Clinical Anatomy 27:4–9 (2014)

## A GLIMPSE OF OUR PAST

# Gabriel Falloppius (1523–1562) and the Facial Canal

**VERONICA MACCHI,[1] ANDREA PORZIONATO,[1] ALDO MORRA,[2] AND RAFFAELE DE CARO[1]***

[1]*Institute of Anatomy, Department of Molecular Medicine, University of Padova, Italy*
[2]*Section of Radiology, Euganea Medica Group, Padova*

Gabriel Falloppius is known for his contributions to anatomy. Indeed, many anatomic structures bear his name, such as the Fallopian tubes, and his descriptions often contradicted those of other notable anatomists, such as Galen and Andreas Vesalius. In his textbook "*Observationes Anatomicae*," he described for the first time the structures of the ear, eye, and female reproductive organs, and elucidated the development of the teeth. Furthermore, Falloppius described the facial canal. The objectives of this paper are to provide an overview of Falloppius's life and to discuss the clinical relevance of the facial canal as understood from his description of this anatomic structure. Clin. Anat. 27:4–9, 2014. 

**Key words: radiological anatomy; medical history; facial canal**

The name of Falloppius is well known because of his immense contribution to anatomy, famous to the point that many anatomic structures bear his name. Curiously, the most frequently mentioned structure, the fallopian tube, was actually described by Herophilus, a great anatomist of the second century B.C. (Wells, 1948; Kothary and Kothary, 1975), whereas one of Falloppius discovers, the Poupart's ligament should be called the Falloppian ligament, since Falloppius described it half a century before the French anatomist Poupart (Wells, 1948).

The aim of this article is to report some information about his life, and to focus the attention on the clinical application of one of his discoveries, the Fallopean canal (aqueduct).

Gabriel Falloppius was born in Modena in 1523 to Catherine Bergomozzi and Girolamo Falloppius (Kothary and Kothary, 1975). Falloppius was 10 years old when his father died. Supported by his relatives, he began studying the humanities, and the open-minded culture and academic environment of Modena was conductive to his education. After a few years, he started to focus on studying medicine and anatomy. The teaching of medicine had not been yet established in Modena, and thus Falloppius conducted his studies in the medical sciences independently. Falloppius became very knowledgeable in the subjects of anatomy, surgery, and pharmacology. He studied the texts of Galen and Berengario of Capri, and performed many dissections on animals and examined the bodies of executed criminals, thereby complementing his reading of texts with cadaveric studies (Belloni Speciale, 1994).

In 1545, Falloppius travelled certainly to Ferrara, where he studied medicine under the guidance of Antonio Musa Brasavola. The Duke of Florence, Cosimo I de Medicine, offered Falloppius the Chair of Anatomy in Pisa, which he held from 1548 to 1551 (Wells, 1948). While in Pisa, Falloppius conducted experiments on the effectiveness of opium administered for the purposes of executing individuals condemned to death, and these efforts led him to be accused of practicing human vivisection (Kothary and Kothary, 1975). In addition, he studied the identification, classification, and pharmaceutical use of plants implemented in the Latin, Greek, and Arabic medical traditions (Belloni Speciale, 1994).

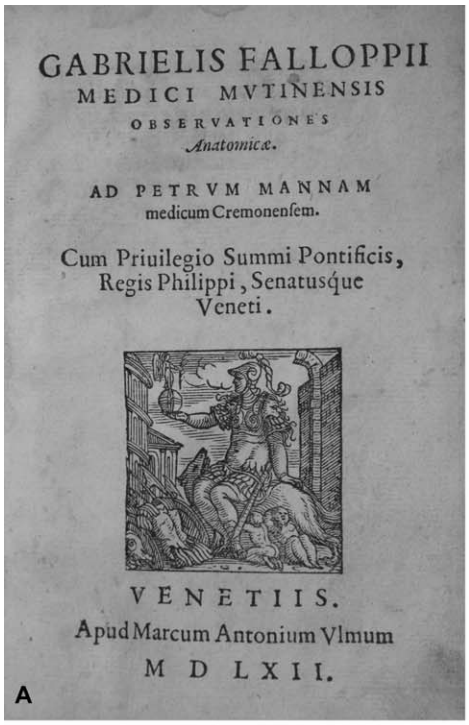
In 1551, Falloppius became Professor of Anatomy, Surgery, and Botany, at the University of Padova, a chair previously held by Andreas Vesalius. His lectures on anatomy mainly involved discussing normal

*Correspondence to: Prof. Raffaele De Caro, Institute of Anatomy, Department of Molecular Medicine, Via A Gabelli 65, 35127 Padova, Italy. E-mail: rdecaro@unipd.it

Received 7 December 2012; Revised 14 February 2013; Accepted 19 February 2013

Published online 1 April 2013 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/ca.22241

anatomy and dissecting human body and animals. In addition to teaching, Falloppius practiced medicine. He was summoned to Rome to treat the brother of Pope Julius III, and he also worked for the Estense family of Ferrara. However, from 1556 to 1557, Falloppius was afflicted with chronic fatigue. His academic responsibilities were tiring for him. Furthermore, he developed a chronic pulmonary infection, and as he taught anatomy mainly during the winter, his work as an instructor was affected. On October 9, 1962, Falloppius became gravely ill and died, likely from tuberculosis (Kothary and Kothary, 1975). He was


GABRIELIS FALLOPPII
MEDICI MVTINENSIS
OBSERVATIONES
*Anatomicæ.*

AD PETRVM MANNAM
medicum Cremonenſem.

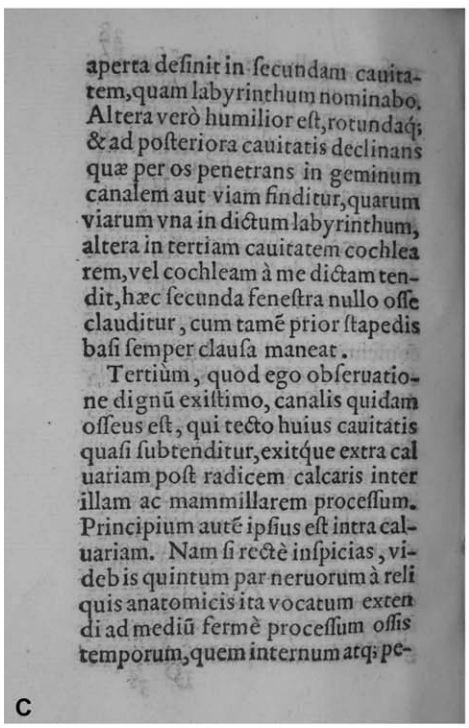
Cum Priuilegio Summi Pontificis,
Regis Philippi, Senatusque
Veneti.

VENETIIS.
Apud Marcum Antonium Vlmum
M D LXII.

A

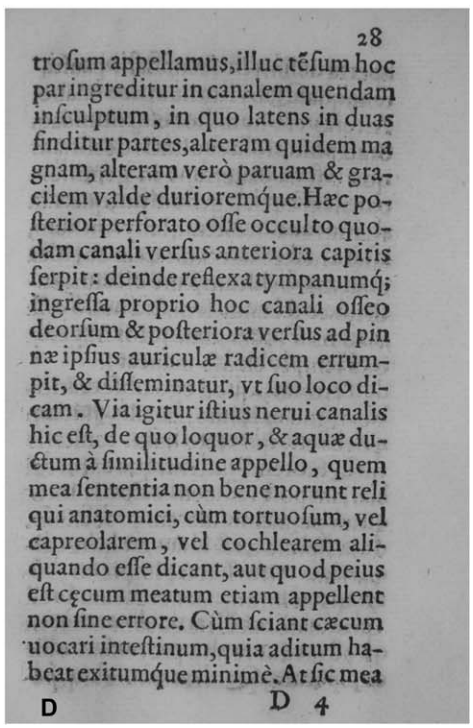

HIC
SEPVLTA FVERVNT OSSA
GABRIELIS FALLOPPII ✝ 1562
ET
MELCHIORIS GVILANDINI ✝ 1589
HORTVS PATAVINVS
TANTORVM VIRORVM MEMOR ET GRATVS
P. MCMII

B


aperta deſinit in ſecundam cauitatem, quam labyrinthum nominabo. Altera verò humilior eſt, rotundaq; & ad poſteriora cauitatis declinans quæ per os penetrans in geminum canalem aut viam finditur, quarum viarum vna in dictum labyrinthum, altera in tertiam cauitatem cochlearem, vel cochleam à me dictam tendit, hæc ſecunda feneſtra nullo oſſe clauditur, cum tamẽ prior ſtapedis baſi ſemper clauſa maneat.

Tertiùm, quod ego obſeruatione dignũ exiſtimo, canalis quidam oſſeus eſt, qui tecto huius cauitatis quaſi ſubtenditur, exitq́ue extra caluariam poſt radicem calcaris inter illam ac mammillarem proceſſum. Principium autẽ ipſius eſt intra caluariam. Nam ſi rectè inſpicias, videbis quintum par neruorum à reliquis anatomicis ita vocatum extendi ad mediũ fermè proceſſum oſſis temporum, quem internum atq; pe-

C


28

troſum appellamus, illuc tẽſum hoc par ingreditur in canalem quendam inſculptum, in quo latens in duas finditur partes, alteram quidem magnam, alteram verò paruam & gracilem valde durioremq́ue. Hæc poſterior perforato oſſe occulto quodam canali verſus anteriora capitis ſerpit: deinde reflexa tympanumq́; ingreſſa proprio hoc canali oſſeo deorſum & poſteriora verſus ad pinnæ ipſius auriculæ radicem errumpit, & diſſeminatur, vt ſuo loco dicam. Via igitur iſtius nerui canalis hic eſt, de quo loquor, & aquæ ductum à ſimilitudine appello, quem mea ſententia non bene norunt reliqui anatomici, cùm tortuoſum, vel capreolarem, vel cochlearem aliquando eſſe dicant, aut quod peius eſt cęcum meatum etiam appellent non ſine errore. Cùm ſciant cæcum uocari inteſtinum, quia aditum habeat exitumq́ue minimè. At ſic mea

D

D 4

entombed at the Saint Anthony Basilica in Padova. In XVIII century his tomb was demolished for the purposes of restoration of the church, and his remains were placed in the tomb of his friend Melchiorre Guilandino (Belloni Speciale, 1994; Fig. 1b).

Falloppius stressed the need for instructors of anatomy to utilize a methodology that emphasized direct observation ("*quoniam former sense hoc east cognoscendum not autem ex ratione*"), and he highlighted the differences between his observations of anatomic structures and those reported in textbooks by Galen and Vesalius. In 1557, Falloppius began writing the textbook "*Observationes Anatomicae"*. He attempted to elucidate anatomic development by studying fetuses, infants, children, and adults, introducing the method of developmental anatomy and embryology. This method was then developed by two of his most famous students, Hieronymus Fabricius ab Aquapendente and Volcher Koyter. In particular, Aquapendente starting from the dissection and anatomy of a structure, describes then its independent action, and its interdependent function in the body (Smith et al., 2004).

Unlike many of his contemporaries, Falloppius did not include illustrations of anatomic structures in *Observationes Anatomicae*, published in Venice in 1561 (Fig. 1a), in which the numerous discoveries, that Falloppius made, are noted. This book consisted mainly of corrections to and commentaries on Vesalius's Fabrica (Kothary and Kothary, 1975). Albrecht van Haller states that Falloppius, in his controversy with Vesalius, was generally on the right side (Wells, 1948). Falloppius made more discoveries than Vesalius did, and Falloppius's research is considered more precise than that of Vesalius (Ongaro, 2001), "*Fallope avait le génie de l'invention; Vésale, le géenie de la méthode; ou plutôt Fallope avait du génie, Vésale n'avait que du savoir'"* (Daremberg, 1870).

In addition to the fallopian tubes, the following structures bear Falloppius's name: the opening in the petrosal bone through which the greater superficial petrosal nerve passes (falloppian hiatus), and the small canal in the petrous portion of the temporal bone through which the facial nerve passes (falloppean canal or aqueduct). Moreover, he described an obstetrical anomaly in which implantation of the embryo occurs in one of the fallopian tubes (falloppian gestation or tubal pregnancy). Falloppius was the first scholar in the Modern Age to develop the concept of tissues, which he referred to as *"partes similares,"* and the first to state that muscle is made of connective tissue (Table 1; Tosoni, 1844; Wells, 1948; Speert, 1955; Kothary and Kothary, 1975; Ongaro, 2001; Mortazavi et al., 2012; Porzionato et al., 2012).

The facial canal, or fallopean canal, runs across the medial wall and down the posterior wall of the tympanic cavity to the stylomastoid foramen (Proctor, 1989). The canal of the facial nerve is located inside the temporal pyramid, and is classically divided into three segments that are separated by the genu. The first, or labyrinthine segment, is horizontal, is directed in an anterior direction, extends from the internal auditory canal, and is located perpendicular to the axis of the pyramid; then, it bends sharply going parallel to the greater axis of the pyramid to become the second or tympanic portion, and then bends a second time to become vertical until it emerges at the stylomastoid foramen as the third or mastoid portion (Proctor, 1989) (Figs. 1c and 1d).

While the facial nerve runs in its canal, three branches, which are the greater petrosal nerve, stapedius nerve, and chorda tympani, exit from the main trunk. Consequently, the number of nerve fibers decreases as the nerve approaches the canal exit and the width of the facial nerve on the distal end is significantly smaller (Schröder, 1994). The main cross-sectional area of the exit of the facial canal is wider compared to the entrance (Dawidowsky et al., 2011), which Falloppius himself reports (Figs. 1c and 1d).

The size of the facial canal is an important factor in Bell's palsy, which is the most common cause of peripheral paralysis in the world. It results from acute damage to the facial nerve. Several hypothesis concerning its etiology have been proposed, such as ischemic neuropathy, infection, and genetic and immunologic causes. Edema of the facial nerve plays a role in the pathophysiology of Bell's palsy

---

**Fig. 1**. (**A**) The frontispiece of the textbook "Observationes Anatomicae" published in 1561 in Venice. (**B**) The tomb of Falloppius in the Saint Anthony Basilica. (**C,D**) Original description of facial canal at page 27 and 28 of Observationes anatomicae, in which one reads "the third thing, that I think worthy of attention, is a bony canal [canalis n. facialis] that runs almost below this cavity [n.d.t. coclear cavity] and exits from the skull behind the ear burls, more precisely between that and the mastoid process [foramen stylomastoideum]. It begins in the cranial cavity; if you look closely, you'll see the fifth pair of nerves, named this way from other anatomists, extend almost to the middle of the process of the temporal bone, which we call internal or petrosal; expanding in this direction, this pair of nerves enters a channel into the bone [meatus acusticus internus] and inside of it, it divides into two branches, a big [n. vestibulocochlearis] and a small very thin and hard one [n. facialis]. This posterior branch, pierces the bone, flows in the direction of the front of the head by a hidden channel, then reflects back, enters the tympanum and, thanks to its own bony canal, goes down and back, to the root of the wing ear, spreading as I will describe later. The path followed by this nerve is the channel I'm talking about, which I call by similarity 'aqueduct' and which the other anatomists, in my opinion, do not know well, since they describe it as tortuous, or as a goat's horn, or sometimes spiral, calling also, what is worse, blind meatus, not without error, because they should know that a part of the intestine is called 'blind' in that it has an input and not an output. This channel instead has an outlet hole, which is more evident than that of the input".

**TABLE 1. Discoveries of Falloppius**

| System | Discoveries | Descriptions | Invention of names |
|---|---|---|---|
| Bones and cartilages | Sphenoid sinus | Ethmoid and sphenoid bone, sphenoid sinus, lacrimal bone with lacrimal duct, condyles of the humerus and femur and the tuberosity of the tibia. Primary and secondary ossification (skull, sternum and innominate bones) | Cricoid |
| Nerve | | Auditory (CN VIII) and glosso-pharyngeal nerve (CN IX) which is separated from the accessory nerve (CN XI), oculomotor (CN III), trigeminal (CN V), and hypoglossal nerve (XII), origin of the troclear nerve (IV), the cardiac plexus | |
| Muscles | Levator palpebrae muscle | Attachments of the intercostal muscles, extrinsic muscles of ear, muscles of head and neck, muscle of mastication, muscle of the soft and hard palates | Pyramidalis (Falloppian) Muscle |
| Ear | Stape[a] | Round and oval windows, scala vestibuli, semicircular canals, incudo-malleolar joint | Cochlea, labyrinthtympanum |
| Female reproductive | | Ovaries, round ligament, clitoris, hymen, vagina and placenta | Vagina, placenta, Falloppian tubes |
| Eye | | Combined action of the oblique muscles and trochlea of superior oblique | |
| Tooth | Connection between surface mucous membrane and dental lamina | Primary dentition, follicle of tooth and development of secondary tooth | |
| Bowel | Villi and valvulae conniventes | Ileocecal valve | Falloppian ileocecal valve |
| Kidney | Straight tubules, calyxes, three layered muscular coat of the bladder | | |

[a]Some authors attributed the discovered of the stape to Ingrassia (Kothary and Kothary, 1975).

(Yanagihara et al., 2000). Magnetic resonance imaging suggests that Bell's palsy may be caused by viral neuronitis either in the labyrinthine segment at the apex of the internal auditory canal, or in the adjacent brainstem (Schwaber et al., 1990; Yetiser et al., 2003; Lim et al., 2012). Furthermore, controversial reports about the dimensions of the facial canal in patients with Bell's palsy have been published (Wadin et al., 1987; Kefalidis et al., 2010). During dissection, Yanagihara et al (1988) identified the tympanic portion as the narrowest part of the facial canal. Microscopic studies with three-dimensional reconstructions demonstrate that the narrowest parts are the proximal part of the labyrinthine portion and the middle part of the tympanic portion (Nakashima et al., 1993; Kefalides et al, 2010; Murai et al., 2012).

Developments in compute tomography (CT) imaging allow for more detailed studies of anatomic structures. Multiplanar reformatting and three-dimensional CT reconstructions are used to evaluate the facial canal (Fatterpekar et al., 2006) (Fig. 2). At high resolution, the cross-section of the bony canal might vary in shape (Kefalidis et al., 2010). Furthermore, greater variation among subjects in the size of the facial canal or foramen and intra-subject variation in the left and right portions have been reported, which confirms that asymmetry is a more important marker for abnormality than actual size (Sepahdari and Mong, 2013). In patients with Bell's palsy, CT examinations reveal that the mean combined cross-sectional area of the labyrinthine and horizontal segments of the facial canal is significantly smaller on the affected side than on the unaffected side.

In conclusion, Falloppius described the structure of the facial canal accurately and discussed the dimensions of its entrance and exit points. The facial canal is clinically relevant. Modern imaging techniques allow the acquisition of sectional images and reconstruction of three-dimensional models for visualizing internal structures. These images are useful for the purposes of education in anatomy (Macchi et al., 2012).

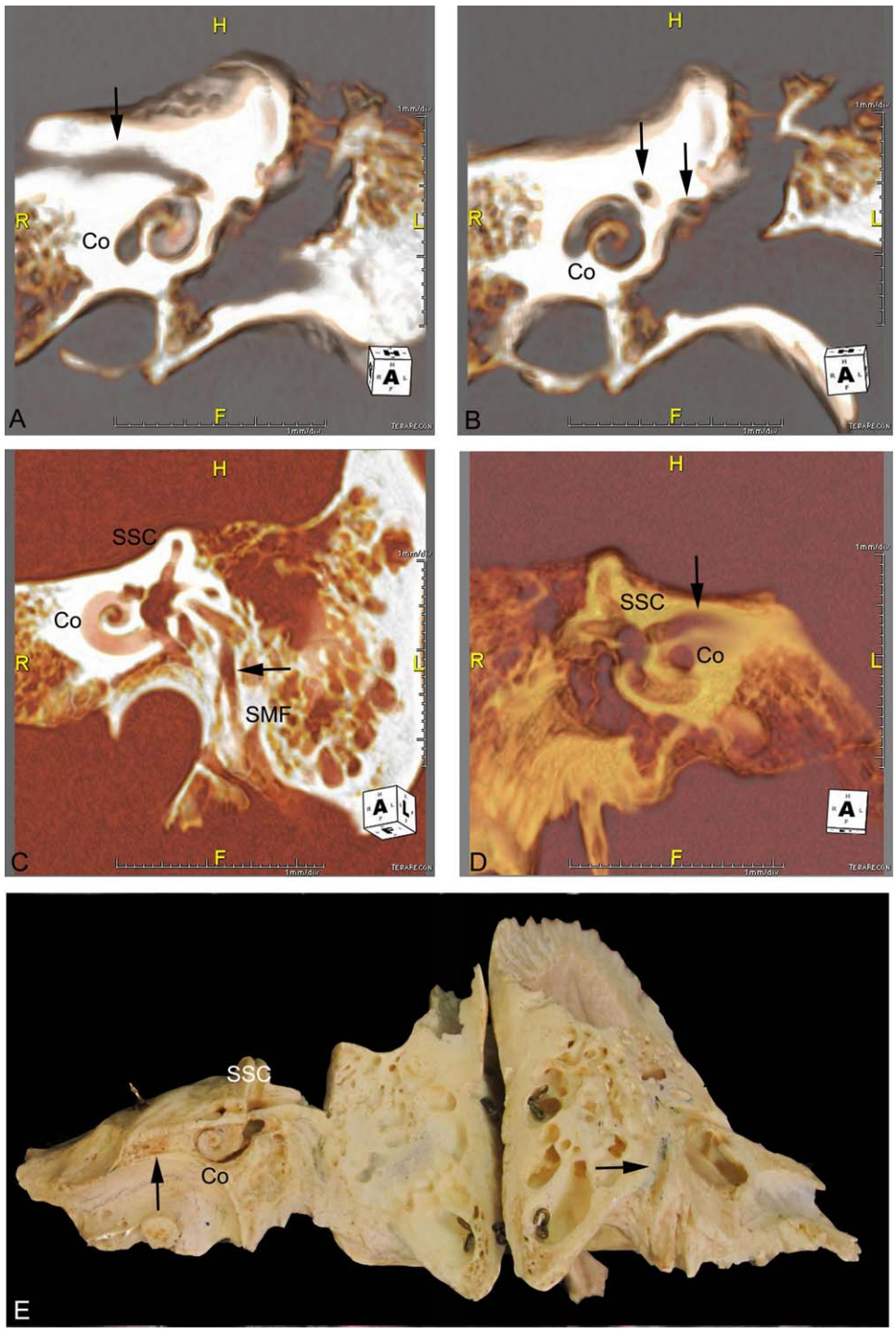



**Fig. 2**. (**A–D**): 3D-CT reconstruction of a skull showing the three segments of the facial canal (a. labyrinthine, b. tympanic, c. mastoid). e. picture of an open tympanic pyramid. Co, coclea, SCC superior semicircular canal, SMF, stylomastoid formanen. Arrows pointed the facial canal. CT images were obtained on a 256-slice multidetector CT scanner (Philips iCT 256; Philips Medical Systems; the Netherlands) with the following parameters: slice thickness 0.67 mm, kV 120, mA 65. Analysis and postprocessing of scans were carried out on a Terarecon Acquarius iNtuition 4.4.7. [Color figure can be viewed in the online issue, which is available at wileyonline library.com.]

## ACKNOWLEDGMENT

The authors are grateful to Dr. Anna Rambaldo, Gloria Sarasin and to Gianpaolo Mornata for skilful technical assistance, to Miss Alberta Coi and Dr. Giulia Rigoni for the help with the references, to Dr. Giulia Andretta for the English review. They also thank Euganea Medica for the radiological study.

## REFERENCES

Belloni Speciale G. 1994. Falloppia Gabriele. Dizionario Bibliografico Treccani. Vol 44. Available at: http://www.treccani.it/enciclopedia/gabriele-falloppia_(Dizionario_Biografico).

Dawidowsky K, Branica S, Batelja L, Dawidowsky B, Kovać-Bilić L, Simunić-Veselić A. 2011. Anatomical study of the facial nerve canal in comparison to the site of the lesion in Bell's palsy. Coll Antropol 35:61–65.

Daremberg CV. 1870. Histoire des Sciences Médicales. Paris: Baillière.

Fatterpekar GM, Doshi AH, Dugar M, Delman BN, Naidich TP, Som PM. 2006. Role of 3D CT in the evaluation of the temporal bone. Radiographics 26:S117–S132.

Kefalidis G, Riga M, Argyropoulou P, Katotomichelakis M, Gouveris C, Prassopoulos P, Danielides V. 2010. Is the width of the labyrinthine portion of the fallopian tube implicated in the pathophysiology of Bell's palsy? A prospective clinical study using computed tomography. Laryngoscope 120:1203–1207.

Kothary PC, Kothary SP. 1975. Gabriele Fallopio. Int Surg 60:80–81.

Lim HK, Lee JH, Hyun D, Park JW, Kim JL, Lee Hy, Park S, Ahn JH, Baek JH, Choi CG. 2012. MR diagnosis of facial neuritis: diagnostic performance of contrast-enhanced 3D-FLAIR technique compared with contrast-enhanced 3D-T1-fast-field echo with fat suppression. AJNR Am J Neuroradiol 33:779–783.

Macchi V, Porzionato A, Stecco C, Morra A, De Caro R. 2012. Comment on: the anatomical collection of Giovan Battista Rini (1795–1856). Clin Anat. 2012:788–790.

Mortazavi MM, Adeeb N, Latif B, Watanabe K, Deep A, Griessenauer CJ, Tubbs RS, Fukushima T. 2012. Gabriele Fallopio (1523–1562) and his contributions to the development of medicine and anatomy. Childs Nerv Syst. Sep 11. [Epub ahead of print].

Murai A, Kariya S, Tamura K, Doi A, Kozakura K, Okano M, Nishizaki K. 2012. The facial nerve canal in patients with Bell's palsy: An investigation by high-resolution computed tomography with multiplanar reconstruction. Eur Arch Otorhinolaryngol. Nov 11. [Epub ahead of print].

Nakashima S, Sando I, Takahashi H, Fujita S. 1993. Computer-Aided 3D recnstruction and measurement of the facial canal and facial nerve. I. Cross sectional area and diameter: Preliminary report. Laringoscope 103:1150–1156.

Ongaro G. 2001. Scientific and cultural history: the Medieval and Early Modern University—Medicine. In: Del Negro P, editor. The University of Padova: Eight Centuries of History. Padova: Signum Ed.

Porzionato A, Macchi V, Stecco C, Parenti A, De Caro R. 2012. The anatomical school of Padua. Anat Rec (Hoboken) 295:902–916.

Proctor B. 1989. Surgical anatomy of the ear and temporal bone pp:89–112. Thieme Medical Publishers: New York.

Schröder JM. 1994. Changing ratio between myelin thickness and axon caliber in developing human facial nerves. Eur Arch Otorhinolaryngol Dec:S16–S17.

Schwaber MK, Larson TC III, Zealear DL, Creasy J. 1990. Gadolinium-enhanced magnetic resonance imaging in Bell's palsy. Laryngoscope 100:1264–1269.

Sepahdari AR, Mong S. 2013. Skull base CT: normative values for size and symmetry of the facial nerve canal, foramen ovale, pterygoid canal, and foramen rotundum. Surg Radiol Anat 35:19–24.

Smith SB, Macchi V, Parenti A, De Caro R. 2004. Hieronymus Fabricius Ab Aquapendente (1533–1619). Clin Anat 17:540–543.

Speert H. 1955. Gabriele Falloppio and the fallopian tubes. Obstet Gynecol 6:467–470.

Tosoni P. 1844. Della Anatomia degli Antichi e della Scuola Anatomica Padovana. Padova: Tipografia del Seminario.

Wadin K, Thomander L, Wilbrand H. 1987. The labyrinthine portion of the facial canal in patients with Bell's palsy investigated by computed tomography. Acta Radiol 28:25–30.

Wells WA. 1948. Gabriel Fallopio, one of the 16th century founders of modern anatomy; also distinguished physician and surgeon, 1523–1562. Laryngoscope 58:33–42.

Yanagihara N, Honda N, Hato N, Murakami S. 2000. Edematous swelling of the facial nerve in Bell's palsy. Acta Otolaryngol 120:667–671.

Yanagihara N. 1988. Incidence of Bell's palsy. Ann Otol Rhinol Laryngol Suppl 137:3–4.

Yetiser S, Kazkayas M, Altinok D, Karadeniz Y. 2003. Magnetic resonance imaging of the intratemporal facial nerve in idiopathic peripheral facial palsy. Clin Imaging 27:77–81.