



## **Pars Marginalis and Pars Bracket Sign for Easy and Fast Localization of the Central Sulcus on Axial Brain MRI**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Author YSA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KEB managed the analyses of the study and made the final corrections of the manuscript. Both authors read and approved the final manuscript.*

### **Article Information**

#### Editor(s):

(1) Dr. Ekanem Eyo Philip-Ephraim, University of Calabar Teaching Hospital, Nigeria.

#### Reviewers:

(1) Rimpi Gupta, Pt B. D. Sharma University of Health Sciences, India.

(2) Kishore Balasubramanian, Dr Mahalingam College of Engineering and Technology, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/58052>

**Original Research Article**

**Received 10 April 2020**

**Accepted 17 June 2020**

**Published 25 June 2020**

### **ABSTRACT**

**Background:** Correct identification of the central sulcus and adjacent gyri is essential for localizing tumors and planning effective surgery. With brain lesions central sulcus and surrounding sensory and motor eloquent areas may be obliterated. Central sulcus is the sulcus anterior to the pars marginalis on axial images.

**Purpose:** To evaluate the presence of marginal sulcus in axial cuts brain MRI among Sudanese population and to use it as land mark for central sulcus localization.

**Methodology:** The study included 100 normal MRI of both sex of adult age group. The pars marginalis and pars bracket sign was assessed and the direct relation to the central sulcus was observed.

**Results:** This study included 100 participants, (55 males and 45 females). The mean age of patients was 32.2 (+/- 7.4) years (range, 18–73 years). Pars marginalis and bracket sign were observed in all cases. In all cases, the central sulcus was observed to be anterior to the pars

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bracket. In 97 cases (53 males and 44 females), the central sulcus enters into the bracket, while in the remaining 3 cases it did not reach the pars bracket. No significant difference was observed between males and females.

**Conclusion:** Pars bracket sign was proved to be a reliable and quite effective signs to localize the central sulcus.

*Keywords: Pars marginalis; pars bracket sign; cingulated sulcus; central sulcus.*

## 1. INTRODUCTION

The cingulate sulcus is a sulcus in the medial surface of the cerebral hemisphere. It terminates as the marginal sulcus of the cingulate sulcus. The cingulate sulcus separates the frontal and parietal lobes from the cingulate gyrus [1].

The marginal sulcus is the extension of the cingulate sulcus posterosuperiorly, separating the paracentral lobule from the precuneus on the medial surface of the cerebral hemispheres and seen on the sagittal images [2].

On axial images, the marginal sulcus appears as a short sulcus, reaching the apex but not extending more laterally. It helps to confirm the location of the central sulcus, which is located one sulcus anterior to the marginal sulcus [2].

Identification of the central sulcus is important to localize the motor and sensory areas (contained in the precentral and postcentral gyri). The central sulcus (CS) is visible on 93% of CTs and 100% of MRIs [3].

The central sulcus curves posteriorly as it approaches the inter-hemispheric fissure, and often terminates in the paracentral lobule, just anterior to the pars marginalis within the pars bracket [3].

The central sulcus is one of the most important and consistent landmarks in the convexity of the brain. It separates frontal from parietal lobes. Starting medially, it descends anteriorly along the lateral surface of the hemisphere. It resembles an "S" in appearance with three distinct curves or genua: the superior and inferior genua, which are convex anteriorly, and the middle genu – the deepest curve – which is concave anteriorly. This remarkable shape of the middle genu of the central sulcus has been compared to an inverted Greek letter Omega [4].

The other main signs for localisation of the central sulcus in both anatomical and radiological

methods are: The relative morphologies of the superior frontal sulcus and the precentral sulcus, the hook-shaped aspect of the middle part of the central sulcus (omega sign), the medial end of the central sulcus projection anteriorly to the pars marginalis, the bifid nature of the internal end of the posterior central sulcus contouring the pars marginalis, and the lesser thickness of the posterior central gyrus compared with the precentral gyrus [5].

Magnetic resonance imaging (MRI) provides tools both to recognize the central sulcus anatomically and to visualize the location of the lesion with regards to this important landmark. The central sulcus is identified on the sagittal and axial images and, using the lateral and axial views [4].

Localisation of intracranial pathologies is mandatory for both diagnosis and during surgery; however marginal sulcus is a good land mark for localization of central sulcus and so pre and post-central gyri.

Searching the published data worldwide revealed no enough studies regarding the pars marginalis and pars bracket sign as well as no local or regional study about these important land marks which may help to easy and fast localization of the central sulcus. Also few literature as well as anatomy text books describe this sulcus.

Functional MRI and neuro-physiological monitoring during operations are very important and useful tools to localize different brain eloquent areas which may not be available in most of underdeveloped countries, so we using the pars bracket sign and pars marginalis as land marks are good and easy and more safe for localization of central sulcus and different neighboring brain areas.

This study aimed to study the presence of pars marginalis and pars bracket sign as land mark for central sulcus localization using MRI sagittal cuts among Sudanese populations.

## 2. MATERIALS AND METHODS

This was a cross-sectional study, in which evaluation of the marginal sulcus in axial conventional brain MRI in 100 Sudanese participants of both sexes and of adult age group was done. This study was performed at different radiological centers in Khartoum state- Sudan in a period from March 2019 to March 2020.

### 2.1 Patient Selection and Ethical Considerations

Patients without obvious anatomical brain lesions were included. Clinical data were obtained from the medical records. Patients with imaging data of insufficient quality for analysis or refused to participate in the study were excluded.

### 2.2 Imaging Technique and Image Analysis

All examinations were performed on a 1.5T clinical MRI scanner (different companies MRI machines according to different radiological centers). Conventional MRI for morphologic studies included T1WI and T2WI were used to assess. Using the imaging pac system software, images were analyzed in axial cuts for the pars

marginalis and pars bracket sign as land mark for the central sulcus localization. After localization of the central sulcus, the medial end of the central sulcus was observed for its termination either reaching the pars bracket or not.

### 2.3 Statistical Analysis

SPSS version 22 was used for the analysis of data. Results were obtained in tables and graphs.

## 3. RESULTS

The axial brain images of 100 normal adult Sudanese patients were analyzed. Fifty five of the patients were males and 45 were females. The mean age of patients was 32.2 (+/- 7.4) years (range, 18–73 years). Pars marginalis and bracket sign were observed in all cases (100%).

In all cases, the central sulcus was observed to be anterior to the pars bracket (Fig. 1). In 97 cases, (53 males and 44 females) (n=97/100, 97%), the central sulcus enters into the bracket, while in the remaining 3 cases it did not reach the pars bracket (Figs. 2 & 3). No significant difference was observed between males and females.

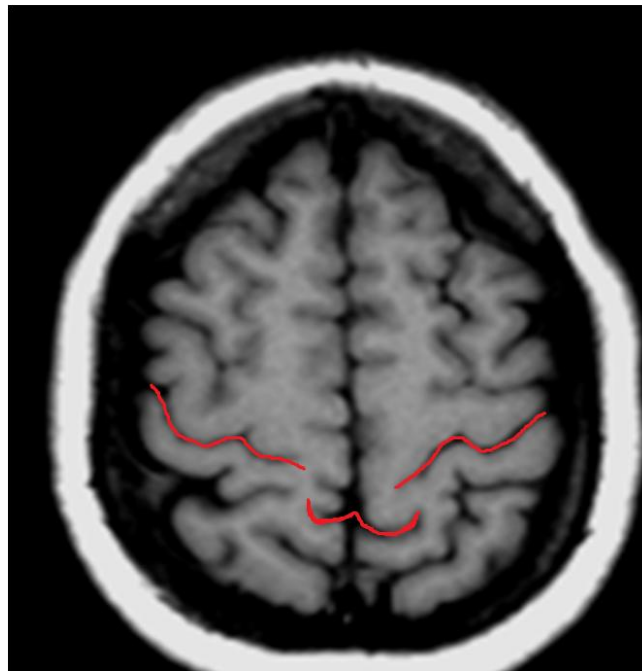
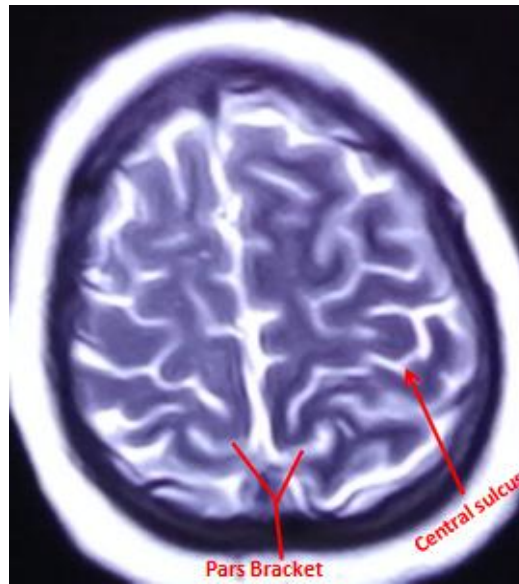
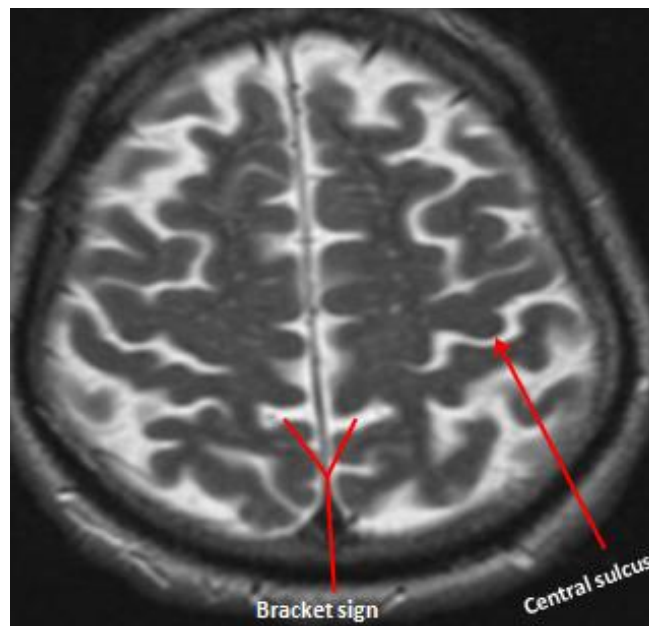


Fig. 1. T1 axial brain MRI without contrast with bilateral central sulci anterior to and reaching the pars bracket in the midline



**Fig. 2.** T2 axial brain MRI with central sulcus anterior to and reaching the pars bracket in the midline



**Fig. 3.** T2 axial brain MRI with central sulcus anterior to the pars bracket but not reaching it

#### 4. DISCUSSION

Knowledge of neuroanatomy and radiology are essential to interpret modern brain imaging. Neuroanatomical landmarks are useful in the identification of specific areas of functional significance, allowing radiology reports to adequately convey the location of pathology to treating physicians and surgeons and make the

localization of lesions more accurate and safe for the surgeons and patients.

A lot of anatomical imaging landmarks and morphological appearances can be used to identify the central sulcus. In the axial images, the superior frontal sulcus located immediately paramedian to the anterior inter-hemispheric fissure. The superior frontal sulcus ends

posteriorly by joining the precentral sulcus, which runs immediately anterior and parallel to the central sulcus. Central sulcus is then confirmed by tracing it medially toward the inter-hemispheric fissure where it curves slightly posteriorly and ends in 94 to 96% of cases by pointing at the horizontal bracket formed by pars marginalis (pars "bracket" sign) [6].

In cases when the regional anatomy is effaced and distorted by tumor mass effect and edema, it is difficult to localize the central sulcus. So different methodologies are invariably successful in identifying the central sulcus and surrounding areas [7].

To overcome the problem, many techniques are used to localize the central sulcus. One of the techniques is the functional MRI, which based on the changes of local cerebral blood flow and oxygen consumption associated with neuronal activation (BOLD effect) [8]. Another technique is magneto-encephalo-graphy (MEG), which topographically displays the activity of specific cerebral areas [9]. A third technique is the intra-operative cortical mapping [10]. These techniques and methods are not available to every neurosurgeon especially in developing countries.

As one of the land marks for localization of the central sulcus, pars marginalis and pars bracket will be of high values in cases of brain tumors and other brain pathologies like arterio-venous malformations (AVM), and intra-cranial infections in this region that may effaced the normal anatomy.

Pars marginalis or the marginal ramus is a superior directed branch of the cingulate sulcus on the inter-hemispheric surface that terminates by curving over the apex of the cerebral convexity immediately posterior to the central sulcus. In cases of intracranial lesions, some sulci and gyri may be obliterated, so pars bracket sign may be useful sign for localisation of the central sulcus and so the eloquent brain areas containing the motor and sensory areas contained in the pre and post central gyri.

Few studies were done regarding the relation between central sulcus and the pars marginalis bracket sign on axial images. One study done by Naidich TP et al. [11], described that the central sulcus lies anterior to pars marginalis and reaching the bracket sign in 96% of cases.

Another study by Carrasco et al. [12], demonstrated the same with 95% incidence. Table 1 below summarizes the results of the present study and previous studies.

The results of the present study reported that the central sulcus lies anterior to the pars marginalis and it enters the bracket sign in 97%.

From the results of this study and from the few previous studies, the pars bracket sign is highly reliable in confirming the location of the primary sensory and motor areas.

**Table 1. Central sulcus anterior to pars marginalis and reaching the pars bracket, comparison between the present study and previous studies**

Study author	Central sulcus reaching the pars bracket %
Naidich TP et al. [11]	96
Carrasco et al. [12]	95
Yasser (Present study)	97

## 5. CONCLUSION

The pars marginalis and pars bracket sign are proved to be easy and reliable landmarks for identification and localization of the central sulcus in MRI brain axial images. This may help during neurosurgical planning, practice, and treatment of lesions adjacent to the sensory and motor areas requires localization of the central sulcus.

## CONSENT AND ETHICAL APPROVAL

All patients were informed and gave consent for participating in the study with full patient confidentiality. Ethical approval of institutional board was obtained.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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