Endoscopy of Meckel's cave, cisterna magna, and cerebellopontine angle

Technical note

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A new 1.45-mm endoscope is described that can be inserted through a thin-walled No. 16 needle. The instrument was used in 10 cadavers for endoscopic exploration of the cisterna magna, the C1–2 space, Meckel's cave, and the cerebellopontine angle. Its potential clinical application is discussed.

KEY WORDS • endoscopy • suboccipital puncture • Meckel's cave • cerebellopontine angle • cranial nerve • cordotomy

Endoscopic techniques allow examination of areas inside the body with minimal trauma and play an important role in almost every medical field. Endoscopy of the central nervous system has also been employed since the early days of neurosurgery. Ventriculoscopy has been reported by many authors.2,4,8,17,18,20 Burman,2, Stern,19 and Pool15 performed myeloscopy or “spinascopy.” Since the development and clinical application of the new model of the cerebral ventriculofiberscope in 1968,5,6 it has been the author's purpose to develop an extremely fine scope for exploration of the very restricted spaces in the nervous system. Recently a new optical glass, Selfoc,* has been developed, making it possible to manufacture an endoscope with a very small caliber.21 The preliminary results using a 1.7-mm Selfoc-scope in the lumbar spinal canal have been reported previously.7 The present report introduces a new 1.45-mm Selfoc-

*Selfoc glass from the Nippon-Ita-Glass Co. and Olympus Optical Co., Tokyo, Japan.

Description of the Instrument

The endoscope consists of a Selfoc glass rod and a special lens of the same material (Fig. 1). The optical principle of Selfoc glass is that its refractive index is greatest along its central axis, decreasing gradually toward the periphery (Fig. 2). This relation is formulated in the following equation: \( n = n_0 \left(1 - \frac{1}{2} kr^2\right) \), where \( n_0 \) is the refractive index along the central axis, \( n \) is the refractive index at a distance \( r \) from the axis, and \( k \) is a constant (Fig. 2 A). Thus, a single Selfoc glass rod can convey images by sine wave transmission (Fig. 2 B). The Selfoc lens has a wide view angle (54° in the present model), with a focal length extending from zero to infinity. These optical characteristics of Selfoc glass have permitted the manufacture of endoscopes much smaller than the conventional lens-telescopes or fiberscopes. However, they have retained excellent optical resolution. They were first used clinically by Watanabe21 for endoscopy of...
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Fig. 1. Left: Diagram of a cross section of the Selfoc-scope. Right: Photograph of the new 1.45-mm Selfoc-scope with OM-1 camera, light guide, and No. 16 gauge thin-walled spinal needle.

Small joints. In 1974, Fukushima and Schramm successfully used the Selfoc-scope for exploration of the spinal canal. The new model has a working length of 10.5 cm, with an outer diameter of only 1.45 mm; thus it can be inserted through a thin-walled No. 16 gauge spinal needle (Fig. 1 right). Clear pictures can be obtained with illumination by a xenon cool light supply via glass fibers arranged around the Selfoc rod. Color photographs are taken by means of an Olympus OM-1 camera using Kodak high-speed Ektachrome film (EH-135, daylight, ASA 160) with a shutter speed of ¼ or ⅛ sec. The films are developed by a push process to ASA 400.

Endoscopic Procedures and Results

In order to evaluate potential clinical applications for small-space endoscopy in the brain, the endoscope has been used in 10 fresh cadavers chosen because of the absence of neurological disease. Various approaches were used for cisternal endoscopy. Routine suboccipital puncture demonstrated that it was possible to observe the dorsal surface of the medulla and the arachnoid membrane (Fig. 3 H). However, because of the restricted mobility of the puncture needle, it was difficult to see the details of the cerebellar tonsils and the obex areas by this route. Puncture at C1-2 was attempted in an effort to evaluate the possibility of producing a cordotomy lesion under direct vision. The relations between ventral and dorsal roots and the dentate ligaments could be determined in only two of five cases examined. The difficulty in orientation was due to the narrowness of the subarachnoid space in this region. Figure 3 G illustrates a C-2 dorsal root and the dentate ligament. Meckel's cave (cisterna trigeminalis) was observed through a foramen ovale puncture with the same technique used in coagulation or injection of the ganglion. The needle position was confirmed by x-ray film. In this area, the field of vision was also restricted, due to the small size of the cisternal space and the lack of needle mobility. Rootlet structures were recognized in only three of eight punctures. Sometimes, the view was obstructed by ooze.

Fig. 2. Optical principles of the Selfoc glass rod. No = refractive index along the central axis; N = a refractive index at distance r from the axis; and k = constant.

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Fig. 3. Pictures taken through the 1.45-mm Selfoc-scope. A: Trigeminal nerve; B: Abducens nerve, arrow indicates foramen of Doretti; C: Facial and acoustic nerves; D: Acoustic nerve with labyrinthine artery; E: Glossopharyngeal and vagus nerves; F: Accessory nerve with PICA; G: C-2 posterior root and denticulate ligament; H: Dorsal medullary surface; I: Gasserian ganglion and trigeminal rootlets. Pictures B, D, E, and G were taken with CSF replaced by air. FM = foramen to Meckel’s cave; a = arachnoid; P = pons; M = internal auditory meatus; AICA = anterior inferior cerebellar artery; LA = labyrinthine artery or internal auditory artery; PICA = posterior inferior cerebellar artery, PRCl = posterior root of C-2; med = medulla; PRV = posterior root of trigeminal nerve; G = Gasserian ganglion.

From small veins. Figure 3 I illustrates the view that can be obtained of the Gasserian ganglion and the trigeminal rootlets.

For endoscopy of the cerebellopontine (CP) cistern, the scope was introduced through a small, 1.5-cm burr hole made at the junction of the mastoid process and the transverse sinus. After the dura was cut, a No. 8 Nelaton rubber catheter was inserted over the cerebellar surface and directed toward the nasion. After several insertions with the rubber catheter accompanied by flushing with saline, the arachnoid membranes ruptured allowing the scope to reach the region of the CP angle.
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The instrument was then advanced slowly through the rubber catheter. In most cases, two bridging veins were present between the superior cerebellar vein and the superior petrosal sinus. Injury to the vessels and cerebellar surface was avoided by careful insertion. With gentle manipulation of the endoscope rostrocaudally, it was possible to explore almost all of the CP angle structures and even the ventral surface of the pons and the clivus in some cases. The cranial nerves could be clearly observed in situ without significant retraction of the brain. Figure 3 A demonstrates the trigeminal nerve as it emerges from the lateral surface of the pons and enters Meckel's cave. Often a small artery or vein was seen around the trigeminal nerve. In Fig. 3 C and D, the seventh and eighth nerves are clearly demonstrated. Occasionally it was possible to distinguish the cochlear and vestibular components of the eighth nerve. A close relationship between the anterior inferior cerebellar artery or one of its branches and the eighth nerve complex was noticed in about half of the cases (Fig. 3 D). Figure 3 E and F shows the lower cranial nerves. Figure 3 B demonstrates the right sixth nerve at the ventral surface of the pons and the foramen of Doretti in the dura over the clivus.

Discussion

A number of small endoscopes have been designed as technology has advanced. It is now possible to make an endoscope with a diameter as small as 1 mm. However, the diameter is inversely proportional to the resolution. The present data show that the new instrument combines a minimal diameter with acceptable optical resolution.

The advantages of the Selfoc-scope over conventional scopes are as follows: 1) there is better resolution with minimal size; 2) the structure is recognizable even when the lens is in contact with the object; and 3) high magnification is possible in close-up views. The main disadvantage is the lack of flexibility, which limits the field of vision. Endoscopy of the cisterna magna, the CI-2 space, and Meckel's cave was not always satisfactory. The extremely small spaces restricted visualization of structural details. Endoscopic exploration of these spaces could be performed only in selected cases. Endoscopy of the CP angle was first reported by Prott. He used a 5-mm telescopic endoscope via a translabyrinthine approach. The present data have clearly demonstrated the potential clinical use of the Selfoc-scope for CP angle endoscopy. The procedure requires only a small burr hole and the risk appears to be minimal. With careful insertion and manipulation under visual control as described, injury to vessels or the brain can be avoided. The procedure would be useful for the differential diagnosis of small tumors, vascular abnormalities, or so-called neurovascular compression syndromes.

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References

9. Iizuka J: Stereoecephaloscopic findings in internal hydrocephalus. Endoscopy 4:141-149, 1972 (Ger)

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