LABORATORY INVESTIGATION

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The Morphometric Study for the Rolandic Fissure

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Objective : The purpose of this study was to characterize the Rolandic fissure(Rf) and was to identify the Rf using the surface bony landmarks which can be usually exposed on craniotomy.

Methods : After morphological evaluation of the Rfs using 21 Korean adult formalin fixed cadavers, craniometric measurement was carried out from the surface bony landmarks of nasion, glabella, bregma, and lambda.

Results : The Rfs of both hemispheres did not show the mirror image. The Rfs ran forward and downward toward the sylvian fissure keeping the mean angle of 67° from mid-sagittal line as elongated S-shape in left and the elongated reverse S-shape in right hemisphere. Connections between the Rf and the longitudinal fissure and between the Rf and the sylvian fissure were found in 3 (7.1%) and 2 (4.8%) of 42 hemispheres, respectively. Most Rfs extended superiorly to 2-3mm lateral to the most superomedial surface of hemispheres and extended inferiorly to 3-5mm superior to the sylvian fissures. The mean distances from the nasion, glabella, bregma, and lambda to the most superomedial aspect of the Rf were 18.8±0.9cm, 16.6 ±0.8cm, 5.2±0.6cm, and 6.9±1.0cm, respectively. The mean distance measured between the Rf and the nasion using traditional method was 18.4±0.6cm.

Conclusion : The distance between the Rf and the nasion roughly correspond within the range of mean 4 mm compared with that measured by the traditional measurement. These data may be more helpful to delineate the Rf after the placement of drapes for craniotomy.

KEY WORDS : Rolandic fissure · Craniometric measurement · Nasion · Bregma · Lambda.

Introduction

The Rolandic fissure (Rf) defines a discrete cortical area that represents primarily motor responses immediately anterior to the Rf and sensory responses posterior to the Rf[3,5,7]. Previously there have been great efforts to discover the motor and sensory cortical configurations and location of the Rf in surgical fields. Recent studies such as cortical stimulation using previously implanted subdural electrodes, functional magnetic resonance image (fMRI), or somatosensory evoked potential for cortical localization have demonstrated that cortical distribution of the motor and sensory areas is variable and complex[2,9,13]. Thus, craniometric and morphological knowledges for the Rf can provide the simplified illustrations based on the traditional concept. Because anatomical identification of the Rf can be difficult, particularly on the brain partially exposed by craniotomy, and because location of both the Rf and the motor cortex may show individual variation, the simplified details morphological characteristics of the Rf would be useful to identify the Rf in the surgical field.

Neurosurgeons have traditionally used craniometric measurements based on the nasoiniac line method, as originally described in 1900 by Taylor and Haughton[12], for the best cranial opening for a particular lesion. Using this traditional method, the Rf lies along a line connecting the midpoint of the zygomatic arch and a point along the sagittal midline 2cm posterior to the midpoint between the nasion and the inion[15]. Even though the Rf is marked with ink or a needle before placing the drapes using traditional measurement, the drapes will cover most of the pertinent landmarks and can be disorienting. In addition, the Rf can not be measured again during the operation because of the limited surgical field and

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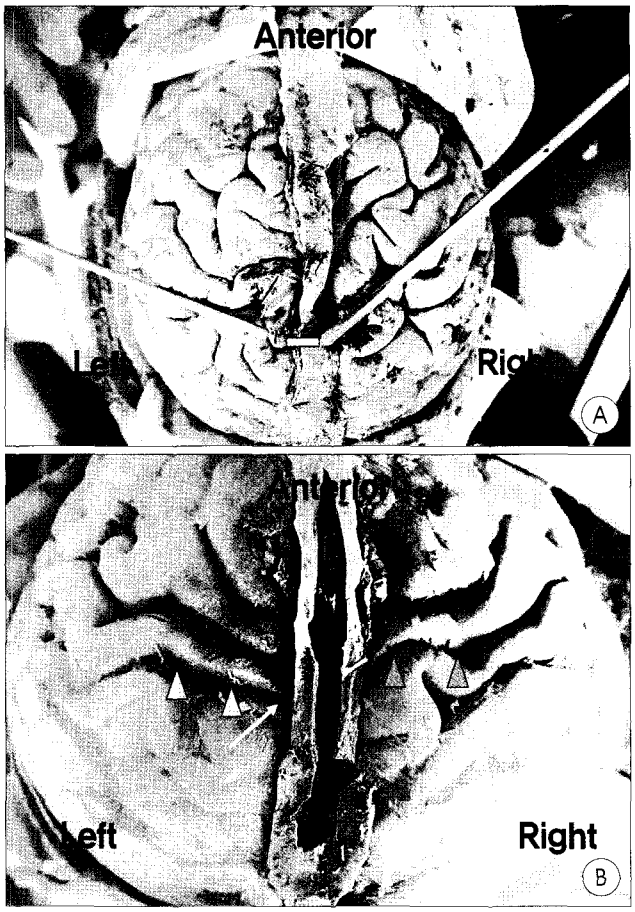

Fig. 1. Photographs showing the superior aspect of the Rolandic cortex. A : Long rods and arrows on both hemispheres indicate the direction of the Rolandic fissure(Rf) descending toward the sylvian fissure. The angle between the long rod and mid-sagittal surface indicates the angle of the Rf descending from the sagittal midline surface. The Rf on the sagittal midline dura is marked with ink (horizontal white rod). B : The right Rf is connected with the longitudinal fissure (green arrows) and shows the elongated reverse S-shape (green arrow heads), whereas the left Rf begin at 2mm lateral to the most medial margin of the hemisphere (white arrows) and shows the elongated S-shape curve (red arrow heads). Mirror image of both hemispheres is not seen. The typical narrow motor strip in front of the Rf is visible. The appearance of sensory cortex behind the Rf is wider and more complex compared with that of motor cortex.

patient's position. In such situation, it is more difficult to identify the Rf in the exposed cerebral cortex if surgeon is not aware of specific morphological characteristics of the Rf.

The purpose of this study was to characterize and identify the Rf using the surface bony landmarks which can be usually exposed on craniotomy, and to verify the location of the Rf compared with the traditional measurement.

Materials and Methods

Twenty-one formalin fixed Korean adult cadavers (16 males, 5 females) were used. After detachment of the whole scalp from the cranium, the calvaria were cut round in one piece passing through 2cm superior to the supraorbital margin and 3cm superior to the external occipital protuberance using bone cutter. Dura mater was widely opened remaining the midline sagittal dura. Arachnoid dissection from the interhemispheric fissure to the sylvian fissure was widely performed to expose the motor and sensory cortex around the Rf. The Rf was first created with the concept of classic narrow motor strip anterior to the deep sulcus which is running from the superior margin of the hemisphere downward and forward toward the sylvian fissure[6]. The Rf was further dissected bilaterally from the longitudinal fissure and investigated the morphological characteristics. Location of the Rf was marked with ink or pin on the mid-portion of the sagittal dura corresponding to which the Rfs end on the medial surfaces of both hemispheres (Fig. 1). About 1cm sized burr hole was made at the site of calvaria corresponding to the most superomedial point of the Rf (Rfp). When putting the calvaria back where it was, the mark on the mid-sagittal dura corresponding to the Rfp could be observed through the burr hole (Fig. 2). Craniometric measurement of the Rf was carried out from the surface landmarks of nasion, glabella, bregma, and lambda. The distance between the nasion and the Rf, which was measured using the traditional method (2cm posterior to midpoint of the nasoiniac line), was compared with the results of this study.

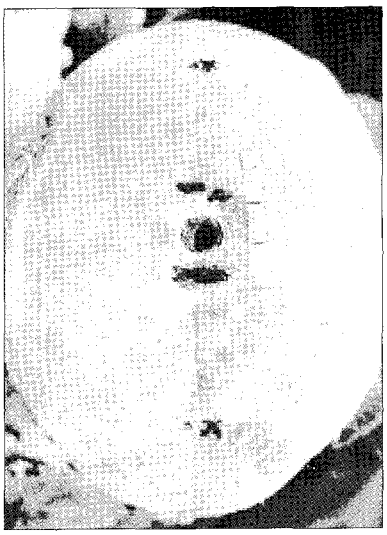

Fig. 2. A photograph showing the calvarial surface for the craniometric measurement of the Rolandic fissure (Rf). Bregma and lambda are marked with black cross. Burr hole is located at the level of the sagittal midline dura corresponding to the most superomedial portion of the Rf.

Results

Morphological characteristics of a Rolandic fissure

The Rfs of both hemispheres did not show the mirror image. The precentral gyrus descended as about 1cm sized strip without sulcus, whereas postcentral gyrus behind the Rf was wider and appeared more complex compared with those of precentral gyrus (Fig. 1). In 3 of 21 specimens, the connection between the Rf and the longitudinal fissure was noted in one hemisphere but not in contralateral hemisphere (Fig. 2). In 3 (7.1%) hemispheres, the Rf was connected with

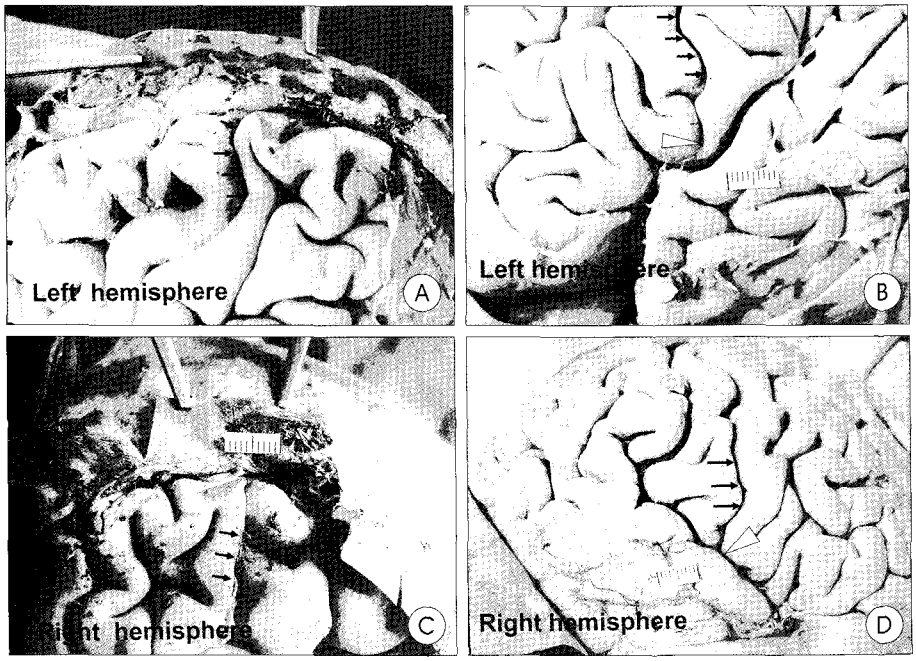

Fig. 3. Photographs showing the lateral views of the Rolandic fissures (Rfs) (arrows). (A) The Rf on left hemisphere is connected with the longitudinal fissure (arrow head) and (B) does not meet the sylvian fissure (arrow head). (C) The Rf on right hemisphere begins at 2mm lateral to the most superomedial margin of the hemisphere (arrow head) and (D) meets the sylvian fissure (arrow head).

Table 1. Distances from the bony landmarks to the Rolandic fissure (Rf) and the angle of the Rf descending toward the sylvian fissure from the sagittal midline dura in 21 cadavers

No. of cases	Sex	Distances to Rf (cm)				Angle(°) of Rf	
		Nasion	Glabella	Bregma	Lambda	Left	Right
1	M	19.5	16.0	4.5	6.3	70	66
2	F	18.8	16.6	5.4	7.5	67	66
3	F	17.5	15.0	4.5	6.5	72	70
4	M	18.5	16.5	5.0	7.0	69	72
5	F	19.0	16.3	5.5	5.7	65	64
6	M	20.0	15.8	5.4	6.5	65	68
7	M	19.0	17.0	6.0	6.5	70	60
8	M	18.0	16.0	5.5	6.5	57	65
9	F	18.5	16.0	5.0	7.5	65	68
10	M	19.0	17.0	5.0	6.5	70	66
11	M	17.7	15.5	4.0	10.0	60	75
12	M	19.0	17.0	4.5	8.7	70	70
13	M	18.0	16.0	4.5	7.0	67	75
14	M	19.6	18.5	6.7	5.0	70	64
15	M	19.5	18.5	6.2	8.3	70	70
16	M	17.0	16.0	4.0	8.0	70	75
17	M	18.0	17.1	5.3	5.5	65	65
18	M	18.4	16.5	5.0	7.5	75	60
19	F	18.8	16.5	4.8	7.0	60	65
20	M	20.6	18.6	7.4	3.8	70	60
21	M	19.5	17.5	5.5	9.4	68	60
Mean±SD		18.8±0.9	16.7±1.0	5.2±0.8	7.0±1.4	67.1±5.4	66.9±6.3

SD : standard deviation

the longitudinal fissure. In the remaining 39 hemispheres, it extended to 2-3mm lateral to the most superomedial surface of hemisphere.

The Rf extended downward and slightly toward the sylvian fissure as elongated S-shape curve in the left hemisphere and the elongated reverse S-shape curve in the right side (Fig. 1). Most Rfs were not connected with the sylvian fissures and extended to 3-5mm superior to the sylvian fissures. However, the Rf was connected with the sylvian fissure in 2 (4.8%) hemispheres (Fig. 3). The mean angle of the Rf running forward and downward from the mid-sagittal dura was 67.4±4.6° in left hemisphere and 67.0±5.1° in right side (Table 1). Even though the angle had a tendency to be wider in male than female cadavers, there was no statistical significance.

Measurement results between the Rf and surface bony landmarks

The mean distance between the nasion and the external occipital protuberance was 32.7±1.2cm in 21 total cadavers, 32.9±1.2cm in 16 male cadavers, and 32.0±0.4cm in 5 female cadavers. In male cadavers, the mean distance was 0.9cm longer than that in female cadavers, with a statistical significance by independent T-test (p=0.026). The mean distances from the nasion, glabella, bregma, and lambda to the Rf were 18.8±0.9cm (range, 17.5-20.0cm), 16.6±0.8cm (range, 15.5-18.5 cm), 5.2±0.6cm (range, 4.5-6.7cm), and 6.9±1.0cm (range, 5.0-8.7cm), respectively, in 21 total cadavers (Table 1). There were no significant difference in the mean distance from the each bony landmark to the Rf according to the sex difference. The mid-sagittal dura corresponding to the Rfp was located at a mean 57% point of nasoiniac

Table 2. Distances between the nasion and the Rolandic fissure (Rf) by the traditional measurement (TM) and the ratio for nasoiniac line compared with results of this study

No. of cases	Sex	Distances(cm)*		Ratio(%) for nasoiniac line†	
		Nasion to EOP	Rf by TM	TM	Presented study
1	M	34.0	19.0	55.9	57.4
2	F	32.0	18.0	56.3	58.8
3	F	32.0	18.0	56.3	54.7
4	M	32.0	18.0	56.3	57.8
5	F	32.0	18.0	56.3	59.4
6	M	33.0	18.5	56.1	60.6
7	M	32.5	18.3	56.3	58.5
8	M	32.5	18.3	56.3	55.4
9	F	31.5	17.8	56.5	58.7
10	M	34.5	19.3	55.9	55.1
11	M	33.0	18.5	56.1	53.6
12	M	34.7	19.4	55.9	54.8
13	M	32.5	18.3	56.3	55.4
14	M	32.5	18.3	56.3	60.3
15	M	32.0	18.0	56.3	60.9
16	M	31.0	17.5	56.5	54.8
17	M	31.4	17.7	56.4	57.3
18	M	32.0	18.0	56.3	57.5
19	F	32.7	18.4	56.3	57.5
20	M	34.4	19.2	55.8	59.9
21	M	35.0	19.5	55.7	55.7
Mean±SD		32.7±1.2	18.4±0.6	56.2±0.2	57.3±2.2

*The Rf by TM is the distance measured from the nasion to the point along the sagittal midline 2cm posterior to the midpoint between the nasion and the EOP. †Ratio (%) for nasoiniac line means the percentage of the distance of the nasion to the Rf for that of the nasion to the EOP. In presented study, ratio (%) for nasoiniac line means the percentage of the distance measured directly from the nasion to the Rf for the distance between the nasion and the EOP. The results of the direct measurement from the nasion to the Rf were represented in table 1. SD : standard deviation, EOP : external occipital protuberance

line (Table 2). The mean distance measured between the Rf and the nasion using the traditional method was 18.4± 0.6cm which was 4mm shorter compared with the result of this study measured directly from the nasion to the Rf.

Discussion

The Rf begins on the medial surface of hemisphere and appears on the lateral surface about midway between the frontal and occipital poles[5]. The depths of the Rf constitute the boundary between the frontal and parietal lobes. Primary motor and somesthetic areas locate anterior and posterior to the Rf, respectively[3]. Cortical distribution of the motor and sensory areas is found variable and complex based on recent study results from cortical stimulation using chronically implanted subdural electrodes, fMRI, and somatosensory evoked potential for cortical localization[2,9,13]. Although the Rf could be identified in the surgical field using the electrical stimulation or recent radiological image techniques, such methods are time-consuming task and need expert personnels, high-tech equipments, and available space. Thus, craniometric and morphological knowledges for the Rf can provide the simplified illustrations based on the traditional practical precept. This Rf is not in a straight line along the lateral hemisphere wall but has bends forward and then backward. It extends downward and slightly forward at about a 70° angle toward the lateral fissure[5]. It is more or less sinuous shape, showing two sharp curves which called the superior and inferior genu. The concavity of the superior knee is directed anteriorly and that of the inferior knee posteriorly[11]. In this study, the Rf was shaped as elongated S-shape curve in the left hemisphere and the reverse S-shape curve in the right side.

Even though the paired cerebral hemispheres have been known to be mirror image duplicates consisting of a highly convoluted gray cortex (pallium), an underlying white matter, and a collection of deep neuronal mass[3], Harkey et al.[10] reported that the convolutions of the cerebral hemispheres vary from brain to brain and even between the two sides[3,10]. Amunts et al.[1] reported that anatomical asymmetries in the region of motor cortex covary with asymmetries in motor cortex. Using MR imaging, they described asymmetry intrasulcal length of the posterior bank of the precentral gyrus as a marker for the size of the cortical motor hand representation area. Right-handers had a deeper Rf on the left than on the right side. Lefthanders had a deeper right than left Rf on dorsal sections through the precentral gyrus. The asymmetry was more pronounced in right- than in left-handers and it was associated with handedness. The authors have tried to differentiate dominant from non-dominant hemisphere using the angle of Rf descending from the superior margin of the hemisphere toward the sylvian fissure. However, statistical significance between dominant and non-dominant hemispheres could not be found. In this study, the Rf ran forward and downward keeping the angle of mean 67° from the mid-sagittal line.

Usually, the Rf does not extend onto medial surface of the hemisphere and is connected with the sylvian fissure in 5-19%[6,7]. However, Ono et al.[11] reported that the superior end of the Rf extend to the medial surface in 56% of the right hemisphere and 72% in the left hemisphere and the extension into the sylvian fissure is 16% in both hemispheres, respectively. Their results were based on the only lateral surface of the hemisphere. In this study, bilateral Rfs did not show the mirror image in all specimen. In about 7.1% of 42 hemispheres, the Rf was connected with the longitudinal fissure. Most Rfs extended to 2-3mm lateral to the most superomedial surface of hemisphere. The connection between the Rf and the sylvian fissure was found in only 4.8%.

Cushing[7] reported that the motor cortex would be limited

to a narrow strip of about 1 cm anterior to the Rf. He used the term 'narrow motor strip' for the first time. Uematsu et al.[13] examined the records of cortical mapping done by electrical stimulation of the cerebral cortex via implanted subdural electrode grids in patients with seizure disorders. They found that two-thirds (65.9%) of the primary motor responses were located within 10mm of the Rf, and the remaining one-thirds (34.1%) were more than 10mm anterior to the Rf. Event though their results indicated that primary motor cortex may extend beyond the gyrus immediately anterior to the Rf, the primary motor cortex is generally designated as lying within the narrow strip[6]. Yousry et al.[14] reported that the functional representation of the motor hand area can be localized to a precise anatomical landmark on the precentral sylcus, described as a knob-like structure, that is shaped like an omega or epsilon in the axial plane and as a hook in the sagittal plane using fMRI. Foundas et al.[8] suggested that anatomic asymmetries of the motor hand area may be related to hand preference because of the differences in right-handers and left handers. The postcentral gyrus posterior to the Rf has been known usually not to be continuous, but break up into superior and inferior segment[3]. In this study, the authors decided the location of the Rf based on the narrow motor strip anterior to the Rf as Cushing[7] mentioned. The results of this study showed that the precentral gyrus had a tendency to descend continuously without interruption as a pattern of about 1cm sized strip, whereas postcentral gyrus behind the Rf was wider and appeared more complex compared with those of precentral gyrus.

In planning a scalp incision, the surgeon should be able to visualize the location of key intracranial structures while looking at the external surface of the patient's head. The nasoiniac line is the key to outlining the underlying brain anatomy. It is defined as a line drawn over the surface of the head in the midline from the nasion to the inion. The nasion is the midpoint of the nasofrontal suture. It is identified as the depression at the root of the nose, below the glabella. The inion is the external occipital protuberance[4]. To localize the sylvian fissure and the Rf, craniometric measurement has been used since 1900[12]. The Rf lies along a line connecting the midpoint of the zygomatic arch and a point along the sagittal midline 2cm posterior to the midpoint between the nasion and the inion. It lies along a line drawn from the 54% mark on the nasoiniac line[4,15]. Even though the Rf is marked with ink or a needle before placing the drapes using traditional measurement, the drapes will cover most of the pertinent landmarks and can be disorienting. Thus, it may be of value to make bony landmarks for the purpose of orienting the surgeon. In this study, the Rf was located at the mean 18.8cm, 16.6cm, and 5.2cm posteriorly from the nasion, glabella, and bregma, respectively, and 6.9cm anteriorly from the lambda. The mid-sagittal dura corresponding to the Rfp was located at a mean 57% point of nasoiniac line. The distance measured directly from the nasion to the Rf was about 4mm longer compared with the data calculated in terms of traditional measurement.

Conclusion

The Rf run forward and downward keeping the angle of about 67° from the mid-sagittal line. It shows the elongated S-shape curve in the left and the reverse S-shape curve in the right hemispheres. Most of the Rfs do not meet the longitudinal and sylvian fissures. The mid-sagittal dura corresponding to the Rfp locate at the 19cm, 17cm, and 5cm posterior to nasion, glabella, and bregma, respectively, and 7cm anterior to lambda. These results may be more helpful to delineate the Rf in view of the confused landmark after the placement of drapes for craniotomy.

References

1. Amunts K, Schlaug G, Schleicher A, Steinmetz H, Dabringhaus A, Roland PE, et al : Asymmetry in the human motor cortex and handedness. **Neuroimage 4** : 216-222, 1996
2. Bittar RG, Olivier A, Sadikot AF, Andermann F, Reutens DC : Cortical motor and somatosensory representation : effect of cerebral lesions. **J Neurosurg 92** : 242-248, 2000
3. Carpenter MB : **Gross anatomy of the brain, Core text of neuroanatomy,** ed 4. Baltimor : William & Wilkins, 1991, pp23-56
4. Clatterbuck RE, Tamargo RJ : Surgical positioning and exposures for clinical procedures, in Winn HR (ed) : **Youmans Neurological Surgery,** ed 5. New York : Saunders, 2004, Vol 1, pp623-630
5. Crosby EC, Humphrey T, Lauer EW : Chapter 7 Telecephalon, Part 1-Gross structure of the telencephalon, **Correlative anatomy of the nervous system,** New York : Macmillan, 1983, pp343-355
6. Cunningham DJ : **Contribution to the surface anatomy of the cerebral hemisphere.** Dublin : Royal Irish Academy, 1892, pp306-355
7. Cushing H : Surgery of the head. in Keen WW(ed) : **Surgery-Its Principles and Practice.** Philadelphia : W.B. Saunders Co., 1908, pp17-248
8. Foundas AL, Hong K, Leonard CM, Heilman KM : Hand preference and magnetic resonance imaging asymmetries of the central sulcus. **Neuropsychiatry Neuropsychol Behav Neurol 11** : 65-71, 1998
9. Goldring S, Gregorie EM : Surgical management of epilepsy using epidural recordings to localize the seizure focus. **J Neurosurg 60** : 457-466, 1984
10. Harkey HL, Al-Mefty O, Haines DE, Smith RR : The surgical anatomy of the cerebral sulci. **Neurosurgery 24** : 651-654, 1989
11. Ono M, Kubik S, Abernathey CD : Chapter 8 Frontal lobe : Lateral Surface, **Atlas of the Cerebral Sulci.** Stuttgart : Georg Thieme Verlag, 1990, pp36-40
12. Taylor EH, Haughton WS : Some recent researches on the topography of the convolutions and fissures of the brain. **Trans R Acad Med Ireland 18** : 511-522, 1900
13. Uematsu S, Lesser RP, Gordon M : Localization of sensorimotor cortex : The influence of Sherrington and Cushing on the modern concept. **Neurosurgery 30** : 904-913, 1992
14. Yousry TA, Schmid UD, Alkadhi H, Schmidt D, Peraud A, Buettner A, et al : Localization of the motor hand area to a knob on the precentral gyrus. A new landmark. **Brain 120** : 141-157, 1997
15. Wilkins RH : *Principles of neurosurgical operative technique, in* Wilkins RH, Rengachary SS (eds) : **Neurosurgery,** ed 2. New York : McGraw-Hill, 1996, Vol 1, pp517-529

Commentary

Rolandic fissure which divides the eloquent cortex is the important anatomical landmark in the neurosurgery. The radiological characteristics of the Rolandic fissure have been published before[1]. However, this paper has been added and pointed on the craniometric measurement from the surface anatomical bony land marks of nasion, glabella, bregma and lambda. This study will give the valuable information and anatomical evidences whether the neurosurgeons decide and carry out the safe caraniomy during the major intracranial surgeries.

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Reference

1. Devaux B, Meder JF, Missir O, Turak B, Dilouya A, Merienne L, et al : The rolandic line : a simple baseline for the identification of the central region. An MRI study and functional validation. **J Neuroradiol 23** : 6-18, 1996