Muscle Insertion Line as a Simple Landmark To Identify the Transverse Sinus When Neuronavigation Is Unavailable

Juri Kivelev[1], Riku Kivisaari[2], Mika Niemelä[2], Juha Hernesniemi[2]

■ OBJECTIVE: **Skull opening in occipital and suboccipital regions might be associated with risk of damage to the transverse venous sinus and the confluence of sinuses. We analyze the value of magnetic resonance (MR) imaging in localizing the venous sinuses in relation to the superior muscle insertion line (MIL) on the occipital bone.**

■ METHODS: **We retrospectively analyzed head MR images of 100 consecutive patients imaged for any reason from 1 January 2013. All MR images were interpreted by a radiologist (R.K.). The superior MIL was identified at the midline and on both midpupillar lines, which represent the most frequent sites of skin incision and craniotomy (median and lateral suboccipital craniotomy, respectively).**

■ RESULTS: **Patients comprised 56 women (56%) and 44 men (44%). Their mean age was 54 (range 18–84) years. The muscles of the posterior skull were readily visible and clearly identified in both T1 and T2 images of all patients. Identification of the insertion zone and its relation to the venous structures was most readily made in the sagittal plane.**

■ CONCLUSION: **We found that the upper muscle insertion line on occipital bone corresponds to the underlying venous sinus and can be used as a reliable anatomic landmark. We identified it in 100% of preoperative MR images of heads with an intact occiput.**

INTRODUCTION

One of the most important steps in posterior cranium opening is localizing the dural venous sinuses. Intraoperative damage of the transverse sinus and confluence of sinuses may result in profuse bleeding and later thrombosis, venous outflow disturbances, and increased intracranial pressure. When operating in a sitting position, inadvertent sinus opening causes air embolism. Modern frameless neuronavigation systems are useful in localizing venous sinuses before craniotomy, but they are not yet widely available due to high price. Furthermore, when surgery is performed in a sitting or prone position, some difficulties with neuronavigation may occur. Many studies have been conducted regarding the role of external skull bony landmarks in localization of posterior venous sinuses. Our study is the first to analyze a simple and effective way to localize the venous sinuses in relation to the superior muscle insertion line (MIL) on occipital bone. In this region, a surgical view after skin incision includes (from cephalad to caudal) the occipital bone surface, MIL, and muscles covered by the superficial layer of cervical fascia. Thus identifying the MIL is easy, and the neurosurgeon can confidently navigate further according to a corresponding finding on preoperative magnetic resonance imaging (MRI). The goal of this study was to show that MIL may be clearly identified in the preoperative MRI sagittal view and thus could be used as an anatomic landmark after skin incision in every particular case.

METHODS

The study was carried out at the Neurosurgical Department of Helsinki University Central Hospital. We retrospectively analyzed head magnetic resonance images of 100 consecutive patients imaged for any reason. Cases included in the study comprised patients older than 18 years with no previous surgery in the posterior skull or neck region and with either a T1 or T2 sagittal view MRI (Signa 1.5T, GE Medical Systems, Wauwatosa, Wisconsin, USA) available. All magnetic resonance images were analyzed by a radiologist (R.K.). The superior muscle insertion line (MIL) was identified at the midline and on both midpupillar lines, which represent the most frequent sites of skin incision and craniotomy (median and lateral suboccipital craniotomy, respectively). To identify the relationships with underlying venous sinuses, we drew on MRI sagittal images an imaginary line through the MIL

Key words
- Posterior craniotomy
- Muscle insertion
- Venous sinuses

Abbreviations and Acronyms
MIL: Muscle insertion line
MRI: Magnetic resonance imaging
SNL: Superior nuchal line

From the Department of Neurosurgery, [1]Turku University Central Hospital, Turku, Finland; and [2]Helsinki University Central Hospital, Helsinki, Finland

To whom correspondence should be addressed: Juri Kivelev, M.D., Ph.D. [E-mail: j.v.kivelev@gmail.com]

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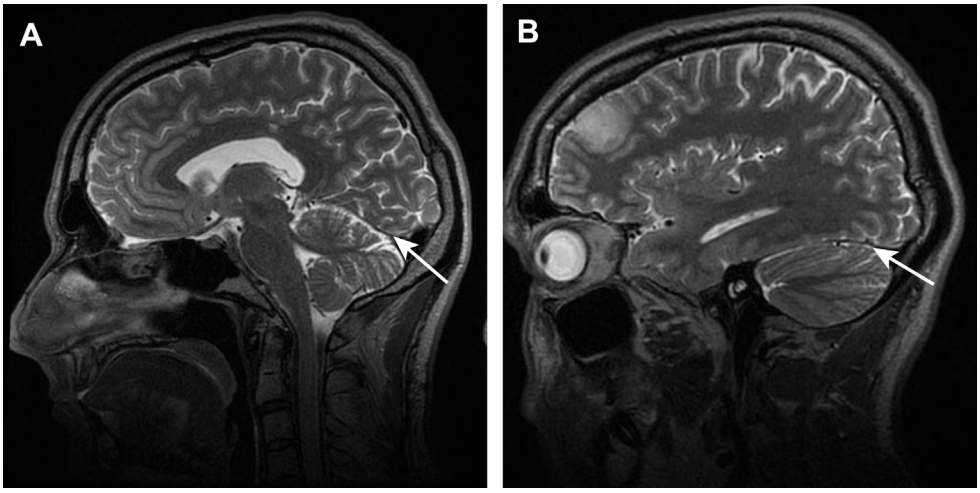

Figure 1. Sagittal view of head magnetic resonance image. *White arrow* delineates a muscle insertion line crossing confluence of sinuses at the midline (**A**) and midpupillary line (**B**).

perpendicular to the bone surface and measured the distance from this line to the upper and lower margins of the sinuses (Figure 1). This MIL passed the sinus in different manners: 1) under the lower margin of the sinus, 2) above the upper margin of the sinus, and 3) crossing the sinus.

Statistical analysis included univariate test (Pearson's χ^2 test) and used SPSS software for Windows, version 19.0 (SPSS, Inc., Chicago, Illinois, USA). The level of significance was set at $P < 0.05$.

RESULTS

Patients comprised 56 women (56%) and 44 men (44%). Their mean age was 54 (range 18–84) years. MIL could be reliably identified on MRI in all patients. The muscles of the posterior skull were readily visible and clearly identified in both T1 and T2 images. Identification of the insertion zone and its relation to the venous structures was most conveniently made in the sagittal plane. For identification purposes, the use of contrast is unnecessary. The confluence of sinuses was visible in all patients, whereas the transverse sinus was unidentifiable on the left in 4 patients (4%) and on the right in 1 patient (1%). The MIL crossed the sinus in the midline most frequently, in 78 of 100 patients (78%), whereas on the right paramedian this was the case in 48 of 99 patients (48%) and on the left paramedian in 60 of 96 patients (63%). The MIL passed below the lower sinus margin in the midline in 14 cases (14%), on the right paramedian in 44 cases (44%), and on the left paramedian in 18 cases (19%) (Figure 2). Passing of the MIL above the upper margin of the sinus was uncommon, occurring in the midline in 8 cases (8%), on the right paramedian in 7 cases (7%), and on the left paramedian in 18 cases (19%) (Figure 3).

Neither sex nor age showed any correlation with the MIL relationship with venous sinuses. There were inverse correlations between midline and paramedian MIL locations; when it passed below the sinus in the midline, it did not pass above the sinus on either the right ($P = 0.004$) or left paramedian site ($P = 0.037$). When the MIL passed above the sinus in the midline, it did not pass below the sinus on either the right or left paramedian.

DISCUSSION

The muscle insertion line on occipital bone appears to be a simple and reliable anatomic landmark. It allows individualized localization of the posterior venous sinuses, which is crucial when performing a posterior craniotomy without neuronavigation. In the past, neurosurgeons have had to rely solely on anatomic data provided by cadaver measurements; however, these may vary significantly and cannot always be extrapolated to living persons.

Figure 2. Muscle insertion line (white) located below the venous sinus.