ossicle was in fact oval in shape (“non est orbiculare; sed ovale”).

Figure 3.

The ossicles, reproduced from figure V of the 1683 edition of Du Verney's text Traité de l'organe de l'ouïe. He depicts the lenticular ossicle as a lentil-shaped, separate "fourth ossicle" ("le quatrième osselet") (B) located between the long process of the incus (A) and the head of the stapes (C).

Figure 4.

An illustration of the ossicles from figure three of Caecilius Folius' 1645 edition of *Nova Auris Internae Delineatio* demonstrating an additional ossicle that Folius called the "osseus globulus" (g), shown within the adjacent stapes tendon. A similar figure can be found in Thomas Bartholin's 1651 edition of *Anatomia Reformata*. This "fourth ossicle" in the stapes tendon has occasionally been confused with the lenticular ossicle at the distal end of the long process of the incus.

Figure 5.

The distal incus and lenticular process, reproduced from Henry Jones Shrapnell's 1832 publication "On the structure of the os incus." Note numbers 5, 6, and 7 depicting the os lenticulare as a structure distinct from the neck of supporting bone from which it was fractured.

Figure 6.

The incus, reproduced from figures 13 and 18 of Samuel Thomas Soemmerring's 1806 text *Abbildungen des Menschlichen Hoerorganes*. It depicts the incus and shows the "knob" that connects with the stirrup (i, c), the narrow neck of this knob (d), and the long process of the incus (h, b).

Figure 7.

The distal incus, lenticular process, and the incudo-stapedial joint, reproduced from Eysell's 1870 woodcarvings. He depicts the os lenticulare (c) and its connecting stem (b). Note that the os lenticulare does not include its connection.

Figure 8.

A lenticular cloud photographed over Mindin, Nevada demonstrating bi-convex shape of the clouds for which they are named.

Figure 9.

A three-dimensional model depicting the anatomy of the distal incus and the incudo-stapedial joint with the lenticular process representing the most distal portion of the incus exclusively. Image courtesy of The Human Temporal Bone Consortium
<http://temporalboneconsortium.org/> Saumil Merchant, MD, Director. History of Otology