

Magnetic resonance imaging study of the craniocervical junction

A Tassanawipas, S Mookhavesa, S Chatchavong, P Worawittayawong

Department of Orthopaedic Surgery, Phramongkutklao College of Medicine, Bangkok, Thailand

ABSTRACT

Purposes. To confirm the accuracy of the standard parameters of Chamberlain's line, McGregor's line, McRae's line, and Ranawat's line in the diagnosis of basilar impression in a normal Asian population using magnetic resonance imaging (MRI) scans of the craniocervical junction, and to evaluate the use of MRI in the initial diagnosis of basilar impression.

Methods. We retrospectively reviewed MRI scans of the craniocervical junction in 114 Thai patients (61 men and 53 women) aged 20 to 89 years to assess the lines of Chamberlain, McGregor, McRae, and Ranawat. Patients with injury, tumour, or metastasis in the craniocervical junction; congenital anomalies; or clinical symptoms and signs of basilar impression were excluded.

Results. 39 of the 114 patients had the odontoid tip extended above Chamberlain's line by 1 mm to 9 mm (mean, 2.89 mm). Only 7 men and 5 women had the tip of the odontoid process extended beyond the

normal range of 5 mm. The mean distance of the odontoid tip extended past McGregor's line in male and female subjects was 0.33 mm (standard deviation [SD], 1.2 mm) and 0.17 mm (SD, 0.7 mm), respectively, markedly less than those reported previously, although one male patient's odontoid tip extended 8 mm above the McGregor's line. Regarding McRae's line, no patient had the odontoid tip extended above the foremen magnum. The mean Ranawat's line in male and female subjects was 15.75 mm (range, 12–19; SD, 1.71 mm) and 14.09 mm (range, 11–17; SD, 1.38 mm), respectively.

Conclusion. After using MRI to confirm the standard parameters of basilar impression as previously formulated from lateral skull radiographs, we recommend using McRae's line and Ranawat's line in the initial screening for basilar impression for the Asian population. Chamberlain's line and McGregor's line are viable alternatives, but clinicians must be aware of the potential for false positives.

Key words: magnetic resonance imaging; platybasia

INTRODUCTION

Basilar impression, or basilar invagination, is a rare deformity in which the tip of the odontoid process is more cephalad than normal, causing compression of the brainstem and spinal cord into the foramen magnum, potentially resulting in neurological impairment. The primary form is a congenital skeletal abnormality of the craniocervical junction that is often associated with other vertebral defects such as Klippel-Feil syndrome, Arnold-Chiari malformation, odontoid anomalies, and hypoplasia of the atlas.¹⁻³ Secondary basilar impression is an acquired deformity of the skull resulting from systemic diseases that cause softening of the osseous structure at the base of the skull, such as Paget's disease, osteomalacia, rickets, osteogenesis imperfecta, rheumatoid arthritis, neurofibromatosis, or ankylosing spondylitis.³

In addition to the clinical signs and symptoms, numerous measurements have been suggested for the diagnosis or confirmation of basilar impression. The most commonly used diagnostic markers relate to the lines of Chamberlain,¹ McGregor,⁴ McRae,⁵ and Ranawat,⁶ all of which may be measured on lateral radiographs. McGregor's line is used as a routine screening test because its landmarks are most easily defined on a standard lateral radiograph. Computed tomography or magnetic resonance imaging (MRI) of the craniocervical junction can be used to confirm the diagnosis.^{1,3} However, the use of the lateral lines of McGregor and Chamberlain have

been criticised because the anterior reference point, namely the hard palate, can be distorted by abnormal facial configurations or high-arched palates. Another disadvantage to the use of Chamberlain's line is that the posterior lip of the foramen magnum is difficult to define on standard lateral view, and it is often invaginated.

We examined the accuracy of these measurements in the diagnosis of basilar impression in a normal Asian population using MRI scans of the craniocervical junction, which may be more precise than plain lateral radiographs of the skull, especially at the tip of the hard palate.

METHODS

Between June 1997 and May 1998, we retrospectively reviewed MRI scans of the craniocervical junctions of 114 Thai (61 men and 53 women) aged 20 to 89 years who presented to the Army Hospital in Bangkok, Thailand. MRI (Signa Horizon 1.5T; GE Healthcare, Milwaukee [WI], US) measurements were compared with normal values previously determined from plain lateral skull radiographs. Exclusion criteria were patients with: previous traumatic injury of the craniocervical junction; clinical symptoms and signs of basilar impression; congenital structural abnormality of the craniocervical junction such as Klippel-Feil syndrome, odontoid anomalies, or hypoplasia of the atlas; acquired deformity of the skull suggestive of basilar impression development,

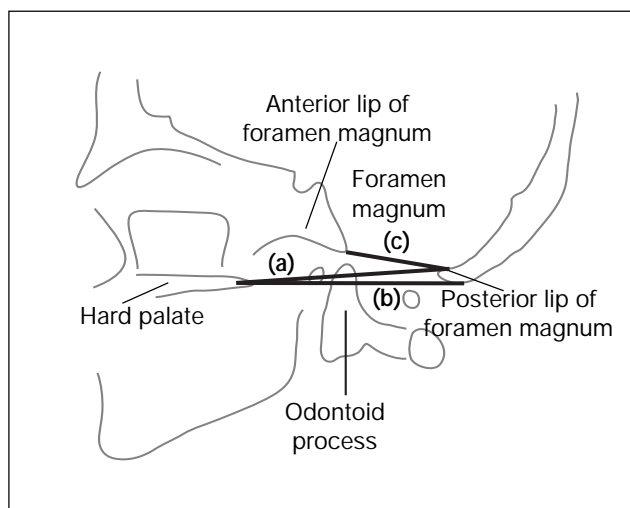


Figure 1 Lateral view of a sketch of the skull showing (a) Chamberlain's line, (b) McGregor's line, and (c) McRae's line.

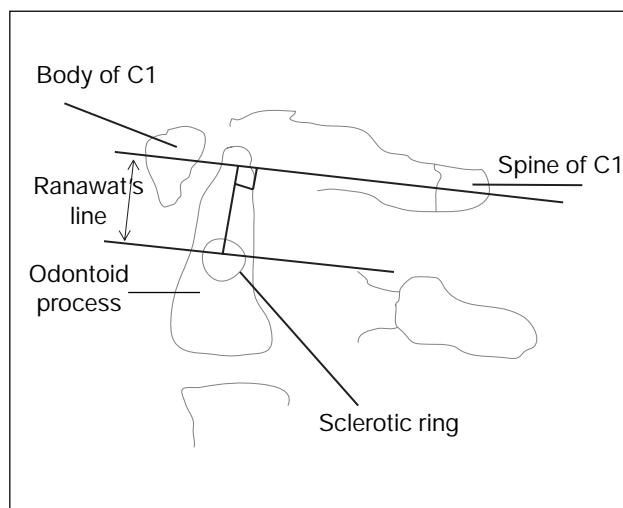


Figure 2 A sketch of the C1 and C2 showing the measurement of the Ranawat's line.

such as Paget's disease, osteomalacia, rickets, osteogenesis imperfecta, rheumatoid arthritis, neurofibromatosis, and ankylosing spondylitis; and brain tumour or metastatic lesion.

Chamberlain's line is drawn from the posterior edge of the hard palate to the posterior border of the foramen magnum. When the odontoid tip extends 5 mm above this line, symptomatic basilar impression causing compression of the brainstem and spinal cord may result (Fig. 1).¹

McGregor's line is drawn from the posterior edge of the hard palate to the most caudal point of the occipital curve, which is much easier to identify on standard lateral radiograph than the posterior lip of foramen magnum for Chamberlain's line. In the diagnosis of basilar impression, the position of the odontoid tip is measured in relation to McGregor's line. In a previous report using plain lateral radiographs, the mean distance that the odontoid tip extended past McGregor's line in male and female patients was 1.45 (SD, 0.73) mm and 0.44 (SD, 2.80) mm, respectively.⁴ A distance of greater than 4.5 mm above this line is considered basilar impression (Fig. 1).⁴

McRae's line determines the anteroposterior dimension of the foramen magnum, and is drawn from the anterior lip to the posterior lip. In normal patients, the odontoid tip falls below this line (Fig. 1).⁵

The Ranawat's line is the perpendicular distance between the centre of the sclerotic ring of C2 and the line drawn along the axis of C1. The normal value of this distance is about 15 (SD, 2) mm: 17 (SD, 2) mm in males and 15 (SD, 2) mm in females (Fig. 2).⁶

RESULTS

39 of 114 subjects had the tip of the odontoid process extended past Chamberlain's line by 1 mm to 9 mm (mean, 2.89 mm). Only 7 men and 5 women had the tip of the odontoid process extended beyond the normal range of 5 mm. The mean distance that the tip of the odontoid process extended past McGregor's line in male and female patients was 0.33 (SD, 1.2) mm and 0.17 (SD, 0.7) mm, respectively, compared with previously reported normal values of 1.45 (SD, 0.73) mm and 0.44 (SD, 2.80) mm, respectively.⁴ In one male patient, the tip of the odontoid process extended 8 mm above McGregor's line. No patient had the tip of the odontoid process extended above the foramen magnum (McRae's line). The mean Ranawat's line in male and female subjects was 15.75 (SD, 1.71; range, 12–19) mm and 14.09 (SD, 1.38; range, 11–17) mm, respectively, compared with

previously reported values of 17 (SD, 2) mm and 15 (SD, 2) mm, respectively.⁴

DISCUSSION

MRI is rapidly supplementing many traditional radiographic modalities for the evaluation of the craniocervical junction, especially the diagnosis of basilar impression.^{1,3} Its readily obtainable anatomic and pathologic information and excellent differentiation between various tissues make MRI superior to plain radiography for anatomical measurement. However, the low cost and accessibility of plain radiography make it important in initial evaluation. Previous studies of the lines of Chamberlain,¹ McGregor,⁴ McRae,⁵ and Ranawat⁶ were reported based on measurements of plain radiographic images. This study was undertaken to determine the accuracy of these values by using the more precise modality of MRI in normal individuals with no basilar impression.

The anteroposterior diameter of the foramen magnum is often easy to determine. McRae's line is generally longer than 30 mm in normal individuals⁷; a diameter of less than 25 mm is almost always associated with neurological symptoms.³ All patients in this study had diameters of greater than 30 mm, and none had the tip of the odontoid process projected above McRae's line, which is consistent with previously identified normal parameters.

Normal individuals should not have the tip of the odontoid process extended above the Chamberlain's line by more than 5 mm.⁴ 39 of our 114 patients had a mean of 2.89 mm (range, 1–9 mm) above this line, including 12 patients (7 men and 5 women) with odontoid processes extending more than 5 mm above this line.

On lateral radiographs of the skull in which the posterior edge of the foramen magnum is indistinct, McGregor's line is usually used to diagnose basilar impression. An odontoid tip extending more than 4.5 mm above this line is considered abnormal. A single male patient in this study was found to have an odontoid process extending 8 mm above this line. In addition, we measured values that deviated markedly from the previously determined normal values in male (-1.12 mm) and female (-0.27 mm) patients.⁴

The Ranawat's line has been defined as normal when its length is 17 mm in men and 15 mm in women.⁶ We found the mean Ranawat's line to be 16 mm in men and 14 mm in women. This observation may be considered normal for Asian people, who are typically of a smaller build than their western counterparts.

CONCLUSION

After using MRI to confirm the standard parameters of basilar impression as formulated from conventional lateral skull radiographs, we recommend using McRae's line and Ranawat's line as the initial screening markers for basilar impression for the Asian

population. Chamberlain's line and McGregor's line are viable alternatives, but clinicians must be aware of the potential for false positives. If there are doubts regarding the measurement of these values by conventional lateral radiography, an MRI scan of the craniocervical junction is recommended for greater accuracy.

REFERENCES

1. Chamberlain WE. Basilar impression (platybasia). *Yale J Biol Med* 1939;11:487-96.
2. Hensinger RN. Osseous anomalies of the craniovertebral junction. *Spine* 1986;11:323-33.
3. Hinck VC, Hopkins CE, Savara BS. Diagnostic criteria of basilar impression. *Radiology* 1961;76:572-85.
4. McGregor M. The significance of certain measurement of the skull in the diagnosis of basilar impression. *Br J Radiol* 1948; 21:171-81.
5. McRae DL, Barnum AS. Occipitalization of the atlas. *Am J Roentgenol Radium Ther Nucl Med* 1953;70:23-46.
6. Ranawat CS, O'Leary P, Pellicci P, Tsairis P, Marchisello P, Dorr L. Cervical spine fusion in rheumatoid arthritis. *J Bone Joint Surg Am* 1979;61:1003-10.
7. Menezes AH, VanGilder JC. Anomalies of the craniovertebral junction. In: Youmans JR, editor. *Neurological surgery*, 3rd ed. Philadelphia: WB Saunders; 1989:1359-420.