Endoscopic anatomy of the chordae willisii in the superior sagittal sinus

MANSOOR SHARIFI, M.D., JACEK KUNICKI, M.D., PAWEŁ KRAJEWSKI, M.D., PH.D., AND BOGDAN CISZEK, M.D., PH.D.

Department of Anatomy, Center of Biostructure; and Department of Forensic Medicine, Medical University of Warsaw, Poland

Object. Chordae willisii are structures located in the lumen of the superior sagittal sinus (SSS). It is thought that they act as flow-improving structures within the sinuses. There are few anatomical descriptions of chordae willisii, and all previous observations were performed through standard anatomical dissections. The purpose of this study was to visualize and describe structural and topographical features of the chordae willisii with the aid of rigid endoscopy.

Methods. Twenty-five SSSs obtained from fresh human cadavers during autopsies were the material for this study. Specimens were flushed with tap water to remove clots. Bridging veins emptying into the sinus were ligated, and continuous flow of a saline solution through the sinus in a physiological direction was achieved by connecting the sinus to an irrigating system. Rigid endoscopes of different diameters (2.7–4.5 mm) and optic (0 and 30˚) were inserted into the lumen of the sinus. The endoscope was connected to a digital camera and a video system to allow for recording of the observed structures. Finally, the sinuses were opened and the chordae willisii were dissected using standard anatomical methods.

The chordae willisii were observed in all examined specimens. Three different types of the cords were found: lamellar, trabecular, and valvelike types. The most common type was the valvelike (mixed) one, which comprised 45.1% of all cords. The chordae willisii were most commonly observed in the parietooccipital region of the SSS.

Conclusions. Without disturbing any structural relationships, the use of endoscopy allowed visualization and description of intraluminal structures as they behaved physiologically.

Key Words • chordae willisii • superior sagittal sinus • rigid endoscopy • cerebrovascular system
Endoscopy of chordae willisi

TABLE 1
Types of chordae willisi found in all examined specimens

<table>
<thead>
<tr>
<th>Chordae Willisi</th>
<th>Total No. (%)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>trabecular</td>
<td>130 (30.1)</td>
<td></td>
</tr>
<tr>
<td>longitudinal</td>
<td>100 (23.1)</td>
<td></td>
</tr>
<tr>
<td>valvelike</td>
<td>195 (45.1)</td>
<td></td>
</tr>
<tr>
<td>accessory cord</td>
<td>7 (1.6)</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>432 (100)</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2
Venous openings and lateral lacunae in the SSS

<table>
<thead>
<tr>
<th>Structure</th>
<th>No. (%)</th>
</tr>
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<tbody>
<tr>
<td>total venous openings</td>
<td>450</td>
</tr>
<tr>
<td>covered</td>
<td>195 (43)</td>
</tr>
<tr>
<td>uncovered</td>
<td>255 (57)</td>
</tr>
<tr>
<td>total lat lacunae</td>
<td>140</td>
</tr>
</tbody>
</table>

Detailed topographical distribution of the different types of chordae willisi in different segments of the SSS are presented in Table 3.

Discussion
The development of the SSS, in particular that from the anterior dural plexus, was well described by Mall, Markowski, Streeter, and Padget. As described by Padget and Markowski, in its distal portion, the anterior dural plexus forms two channels called “marginal sinuses.” These paired vessels then unite to form a single channel.

Fig. 2. Upper: Endoscopic view of a valvelike chorda willisi closely related to the venous openings. Lower: Photograph demonstrating a valvelike chorda willisi partially covering a venous opening. Note the standard dissection of the sinus.
The intraluminal structures of the dural sinuses most probably originate from the cells of the primitive veins of the epidural space, which fuse to different extents into venous sinuses during fetal development.\(^\text{11}\)

The chordae willisii were regarded as functional structures by early anatomists, some of whom termed them “valves.”\(^\text{3}\) Others asserted that the endothelial projections should be regarded as internal extensions of the wall of the sagittal sinus. Finally, others acknowledged the function of the chordae in preventing blood reflux into the interior of the cerebral veins.\(^\text{1,3,15}\) Networks of chordae may act as flow-improving and velocity-regulating structures and may protect the sinus from outside compression.\(^\text{18}\)

The veins from each cortical area join the SSS in a characteristic configuration. The veins arising near the frontal pole are directed posteriorly, in the usual direction of the flow within the sinus, at their junction with the sinus. Veins arising from the posterior portion of the frontal lobe are directed forward as they join the sinus, in a direction opposite that of the flow within the sinus. The terminal ends of the parietal and occipital veins are directed forward as they join the sinus, in a direction opposite that of the flow within the sinus. The terminal ends of the parietal and occipital veins are directed forward and enter the SSS at an angle opposite to the direction of flow.\(^\text{1,3,16}\) All of these competing directions create an unfavorable physiological angle at the vein orifices.\(^\text{18}\)

Because of this unfavorable angle, the majority of the vein orifices in the sinus are half covered by valvelike chordae to prevent backflow of blood into the veins and to ensure drainage from the veins to the sinus. This is one of the most characteristic physiological functions of the valvelike chordae willisii in the sinus and explains their shape and frequent location in the SSS.\(^\text{15,18}\)

### Table 3

<table>
<thead>
<tr>
<th>Type of Chordae</th>
<th>No. of Segments (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ant</td>
</tr>
<tr>
<td>valvelike</td>
<td>30 (7)</td>
</tr>
<tr>
<td>trabecular</td>
<td>25 (5.8)</td>
</tr>
<tr>
<td>longitudinal</td>
<td>35 (8.2)</td>
</tr>
<tr>
<td>total</td>
<td>90 (21.1)</td>
</tr>
</tbody>
</table>

*Pst = posterior.*

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**Fig. 3.** Upper: Endoscopic view of a single cord in the lumen of the SSS. Lower: Photograph demonstrating a chorda as it appeared in the middle of a dissected sinus.

**Fig. 4.** Upper: Endoscopic view of a longitudinal chorda inside the sinus, dividing the lumen into two channels. Lower: Endoscopic view of longitudinal chorda (black arrowhead) in union with a venous lacuna (right) and a venous opening (top).
Endoscopy of chordae willisi

Surgery of the SSS is still challenging neurosurgeons. Parasagittal tumors—especially meningiomas—invade the sinus, and traumatic sinus injuries are the main problems in daily neurosurgical practice. Recently, there has been an increasing tendency to introduce safer and more modern techniques in surgery involving the SSS.\(^1\) Stent insertion of the venous sinus for sinus thrombosis and intracranial hypertension and endovascular treatment of vascular malformations of the brain are rapidly developing treatment modalities.\(^2\) The long-term effectiveness of these methods is still undetermined, but preliminary results are encouraging. Intraluminal procedures within the sinuses require a thorough knowledge of the internal structures of the venous sinus.

Despite broad use of endoscopy in modern neurosurgery, endoscopic techniques have not been applied in venous sinus surgery. It is hard to imagine technical possibilities for the endoscopic exploration of the SSS in a living patient. The presence of intraluminal structures such as arachnoid granulations and chordae willisi are potential pitfalls in the diagnosis of dural sinus pathologies.

Conclusions

Data in this study provided a more accurate view of the interior of the sinus compared with former morphological descriptions. After examining all the specimens, we concluded that the valvelike chordae willisi were the most numerous and functionally the most important of all types of chordae because of their role in the regulation of blood flow. The endoscopic method allowed us to consider the physiological function of the observed structures.

Acknowledgment

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References