Cukurova Medical Journal

Araştırma Makalesi / Research Article

Cranial Index Determination Using Computed Tomography (CT) Scans of Children with Normal Brain Development: A Retrospective Study.

Normal Beyin Gelişimi Gösteren Çocuklarda Bilgisayarlı Tomografi (BT) Taraması İle Kranial İndeksin Belirlenmesi: Retrospektif Bir Çalışma

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Cukurova Medical Journal 2015;40(2):239-244.

ABSTRACT

Purpose: Cranial Index (CI) determination is of clinical significance in the evaluation of skull growth and development in children. This study investigated cranial index in computed tomography (CT) scans of children seen in the Radiology Department of Usmanu Danfodiyo University Teaching Hospital Sokoto, Nigeria.

Materials and Methods: A total of CT scan records of 76 children (42 males and 34 females) with normal brain development were used for this retrospective study. The cranial length (CL) and cranial width (CW) were measured on the axial CT and cranial index calculated as the percentage of cranial width to cranial length multiplied by 100. Mean values of CL, CW, CI as well as standard deviations and standard error of mean were calculated for both sexes.

Results: The overall mean values for cranial length was 16.45±1.01, cranial width 13.01±0.94 and CI was 79.12±3.37. Meanwhile in males, the CI was 78.35±3.23 and 80.08±3.34 in females respectively. Thus, classifying head patterns based on the CI values seen in this study, 55.26% of the children had mesocephalic head shape and 28.95% had brachycephaly. Dolicocephaly and hyperbrachycephaly had a frequency of 7.89% each.

Conclusion: Cranial Index (CI) reported in this study showed that most of the children had mesocephalic head shape (55.26%) with dolicocephaly (7.89%) and brachycephaly (7.89%) less common. The observed difference between the mean cranial index of males and females was statistically significant (p = 0.025). The report from this study is of importance in the field of pediatric neurology, anthropology as well as genetics and forensic medicine.

Key words: Cranial Index, Computed Tomography, Children.

ÖZET

Amaç: Kranial endeksin belirlenmesi çocuklarda kafatası büyümesi ve gelişiminin belirlenmesinde klinik bir öneme sahiptir. Bu çalışmada Nijerya'da Usmanu Danfodiyo üniversitesi Sokoto araştırma hastanesi radyoloji bölümüne başvuran çocukların bilgisayarlı tomografi (BT) taraması ile kranial endeksleri belirlenmiştir.

Materyal ve Metod: Normal beyin gelişimine sahip 76 çocuğun (42 erkek ve 34 kız) BT taraması bu retrospektif çalışma için kullanılmıştır. Kranial uzunluk ve kraniyal genişlik aksiyal BT'de ölçülmüş, kraniyal indeks, kraniyal genişliğin kraniyal uzunluğa oranının 100 ile çarpılması ile hesaplanmıştır. Kranial uzunluk, kraniyal genişlik, kranial indeks'in ortalama değerleri ve ortalamanın standart sapma ve standart hata değerleri her iki cinsiyet için hesaplanmıştır.

Bulgular: Kranial uzunluk için ortalama değer 16.45±1.01, kranial genişlik için ortalama değer 13.01±0.94 ve kranial indeks için ortalama değer 79.12±3.37 olarak bulunmuştur. Kranial indeks erkeklerde 78.35±3.23, kızlarda 80.08±3.34 olarak saptanmıştır. Böylece bu çalışmada kranial indeks değerlerine göre kafa modellerini sınıflandırılmıştır, çocukların

%55.26'sı mesosefalik kafa, %28.95'i ise brakisefaliye sahiptir. Dolikosefali ve hiperbrakisefalinin her birinin frekansı %7.89'dur.

Sonuç: Bu çalışmada rapor edilen kranial indekse göre çocukların büyük kısmı mesosefalik kafa şekline (%55.26), daha az yaygın olarak da Dolikosefali (%7.89) ve hiperbrakisefaliye (%7.89) sahiptir. Erkek ve kızlarda ortalama kranial indeks değerleri arasında gözlenen farklılık istatistiki olarak anlamlıdır (p=0.025). Bu çalışmanın sonucu, pediatrik nöroloji, antropoloji aynı zamanda genetik ve adli tıp bakımından önem taşımaktadır.

Anahtar kelimeler: Kranial indeks, bilgisayarlı tomografi, çocuklar.

INTRODUCTION

Cranial Index (CI) determination is of clinical significance in the evaluation of skull growth and development in children. Cephalic index (CI) is an objective and highly useful parameter for determining the skull shape.[1]It is of importance to the surgeons and neurosurgeons, for assessing the pre- and postoperative correction of skull deformations[1,2,3,4]. It is easy to determine and is highly repetitive. The cranial index is indispensable for planning a surgical procedure and assessment of its effectiveness[5]. The notion of cephalic index (CI) was introduced by van Lindert et al. as percentage of width to length in any skull.[1]The width is defined as the distance between the most projecting points at the sides of the head, above and behind the ears; the length is the distance from the glabella and the most projecting point at the back of the head[1,6,4,7,8,9,10]. One of the methods used for assessing the skull shape and determination of CI is the measurements of skull length and width, performed on computer tomography scans[11].

When the skull shape is determined, we need to take into account the fact that various authors apply various CI ranges when defining a specific shape.11 Standring6 defined dolichocephaly for the CI value up to 74.9, mesocephaly: 75.0–79.9, brachycephaly: 80.0 to 84.9, and hyperbrachycephaly for CI exceeding 85.6 Meanwhile, according to Cohen's classification, the respective categories are as follows: dolichocephaly up to 75.9, mesocephaly: 76.8–80.9, and brachycephaly: 81.0–85.4, with hyperbrachycephalclassified at CI exceeding 85.5.5 Koizumi et al. introduced a classification according to which CI under 76 signifies dolichocephaly, and CI of 76–80.9 signifies mesocephaly, while CI exceeding 81.0 signifies brachycephaly[12].

This study investigated cranial index in computed tomography (CT) scans of children seen in the Radiology Department of Usmanu Danfodiyo University Teaching Hospital Sokoto, Nigeria.

MATERIALS and METHODS

A total of CT scan records of 76 children (42 males and 34 females) with normal brain development were used for this retrospective study. Only CT Scans of children considered to have normal brain development were included in this study while all CT scans of children considered to have cranial diseases or abnormal brain development were excluded. The cranial length (CL) and cranial width (CW) were measured on the axial CT and cranial index calculated as the percentage of cranial width to cranial length multiplied by 100. Mean values of CL, CW and CI, standard deviations and standard error of mean were calculated for both sexes.

For the purpose of this study, the head shape types were analysed based on classification of Standring [1], thus the four categories of skull shape were established: CI < 74.9, dolichocephaly; CI: 75.0–79.9, mesocephaly; CI: 80.0–84.9, brachycephaly; CI: 85.0 or above hyperbrachycephaly.

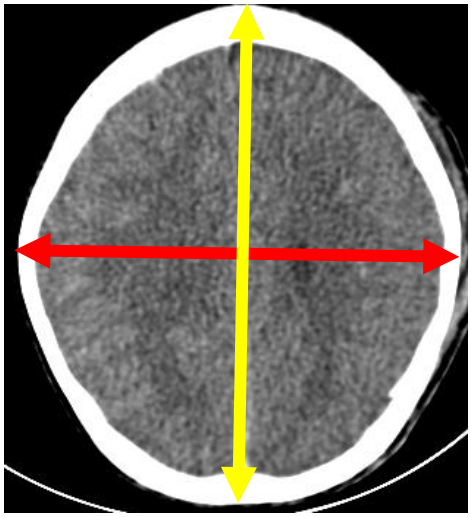

Figure 1. Showing the measurement of cranial length and cranial width on CT scan of a 4-year old boy. NB: Cranial Length (yellow arrow) and Cranial Width (red arrow).

RESULTS

From this present study, the records seen showed the age range of the children to be between 4 and 7 years old with the overall mean age value of 5.5±1.16.

The overall mean values for cranial length was 16.45±1.01, cranial width 13.01±0.94 and CI was 79.12±3.37.

Meanwhile in males, the CL was 16.46±1.07, CW was 12.89±0.93 and CI was 78.35±3.23 while in females the CL, CW and CI mean values were 16.44±0.95, 13.17±0.95 and 80.08±3.34 respectively. Figure 2 below demonstrates these findings.

The observed difference between the mean cranial index of males and females was statistically significant (p = 0.025).

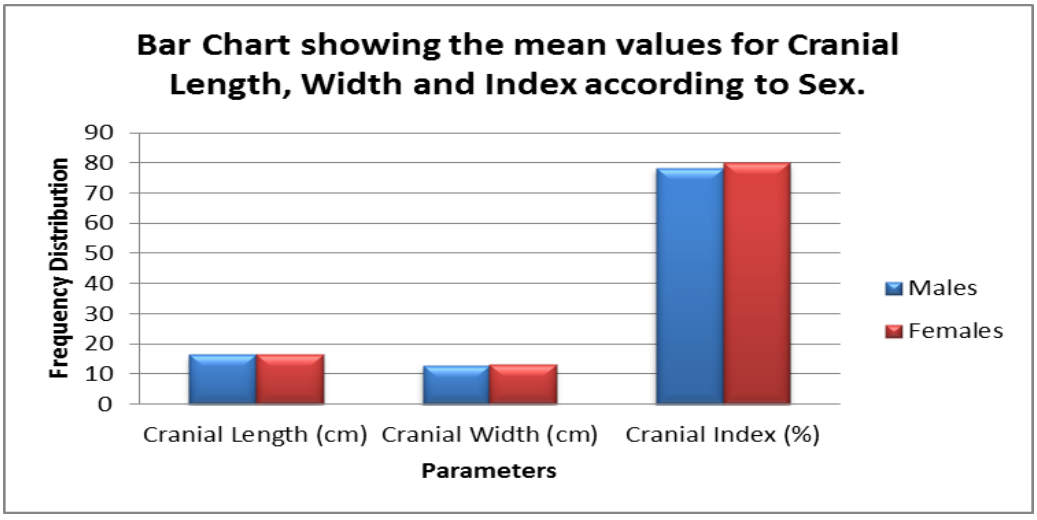

Figure 2. Showing the mean values for Cranial Length, Cranial Width and Cranial index according to Sex.

The head shape types were determined based on the CI values seen in this study. A total of 42 (55.26%) children had mesocephalic head shape, 22 (28.95%) children had brachycephaly, 6 (7.89%) children with dolicocephaly and hyperbrachycephaly also had a frequency of 7.89%.

Moreover, the analysis of head shape in this study according to sexes indicated that the dominating head shape type was mesocephaly in males (36.84%) and brachycephaly in females (19.74%). Hyperbrachycephaly occurred in 3.95% males as well as in females too respectively whereas dolichocephaly was observed in 7.89% of the children with males having 5.26% and females having 2.63% respectively. However, across all the groups, hyperbrachycephaly (7.89%) and dolicocephaly (7.89%) were the least frequently observed category (Figure 3).

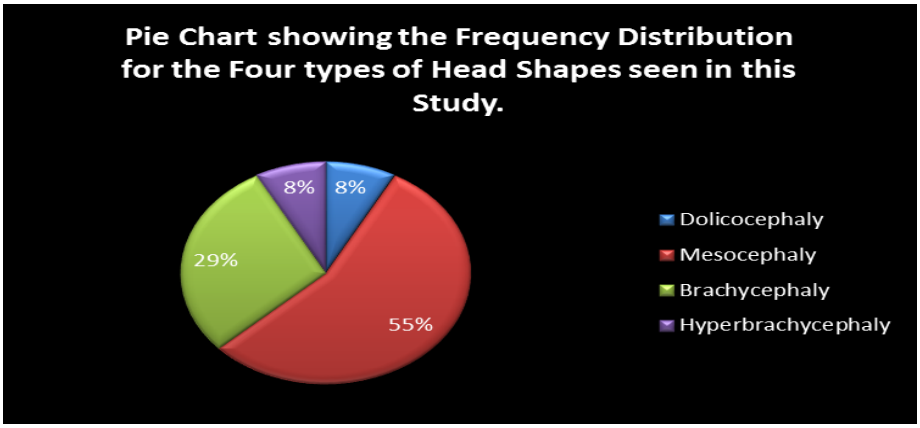

Figure 3. Pie Chart showing the Frequency Distribution of the Four Classification of Head Shapes seen in this study.

DISCUSSION

Reduction of cranial cavity capacity may lead to compression of the normally developing child's brain[11]. The plan of effective treatment in craniosynostoses comprises surgical treatment of skull deformation. For that purpose, the knowledge of skull dimensions of children with normal brain development is indispensable[11]. One of the useful indicators for assessment of child's head shape is the determination of cephalic index, defined as percentage of width to length in any skull [(cephalic width/cephalic length) multipled by 100%][1]. The cephalic index may be determined applying anthropometric methods, dry skull measurements, and radiological methods (measurements on computer tomography scans)[11]. Flattening and asymmetry may have numerous reasons among which could be a combination of genetic and environmental factors[13,14]. The reasons may range from uterine walls compressing fetus head to external reasons that occur after the birth, to which the newborn and infant are particularly exposed. Numerous authors point out that cranial deformations may result from the fact that infants, especially newborns, are invariably arranged in the same position when they are about to sleep[15,16]. Babies call for intensive medical care; premature infants are particularly prone to such changes in skull shape[16]. With minimum differences (measuring error below 5%) in direct measurements of osseous structures of the skull and indirect measurements performed on CT scans of the same skulls, they demonstrated that measurements performed on CT scans are highly

reliable[11]. According to Posnick et al[17], the determination of cephalic index is a quantitatively useful method for comparing skull shape in patients before and after sagittal stenosis surgery[17]. Some studies concerning the determination of cephalic index and assessment of skull shape have been performed on children from other races than Caucasian[12,17,18,19].

Our results show that overall mean value of cranial index for children with normal brain development is 79.12±3.37. This value is lower than what was reported by Likus et al[11], where he reported overall mean value of 81.45±7.06. [11] Also in this present study, the observed difference between the mean values of CI in males (78.35±3.23) and in females (80.08±3.34) was statistically significant. This does not agree with previous studies[11] where no statistical significant difference was observed between sexes. However, the mean CI value in males of the present study (78.35±3.23) is lower than the 82.22±6.87 in males as reported by Likus et al[11], while the 80.08±3.34 reported in females in the present study is slightly lower than 80.54±7.20 reported in females[11]. The difference between the findings in this study and previous study[11] may not be unconnected with the difference in race as well as age range difference among study participants.

Applying the Strandring head shape classification[6], the most frequently occurring type of head shape as per the present study is mesocephaly (55.26%). This also agrees with findings from previous studies where mesocephalic head shape was the most frequently occurring[11,20].

CONCLUSION

Cranial Index (CI) reported in this study showed that most of the children had mesocephalic head shape (55.26%) with dolicocephaly and brachycephaly less common (7.89%). The observed difference between the mean cranial index of males and females was statistically significant (p = 0.025). The report from this study is of importance in the field of pediatric neurology, anthropology as well as genetics and forensic medicine.

Conflict of Interests

None declared by the authors.

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Geliş tarihi/Received on : 01.09.2014
Kabul tarihi/Accepted on: 03.11.2014