BIOMECHANICS AND BIOMETRY OF THE ANTERIOR SKULL BASE

IRINA DOBRIN[1], PATRICK COURTHEOUX[2], N. DOBRIN[3], I. POEATA[4], N. IANOVICI[4]

[1]Emergency Military Hospital "Dr. I. Czihac", Emergency Departament
[2]CHU-Caen, France
[3]Clinical Hospital No.3, Iasi, Neurosurgery Departament
[4]University of Medecine and Pharmacy "Gr.T. Popa", Iasi

We present here some interesting points of view concerning the biomechanics aspects of the skull base. Also several problems are studied concerning the skull base symmetry with some pathological implications.

Keywords: skull base, skull base symmetry, facial asymmetry

INTRODUCTION

In the opinion of the famous anatomist Testut, the skull base is similar to a ship. This illustrative image obviously takes into consideration the existence of a bow designed to balance the undulatory movements caused by the C1 – C2 occipital articulations. It's about the exoskull, which allows through its apophyses the insertion of various muscle groups which ensure the equilibrium of this unstable system at the first sight, should we consider the static equilibrium.

The development symmetry of the skull base ensures the motion symmetry, the asymmetric development generating compensatory movements at the level of the calvarium but also in the C0 – C1 – C2 movement system (4, 7, 10).

One can notice that the symmetry is given by the sagittal plane on the nasion – opistion direction, while the spheno – occipital articulation is similar to a torsion pushrod whose modification may generate various aspects of asymmetry:

-torsion
-lateral rotation
-front-posterior rotation

Similarly, a malposition of the temporal bone between the sphenoid and the occipital may generate forms of asymmetry through the difference of the semi-circular channels.

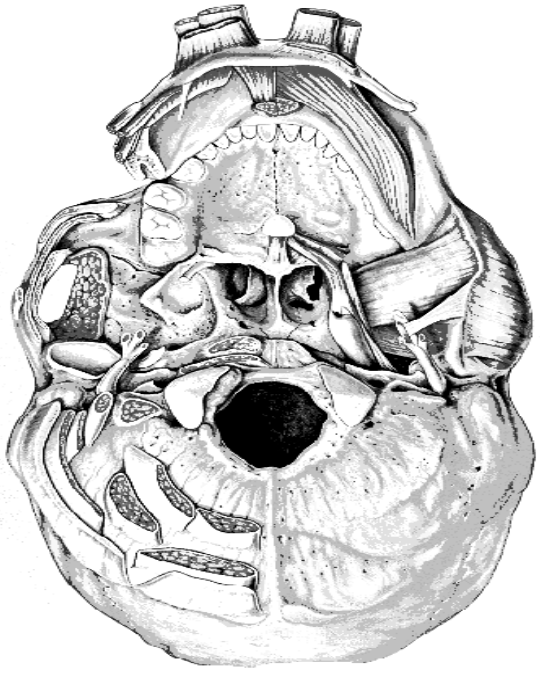

FIG. 1 Exobasis showing the insertion muscle groups

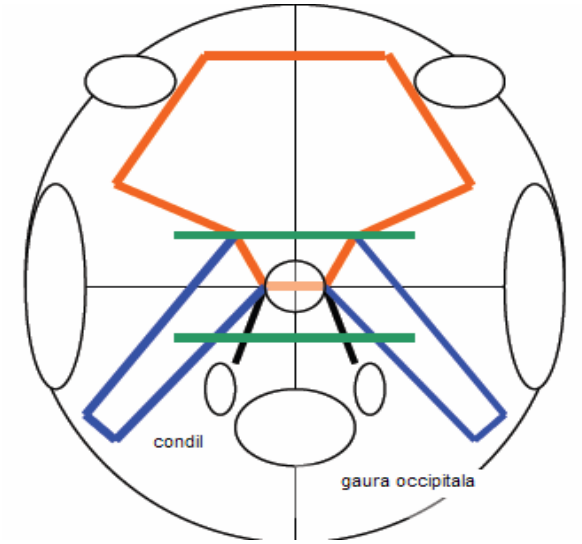

FIG. 2 Schematic representation of the skull base

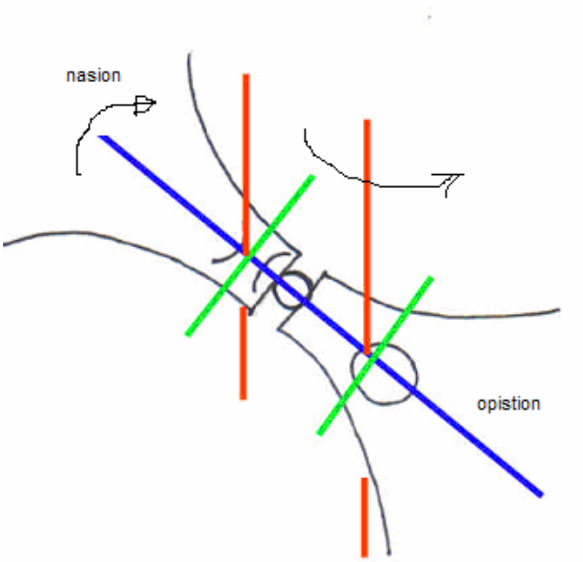

FIG. 3 Schematic representation on the longitudinal plane

According to some authors (J. P. Relier, N. Seguin), the origin of the asymmetries of the skull base is found in the embryonary period under the influence of extrinsic factors – infectious diseases, mother's traumas, but also intrinsic causes such as intra-uterine pressure or various problems during the delivery (2, 3, 10).

The modification of the orientation of the solid pyramids following the traction of the insertion musculature which takes part in the cephalic static and especially the sternocleidomastoidian may generate asymmetries at the level of the skull base.

During the common practice, most of the clinic doctors meet patients with more or less obvious facial asymmetries. Luckily, most of them are nor symptomatic (15).

FIG. 4 Asymptomatic facial asymmetry

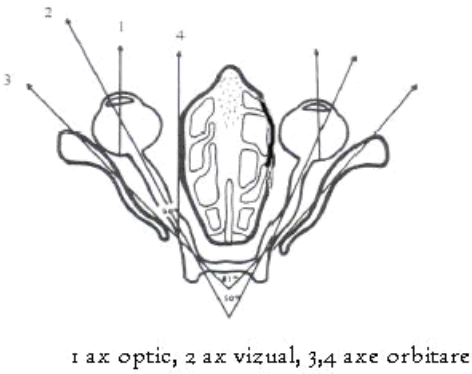

FIG. 5 The importance of the alignment of ocular axes

Nevertheless, an efficient anamnesis may show various attitudes of the child in the suckling period, future modifications in the attention disorders during school, dyslexia, dysortographies with the apparition of cervical pain or vertigo during adulthood.

As clinical implications, the asymmetry of the front floor of the skull base is most frequently met in the case of craniofacial congenital anomalies and may trigger several effects such as: asymmetry of orbital cones, with the modification of the muscles of the oculomotricity, astigmatism, modification of the visual axes with perturbations of the perception of space (2, 4, 16).

The asymmetry of the orbital cones generated by the craniofacial malformations may induce convergence disorders; this is why in certain situations the surgical correction is necessary.

NOTIONS OF BIOMETRY OF THE FRONT FLOOR OF THE SKULL BASE – ANTERIOR SKULL BASE

In the study of ontogenetic and phylogenetic development of the front floor of the skull base it was noticed that this platform which supports the olfactory tracts, the basal part of the front lobes, vascular elements of the fore circulation, does not have a stationary form and structure but changes throughout the course of life. Thus, surgical approach of this region raises problems, depending on the individual situation and anatomic particularities of each subject. In the next stage we set out to analyze the various types of front floor of the skull base at the adult and their clinical surgical implications (17).

DEFINITIONS

-The angle of the orbital ceilings represents the angle of intersection of the two horizontal parts of the frontal bone which forms the orbital ceilings at the junction place with the ethmoid towards the fovea etmoidalis; it is measured in the coronary plane which passes through the zygomatic apophyses of the frontal (UPO).

-The depth of the front floor of the skull base (P) – from the horizontal plane tangent to the convexities of the orbital ceilings a perpendicular line descends on the median line at the crista galli level.

-The depth of the ethmoidal fovea (PFE) is measured imagistically on CT or RMN and the depth angle of the ethmoidal fovea (UP) is defined as the angle set by the horizontal plane tangent to the orbital fossa; it generally passes through the dorsum sellae and the plane which unites the dorsum sellae with the area of maximum declivity of the ethmoidal fovea.

-The sub-frontal approach angle (USF) is limited by the plane which passes through the upper margin of the dorsum sellae, namely the area of maximum declivity of the ethmoidal fovea and the plane which passes through the dorsum sellae with the tip of the superior recessus of the frontal aeric sinus (1, 2).

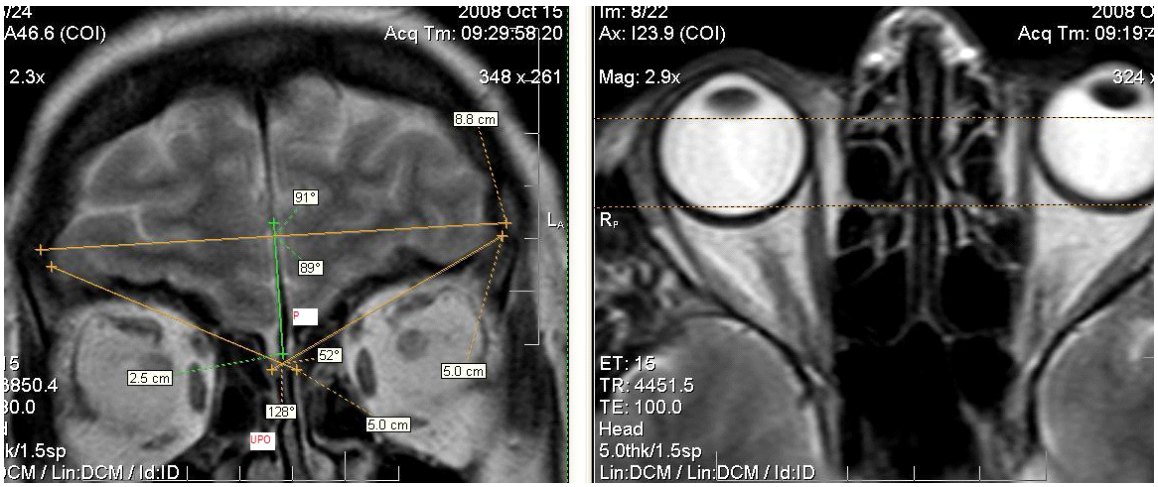

FIG. 6 T2 IRM shows a depth of 2.6 cm. With an UPO of 128°

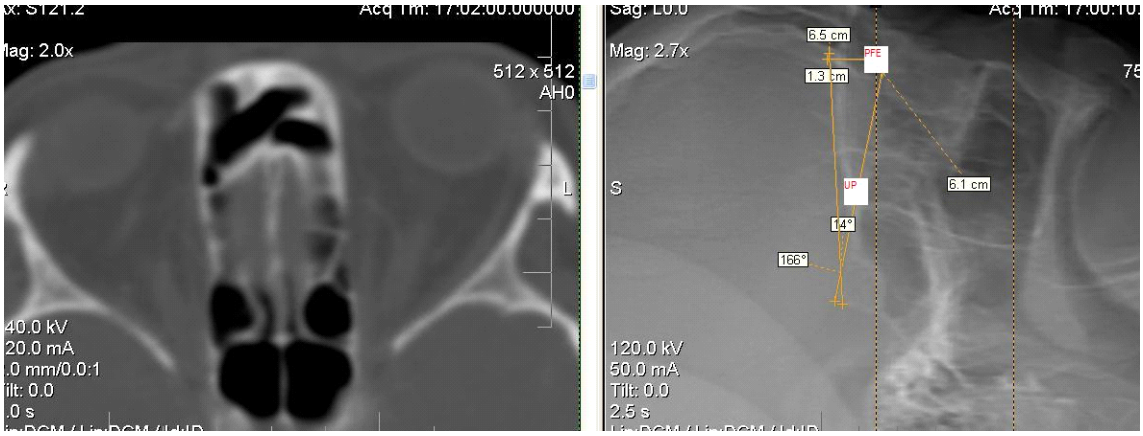

FIG. 7 CT craniocerebral exploration UP= 14° and PFE 1.3 cm

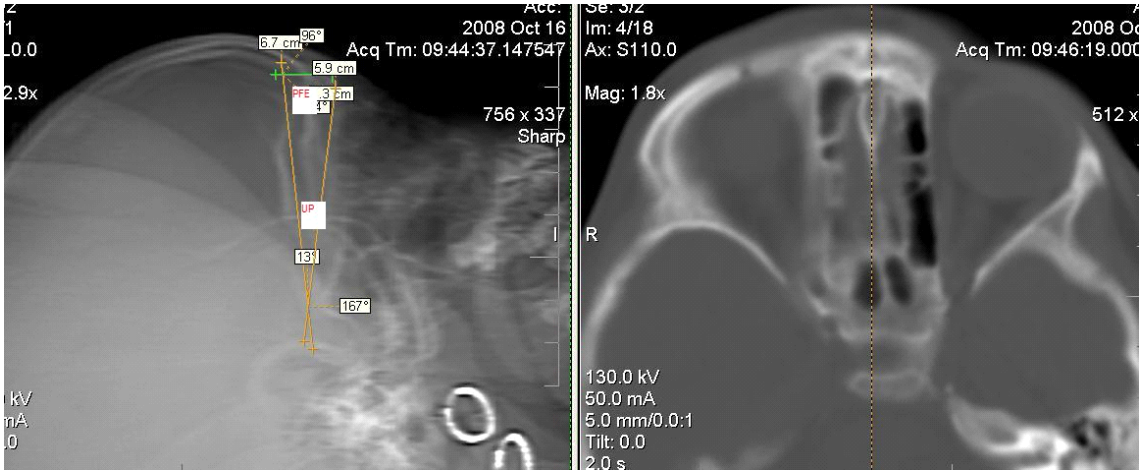

FIG. 8 UP=13°, PFE=1.3cm

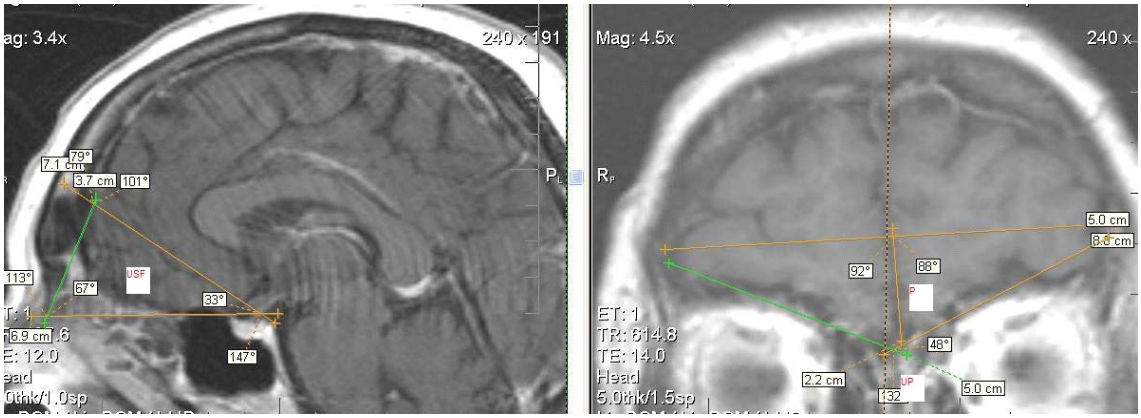

FIG. 9 IRM exploration for the evaluation of the sub-frontal angle USF=33°

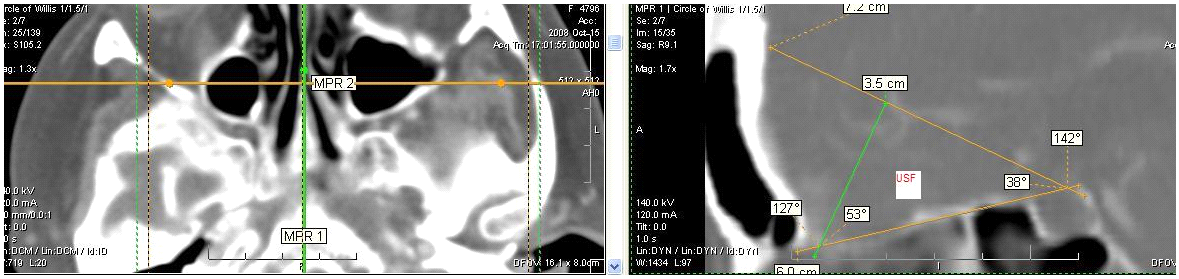

FIG. 10 CT exploration with 3D reconstruction, USF=38°

The practical importance of these aspects

Table 1 The table presents the average values of the angles and distances defined above on a lot of 120 patients randomly selected for study from the imagistic archive of the department of neuroradiology

	P	UPO	USF	UP	PFE
B	3.2	128.3	39	14.2	1.5
F	2.8	127.5	36.5	13.4	1.3

P-D-DEPTH
UPO-ODA-ORBITARY DEPTH ANGLE
USF-SFA-SUBFRONTAL ANGLE
UP-EF-ETHMOIDAL FOVEA
PFE-DEF-DEPTH OF ETHMOIDAL FOVEA

OTHER BIOMETRIC ASPECTS

FIG. 11 Showing various angles modified along the evolution of the skull

There was conducted an anatomic study of 65 skull bases on fresh cadaver samples, having in mind the appreciation of various forms of the front floor of the skull base, of the surface. Various measurements were made: the thickness of the orbit ceiling, the thickness and height of crista galli, the number of perforations at the level of the cribriform plate. The percentage of the surface of the front floor of the skull base of the total surface of the base was calculated (12, 14).

The morphometric aspects of the skull base are considered to be important for various clinical applications, the surgical approaches taking into consideration the various pre-surgical measurements. The dimensional anatomy of the skull base must be

imagistically appreciated in order to facilitate the exposure of various pathological aspects (4, 6, 12).

Similarly, the skull base was analyzed in the context of the cranial ensemble and the elements of phylogenetic evolution.

CONCLUSIONS

The skull base is the platform on which the encephalon rests, provides support and protection and represents the main transit area of the big blood vessels and nerves. The study of the skull base must be conducted taking into consideration its two sides – the exobase and the endobase, but also the neighboring structures.

The human skull has a crucial anatomic and surgical importance. It is considered as the most complex region whose approach implies several specialties, all of them converging towards a nucleus called skull base surgery. The surgical techniques have progressively evolved together with the anesthetic ones, especially since these anatomical areas are filled with vascular and nervous elements of vital importance.

The study of the symmetry of the skull base is especially relevant in solving certain pathological aspects and also the appreciation of the approach angles of the skull base facilitates the various procedures of surgical approach.

REFERENCES

1.Aldescu Corneliu – Neuroradiodiagnostic – Editura Junimea, Iaşi, 1982, 56-64
2.Aldescu Corneliu – Radiologie pentru studenti şi medici stomatologi – Editura Polirom 1999,87-105
3.Arseni C. Afectiunile neurochirurgicale ale sugarului şi copilului mic, Ed. Medicala 1979 67-93
4.Bajenaru O, Pop T - Orbita. In: Rezonanta Magnetica Nucleara in diagnosticul clinic, sub red. Pop T, Ed. Medicala, Bucuresti, 1995 125-147.
5.Beals SP, Joganic EF. Transfacial exposure of anterior cranial fossa and clival tumors. BNI Quarterly. 1992;8:2-28.
6.Bessou P. Cours DIU posture Toulouse janvier 2001
7.Bilsky MH, Kraus DH, Strong EW, et al. Extended anterior craniofacialresection for intracranial extension of malignant tumors.
8.Am JSurg. 1997;174:565-568.
9.Bogousslavsky J. ,Leger Jean-Marc,- Interpretation des Examens Complementaires en Neurologie , Groupe Liaisons 2000
10.Bourjat P, Veillon F - Pathologie oculo-orbitaire-TDM et IRM. In: Imagerie radiologique tete et cou, Paris, Ed. Vigot, 1995.
11.Bouthillier A, van Loveren HR,Tew JM Jr. Anterior approaches tothe clivus: classification and indications. ContempNeurosurg.1994;16:1-8.
12.Ciobanu G.,Mihailovici L. , Ghid practic de tehnica radiologica cranio-faciala ,Editura Facla,1986, 93-109
13.Halimi R.H.,Doyon D., - Traumatismes maxillo-faciales. 1991
14.Housepian EM si colab. - Tumors of the orbit. In: Youmans RJ (ed), Neurological Surgery. Philadelphia, WB, Saunders Co. 1990 458-468.
15.Hasegawa M,Torii S, Fukuta K, et al. Reconstruction of the anteriorcranial base with the galeal frontalis myofascial flap and the vascularizedouter table calvarial bone graft. Neurosurgery. 1995;36:725-731.
16.Hildebrand J. – Neurooncologie, Groupe Liaisons, 2000 36-47
17.Taveras and Ferrucci, Radiology on CD Diagnosis • Imaging • Intervention, Lippincott Williams & Wilkins, Baltimore, 1999 323-365