

Configuration of the Ethmoidal Roof: A Radiologic Anatomical Study

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Background: Currently endoscopic sinus surgery is the standard operation for rhinosinusitis and nasal polyps, including tumors near the anterior skull base. During the surgery, the iatrogenic penetration into the anterior skull base may be at risk. Therefore, information of the anterior skull base configuration is useful for the sinus surgeon.

Objective: To determine the patterns and their prevalence of slopes of the ethmoidal roof assessed from the Computed Tomography (CTs) of paranasal sinuses.

Material and Method: A descriptive study was conducted at Srinagarind Hospital, Faculty of Medicine, Thailand. CTs of paranasal sinuses from 150 patients aged 18 years and above who had attended at Srinagarind hospital between January 1, 2007 and December 31, 2011 were retrieved and reviewed. The slope patterns of the ethmoidal roof were determined by visual assessment of the scans, measuring the height between the ethmoidal roof and floor of nasal cavities in three sagittal planes: medio-sagittal, latero-sagittal, and mid-sagittal. CTs were performed by a Philips 128 slice scanner.

Results: The downslope anteriorly and upslope posteriorly of the ethmoidal roof was found to be commonest in medio-sagittal and mid-sagittal planes. Its prevalence in medio-sagittal and mid-sagittal planes was 80.3% (95% CI 75.5-84.4) and 52% (95% CI 46.4-57.6). The second common pattern in medio-sagittal and mid-sagittal planes was a downslope pattern with the prevalence of 13% (95% CI 9.7-17.3) and 39.3% (95% CI 34-44). The downslope pattern was found to be the most prevalent for the latero-sagittal plane, accounting for 50.7% (95% CI 45.0-56.3), followed by downslope anteriorly and upslope posteriorly of 40% (95% CI 34.6-45.6).

Conclusion: This is the first study to describe the patterns of slopes of the ethmoidal roof (anterior skull base) which demonstrates that there are different patterns depending on the plane of sagittal view. Therefore, the sagittal view of the CT paranasal sinus in each plane should be interpreted before performing the operation to avoid iatrogenic intracranial complications.

Keywords: Ethmoidal roof, Anterior skull base

J Med Assoc Thai 2016; 99 (Suppl. 5): S155-S160

Full text. e-Journal: <http://www.jmatonline.com>

Endoscopic sinus surgery is a popular surgical procedure for nasal/paranasal inflammatory, infectious diseases and tumors. It is also extended as a surgical procedure for anterior skull base tumors. Operations of the ethmoidal roof are at a high risk for intracranial penetration and may lead to a CSF leak. Most of the studies on the ethmoidal roof are about the depth of the olfactory fossa, which is a weak and risky area at the skull base. The anterior skull base is one of the areas that has considerable variations like the depth of

olfactory fossa in Thais and other nationalities⁽¹⁻⁵⁾. However, the slope of ethmoidal roof is important for the sinus surgeon in order to avoid penetration into cranial cavity. The slope of ethmoidal roof is usually mentioned in many textbooks to slant downward as the surgeon moves posteriorly^(6,7). There was only one study on the slope of the ethmoidal roof by Zacharek et al⁽⁸⁾ using Computed Tomography (CT) and they reported that it sloped downward posteriorly. The study, however, measured the height between the ethmoidal roof and floor of nasal cavities only in the mid-sagittal plane through the ethmoid sinus and reported only the mean heights. Moreover, the ethmoidal roof has a width and usually the height at the medial aspect that is lower than the height of lateral aspect. This meant that the slope at the medial and lateral aspects of the ethmoidal roof might not have the

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down slope as in the midsagittal plane. By clinical observation of the CTs, paranasal sinuses observed in the clinical practice showed that there were many CTs of the ethmoidal roof with downslope anteriorly and upslope posteriorly. Therefore, this study was to determine the slope patterns from the anterior to posterior aspects of ethmoidal roof using CTs of paranasal sinuses at three different sagittal planes.

Material and Method

A descriptive study was performed by retrieving consecutive CTs of paranasal sinuses from the databank of patients starting in December 2011 and going backwards until the estimated sample size was reached. CTs of paranasal sinuses were from patients aged 18 years and above. Exclusion criteria were CTs from patients with a history of anterior skull base/ ethmoidal roof injuries or surgeries, tumors at the anterior skull base, or ethmoidal roofs that were eroded, destroyed, or obscured by bony structures at the ethmoidal roof. CTs were performed by a Philips 128 slice scanner (The Brilliance iCT SP), using a standard protocol of the Srinagarind Hospital by performing coronal and axial planes perpendicularly, and parallel to hard palate. Sagittal planes were cut perpendicularly to the hard palate. All views were bone window displays with a window width of 2,500 HU (Hounsfield units) and window centers at 1,000 HU. Coronal and sagittal views were reconstructed from axial views with slice thicknesses of 3 mm and slice increments of 1.5 mm. The slopes from anterior to posterior were assessed in three sagittal planes, being medio-sagittal, latero-sagittal, and mid-sagittal.

The assessments of slopes of the ethmoidal roofs in the sagittal plane were performed in two means. The first assessment was by a rhinologist (ST) and a head & neck radiologist (WP). In case of disagreement, the final assessment was decided by the third otolaryngologist (PK). The types of slopes assessed were classified as:

- Type 1: Downslope
- Type 2: Plateau
- Type 3: Downslope anteriorly and upslope posteriorly
- Type 4: Upslope anteriorly and plateau posteriorly
- Type 5: Others.

The second assessments were performed by measuring the distances between floors of nasal cavities and the ethmoidal roofs at 5-equidistant positions; then the distances of all CTs were summed

and presented as mean distances. The second assessment was performed by comparing the results with the study by Zacharek et al⁽⁸⁾. The 5-equidistant positions were started anteriorly by drawing a line from anterior wall of the ethmoidal bulla perpendicularly to the hard palate and posteriorly by drawing a perpendicular line to the hard palate passing the anterior wall of the sphenoid sinus (Fig. 1). If the height at each position was at least 2 mm more than the nearest position, it meant that the slope was either downslope or upslope between them. If the differences were less than 2 mm. they would be counted as plateaus.

A pilot study was conducted in 15 CTs (30 sides) showing that the prevalence of configuration of the ethmoidal roof at the mid-sagittal plane was downslope and then upslope in 26%. The sample size was estimated by the pilot study with the confidence interval of 95% and precision of 5% that was equal to 295 samples (sides). This present study was then conducted in 150 CTs or 300 sides.

This present study was approved by the Khon Kaen University Ethics Committee for Human Research.

Results

A total of 150 CTs of paranasal sinuses were from 86 males and 64 females with the average age of 48.5 years (range: 20-80 years).

The prevalence of each type of slope pattern of the ethmoidal roof by visual assessments is shown in Table 2 & Fig 2. The highest prevalence was in the medio-sagittal plane and the mid-sagittal planes, which were downslope anteriorly and upslope posteriorly, 80.3% (95% CI 75.5-84.4) and 52% (95% CI 46.4-57.6),

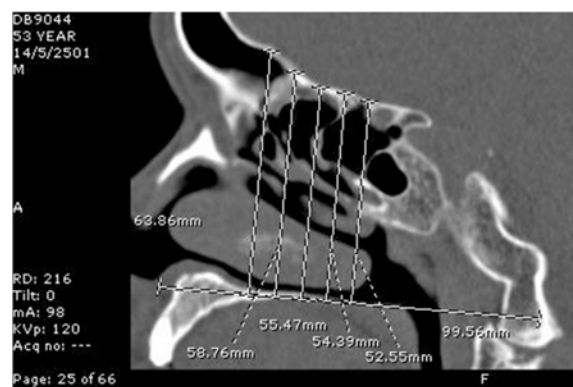


Fig. 1 Five-equidistant positions of measurements from the ethmoidal roof to the hard palate starting from anterior wall of the ethmoid bulla to the anterior wall of sphenoid sinus.

Table 1. Type of configurations of the ethmoidal roofs from anterior to posterior at each sagittal plane by visual assessment

| Configuration of ethmoidal roof | Medio-sagittal plane of ethmoidal roof | | Latero-sagittal plane of ethmoidal roof | | Mid-sagittal plane of ethmoidal roof | |
|---------------------------------|--|------------------|---|------------------|--------------------------------------|------------------|
| | n | % (95% CI) | n | % (95% CI) | n | % (95% CI) |
| Downslope | 39 | 13.0 (9.7-17.3) | 152 | 50.7 (45.0-56.3) | 118 | 39.3 (34.0-44.0) |
| Downslope_Plateau | 12 | 4.0 (2.3-6.7) | 17 | 5.7 (3.6-8.9) | 17 | 5.7 (3.6-8.9) |
| Downslope_Upslope | 241 | 80.3 (75.5-84.4) | 120 | 40.0 (34.6-45.6) | 156 | 52.0 (46.4-57.6) |
| Plateau | 5 | 1.7 (0.7-3.8) | 11 | 3.7 (2.1-6.5) | 8 | 2.7 (1.4-5.2) |
| Upslope_Plateau | 1 | 0.3 (0.1-1.9) | 0 | 0.0 | 0 | 0.0 |
| Others | 2 | 0.7 (0.2-2.4) | 0 | 0.0 | 1 | 0.3 (0.1-1.9) |

Total, n = 300

Table 2. The distances between the ethmoidal roof and floor of the nose presenting in mean, range, SD and 95% confidence intervals in millimeters

| | Range | Mean | SD | 95% CI |
|---|-------------------|------|-----|-----------|
| Medio-sagittal plane of ethmoid roof | | | | |
| Position 1 | 37.6-70.7 | 53 | 0.3 | 52.5-53.6 |
| Position 2 | 37.3-61.8 | 49.4 | 0.3 | 48.8-49.9 |
| Position 3 | 37.1-58.5 | 47.6 | 0.2 | 47.1-48.1 |
| Position 4 | 37.3-58.6 | 47.5 | 0.2 | 47.1-48.0 |
| Position 5 | 36.0-60.1 | 48 | 0.2 | 47.6-48.5 |
| Type of slope assessed from measurement | Downslope-plateau | | | |
| Latero-sagittal plane of ethmoid roof | | | | |
| Position 1 | 40.6-76.7 | 57.4 | 0.3 | 56.8-58.0 |
| Position 2 | 39.5-69.1 | 54.8 | 0.3 | 54.3-55.4 |
| Position 3 | 40.1-64.8 | 52.3 | 0.2 | 51.8-52.9 |
| Position 4 | 40.6-62.9 | 50.9 | 0.2 | 50.5-51.4 |
| Position 5 | 40.3-62.9 | 50.8 | 0.2 | 50.3-51.3 |
| Type of slope assessed from measurement | Downslope-plateau | | | |
| Mid-sagittal plane of ethmoid roof | | | | |
| Position 1 | 42.2-74.3 | 55.2 | 0.3 | 54.6-55.8 |
| Position 2 | 40.4-68.5 | 52.6 | 0.3 | 52.1-53.1 |
| Position 3 | 39.8-63.5 | 50.8 | 0.3 | 50.3-51.3 |
| Position 4 | 40.0-59.9 | 49.6 | 0.2 | 49.2-50.1 |
| Position 5 | 38.6-61.0 | 49.8 | 0.2 | 49.3-49.8 |
| Type of slope assessed from measurement | Downslope-plateau | | | |

respectively, whilst the downslope pattern was found to be most prevalent in the latero-sagittal plane (50.7%, 95% CI 45.0-56.3).

When assessed using measurements between the ethmoidal roofs and floors of the nasal cavities, it appeared that downslope anteriorly and plateau

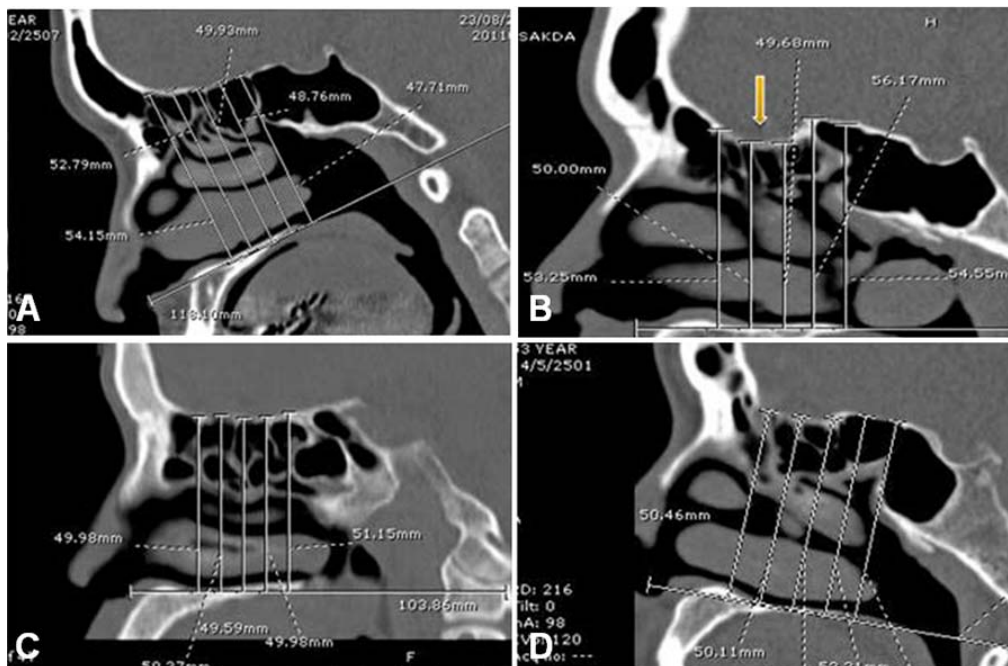


Fig. 2 Different patterns of slope of the ethmoidal roof. A) Downslope, B) Downslope anteriorly and upslope posteriorly, C) Plateau, D) Plateau upslope

posteriorly was found in all medio-sagittal, mid-sagittal and latero-sagittal planes whilst the downslope was found only in the latero-sagittal plane (Table 2).

Discussion

The slope pattern of the ethmoidal roof or anterior skull base was always understood to be downslope^(6,7). This CT study in Thais showed that the type of slope pattern in the sagittal plane depends on the location of the ethmoidal roof. By visual CT assessments, a downslope anteriorly and upslope posteriorly of the ethmoidal roof was found mostly in the medio-sagittal and mid-sagittal planes of 80.3% (95% CI 75.5-84.4) and 52% (95% CI 46.4-57.6), respectively. The downslope pattern of both the anterior and posterior aspects were found mostly in the latero-sagittal plane for 50.7% (95% CI 45.0-56.3).

Compared with the study by Zacharek et al⁽⁸⁾ which showed that the ethmoidal roof was downslope at the mid-sagittal plane; in every sagittal plane, the anterior was downslope and plateaued posteriorly. It might not be appropriate, however, to use the average distance of measurement between the ethmoidal roof and the floor of nasal cavity to assess the slope of the ethmoidal roof. Instead, visual assessment of each CT and each plane should be done to determine the slope. Therefore, the sinus surgeon should assess the slope

of the ethmoidal roof of each patient in each sagittal plane using multiplanar CT.

Conclusion

This is the first study to assess the slope of ethmoidal roof in three different sagittal planes and showed that the most prevalent was downslope anteriorly and upslope posteriorly in mid-sagittal and medio-sagittal planes whilst in the latero-sagittal plane, the downslope pattern was found to be most prevalent.

What is already known on this topic?

The slope of the ethmoidal roof is usually mentioned to be downslope posteriorly.

What this study adds?

This present study shows that the slope of the ethmoidal roof is not always downslope. We classifies into five types, downslope, plateau, downslope anteriorly and upslope posteriorly, upslope anteriorly and plateau posteriorly and others. CT sagittal view is needed for interpreting the slope for each individual.

Acknowledgements

This present study was supported by the Research Affairs of Faculty of Medicine, Khon Kaen

University, Thailand and The Center of Cleft Lip-Cleft Palate and Craniofacial Deformities, Khon Kaen University in Association with Tawanchai Project (Tawanchai Cleft Center). We would like to acknowledge Professor James Will, University of Wisconsin for editing the manuscript via Publication Clinic KKU, Thailand.

Potential conflicts of interest

None.

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ลักษณะการวางตัวของส่วนหลังคาของไขสันน้สเอธมอยด์: การศึกษาลักษณะกายวิภาคทางภาพถ่ายรังสี

สงวนศักดิ์ ธนาวีรัตนานิจ, วรินทร์ พุทธิรักษ์, พรเทพ เกษมศิริ, สุชน เกษสมบุรณ์

ภูมิหลัง: ปัจจุบันการผ่าตัดไขสันน้สผ่านกล้องเป็นการผ่าตัดมาตรฐานที่ใ้ใช้สำหรับรักษาโรคไขสันน้สอักเสบและริดสีดวงจมูก รวมทั้งก้อนเนื้อที่อยู่ใกล้ฐานสมองส่วนหน้า ซึ่งระหว่างการผ่าตัดบริเวณฐานสมองอาจได้รับกัยอันตรายได้ ดังนั้นการศึกษาถึงการวางตัวของฐานสมองจึงมีความสำคัญสำหรับศัลยแพทย์ผ่าตัดไขสันน้ส

วัตถุประสงค์: เพื่อศึกษารูปแบบและความชุกของการลาดเอียงของส่วนเพดานของไขสันน้สเอธมอยด์ โดยประเมินจากภาพถ่ายรังสีคอมพิวเตอร์ของไขสันน้สวัดและวิธีการ: การศึกษาแบบพรรณานี้ดำเนินการที่โรงพยาบาลศรีนครินทร์ คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น โดยค้นข้อมูลภาพถ่ายรังสีทางคอมพิวเตอร์ของไขสันน้สที่ได้รับการถ่ายภาพรังสีระหว่างวันที่ 1 มกราคม พ.ศ. 2551 ถึงวันที่ 31 ธันวาคม พ.ศ. 2554 จำนวนทั้งสิ้น 150 ราย และได้ประเมินรูปแบบการลาดเอียงของหลังคาของไขสันน้สเอธมอยด์จากภาพถ่ายรังสีด้วยสายตาและประเมินจากการวัดความสูงระหว่างหลังคาของไขสันน้สเอธมอยด์ และพื้นโพรงจมูกในระนาบ sagittal 3 ตำแหน่งได้แก่ส่วนที่อยู่ด้านใน ส่วนที่อยู่ด้านนอกและส่วนที่อยู่ตรงกลาง

ผลการศึกษา: ในระนาบ medio-sagittal และ mid-sagittal พบรูปแบบของการลาดเอียงทางด้านหน้าและมีการยกตัวทางด้านหลังบ่่อยที่สุด โดยพบความชุกร้อยละ 80.3 (95% CI 75.5-84.4) และร้อยละ 52 (95% CI 46.4-57.6) ตามลำดับรูปแบบที่พบบ่อยมากอันดับที่สองได้แก่การลาดเอียงลงไปทางด้านหลังโดยพบความชุกร้อยละ 13 (95% CI 9.7-17.3) และร้อยละ 39.3 (95% CI 34-44) ตามลำดับสำหรับระนาบ latero-sagittal พบรูปแบบการลาดลงไปทางด้านหลังร้อยละ 50.7 (95% CI 45.0-56.3) ตามด้วยการลาดเอียงลงทางด้านหน้าแล้วยกตัวขึ้นทางด้านหลังร้อยละ 40 (95% CI 34.6-45.6)

สรุป: การศึกษานี้พบว่ารูปแบบการลาดเอียงของพื้นกระโหลกศีรษะหรือส่วนหลังคาของไขสันน้สเอธมอยด์มีหลายรูปแบบขึ้นกับตำแหน่งของระนาบในแนว sagittal ของไขสันน้สดังนั้นก่อนผ่าตัดไขสันน้สจึงควรประเมินความลาดเอียงจากภาพถ่ายไขสันน้สทางคอมพิวเตอร์ในแต่ละตำแหน่งในท่า sagittal เพื่อป้องกันกัยอันตรายของสมองที่อาจเกิดขึ้นจากการผ่าตัด
