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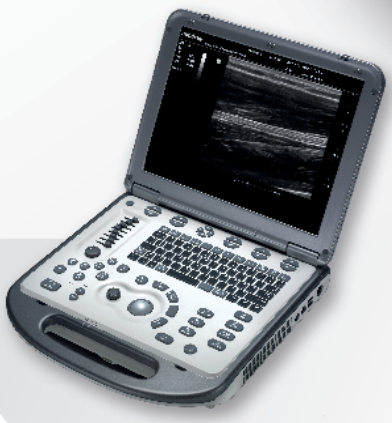

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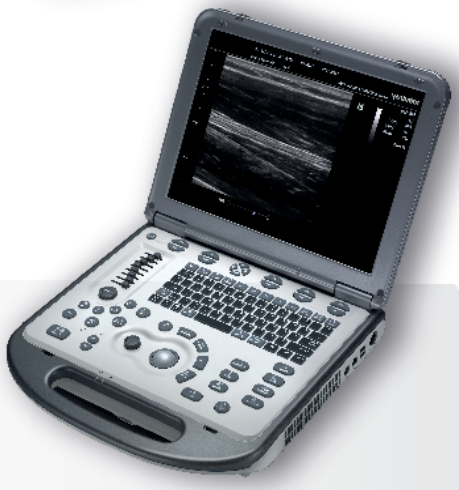

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Skoczkowie polskiej kadry są pod doskonałą opieką profesjonalnego sztabu, który codziennie dba o ich dobrą kondycję i zdrowie. METRUM CRYOFLEX poprzez podpisaną umowę stało się częścią tego medalowego zespołu, a dostarczony przez nich sprzęt pomaga w regeneracji skoczków po obciążających treningach i zawodach, umożliwiając szybki powrót do formy.

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Non-invasive treatment of plagiocephaly with the use of corrective helmets in infants

Nieinwazyjne leczenie plagiocefalii z zastosowaniem korekcyjnych kasków u niemowląt

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Abstract

The use of skull correction is controversial, and treatment recommendations and reporting of results vary. The most commonly observed deformities of the skull are: plagiocephaly, brachycephaly and scaphocephaly. Treatment includes repositioning, physical therapy, and orthotic treatment with an adapted cranial remoulding orthosis (CRO). Positional plagiocephaly should be differentiated from torticollis, which is also one of the main causes of this deformity. Cranial remoulding orthosis yields better and faster results in younger patients, with age the degree of correction slows down with age. CRO is most effective when initiated before the 5th month of age. Apart from positioning therapy, physiotherapy and the use of a CRO shortens the treatment time and improves the results in severe cases of head asymmetry.

Key words:

plagiocephaly, brachycephaly, corrective helmets, infant rehabilitation

Streszczenie

Stosowanie korekcji kształtu czaszki jest kontrowersyjne, a zalecenia dotyczące leczenia i raportowanie wyników są różne. Najczęściej obserwowanymi deformacjami czaszki są: plagiocefalia, brachycefalia oraz skafocefalia. Leczenie obejmuje repozycjonowanie, fizjoterapię oraz leczenie ortotyczne za pomocą dostosowanej ortezy czaszki. Ułożeniową plagiocefalię należy różnicować z torticolis, która także stanowi jedną z głównych przyczyn powstawania tej deformacji. Korekta w kasku następuje najszybciej u młodszych pacjentów, a stopień korekty spowalnia wraz z wiekiem. Kask remodelujący czaszkę jest najskuteczniejszy, gdy zostanie zainicjowany przed 5. miesiącem życia. Fizjoterapia oprócz terapii pozycjonującej oraz stosowanie ortezy czaszki skracają czas leczenia i poprawiają wyniki w ciężkich przypadkach asymetrii głowy.

Słowa kluczowe:

plagiocefalia, brachycefalia, kaski korekcyjne, rehabilitacja niemowląt

Introduction

The nineties of the twentieth century was the time when more attention began to be paid to the shape of the head in newborns. This was closely related to the 1992 "Back to sleep" campaign by the American Academy of Pediatrics (AAP). The aim of the campaign was to reduce the occurrence of sudden infant death syndrome (SIDS) by putting children to sleep in the supine position. By 2000, the incidence of SIDS had decreased by more than 40%, but the incidence of positional plagiocephaly had increased by approximately 600%. As a consequence of the application of the positioning recommendations, the number of children with whom their parents started visiting doctors due to cranial deformities increased [1, 2]. The use of skull correction is controversial, and treatment recommendations and reporting of results vary. Treatment most often includes repositioning, physiotherapy, if indicated, and orthotic treatment with an adapted skull brace [3].

Aim

The aim of the study is to present the basic bone deformities within the skull in newborns and infants and helmet therapy as a modern method of correcting the shape of the skull. The safety of the diagnostic and treatment process is ensured by non-invasive three-dimensional imaging methods, such as direct scanning of the surface of the child's head with the use of optical scanners.

Skull deformations

Deformation refers to an abnormal morphological structure of the skull leading to head asymmetry. In addition, measurement of the circumference and/or the width or the anterior-posterior length is assessed. The causes of deformities can be divided into primary (perinatal) and secondary (postnatal). The risk factors for deformities in fetal life include: genetic syndromes, multiple pregnancy, high fetal weight, small uterus, uterine malformations, forceps delivery, male sex, and metabolic disorders during pregnancy. The risk factors for postpartum deformities include: prematurity, high birth weight, low child activity, muscle tone asymmetry, torticollis, bone mineralization disorders, reduced muscle tone, habitual posture [4]. The most frequently observed cranial deformities are: plagiocephaly, brachycephaly and scaphocephaly. Plagiocephaly - oblique head deformity is a deformity characterized by a flattening of one side of the back of the head, with compensation of the one-sided front bulge. The mechanism underlying the development of positional plagiocephaly is as follows: when part of the skull becomes flat, the infant's head is naturally gravitationally inverted towards the flattening. The degree of flattening gradually increases and the asymmetry of the skull is evenly observed. Ultimately, the skull is shaped like a parallelogram, and the position of the ear, mandible and eye cavity changes, leading to facial asymmetry [2]. Plagiocephaly (Fig. 1) is accompanied by a ventral shift of the ear on the affected side and craniofacial asymmetry, such as the higher position of the eye on the flattened side. Plagiocephaly occurs with a frequency of 1: 300 live births and is 77% of the flattening of the right side.

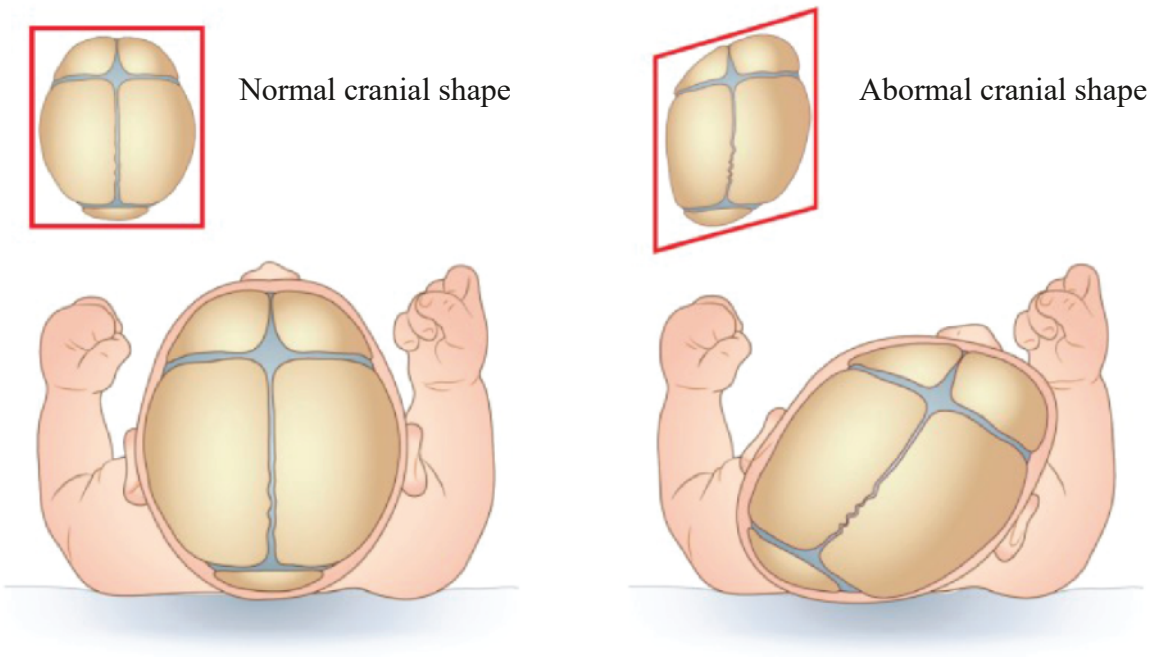


Fig.1. Positional plagiocephaly [2]

The main cause of postpartum plagiocephaly is repeated external pressure on one side of the rapidly growing skull, most often (88%) it is an unchanged position during sleep [5]. Another cause is premature overgrowth of the cephalic suture, which is one of the types of craniosynostosis, this type of plagiocephaly occurs with the frequency of 1: 100,000 live births [6]. Argenta et al. [8] undertook the classification based on clinical features (Fig. 2). The disadvantage of this classification is that the severity of individual abnormalities is not reflected. This makes it difficult to assess their course.
There are five features that characterize plagiocephaly: unilateral

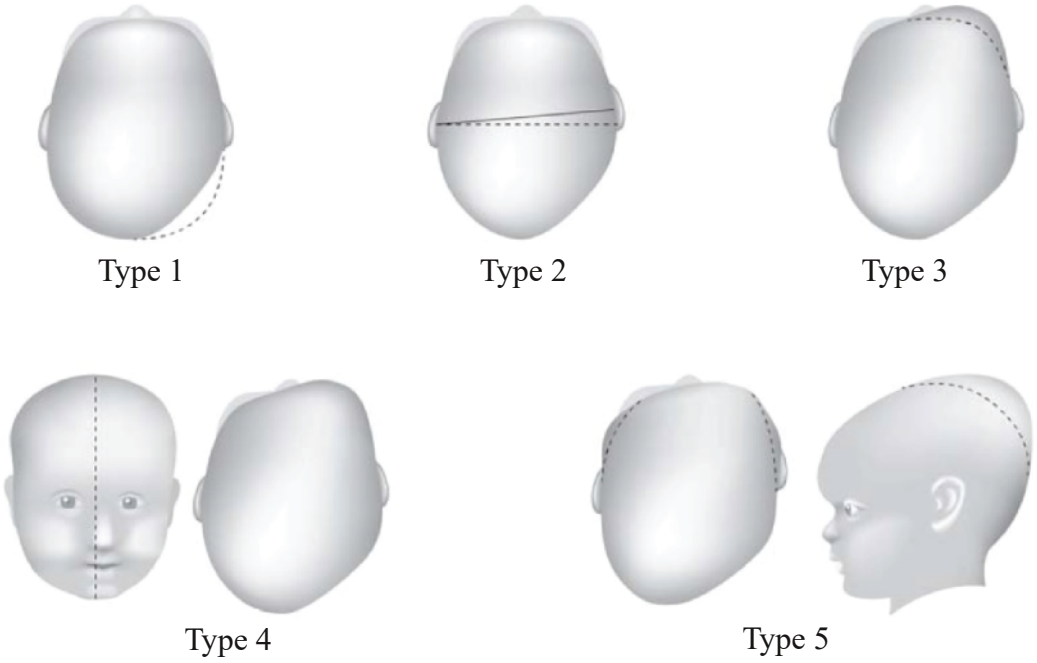


Fig. 2. Types of plagiocephaly [7] (according to Argenta [8])

flattening of the occiput, forward shift of the ear, forehead prominence on the side as the flattening, facial asymmetry, compensatory temporal prominence or vertical growth of the occiput [7]. Positional plagiocephaly should be differentiated from torticollis, which is also one of the main causes of this deformity. Torticollis is a congenital muscular dystrophy that causes fibrosis through abnormal blood supply to the muscle. The shortened muscle places the child's head in a forced position, resulting in a one-sided flattening of the back of the head and a compensatory bulging of the forehead. Brachycephaly (Fig. 3), the second most common deformity, is also known as short head deformity.
It is characterized by a flattening of the occipital part of the skull, i.e.

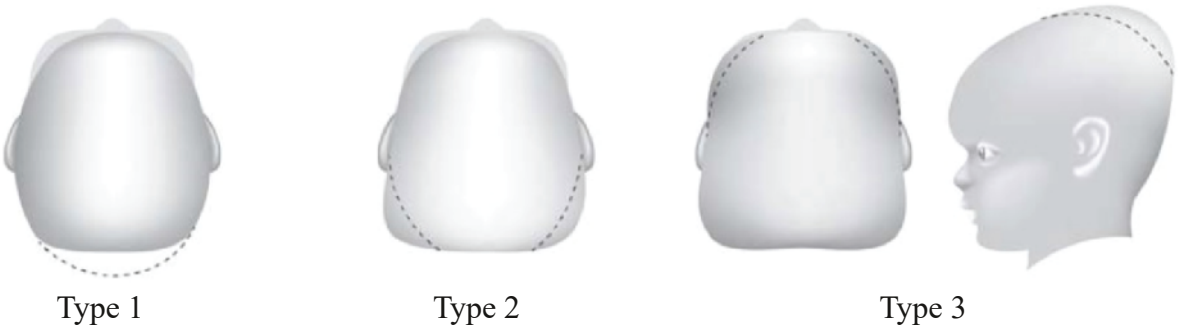


Fig. 3. Brachycephaly [7] (according to Argenta [8]). Characteristic: flattening of the entire occiput, enlargement of the occiput, compensatory widening of temporal or vertical occipital growth

a shortening of the anterior-posterior dimension (AP) and a compensatory expansion of the lateral dimension (ML). Common for brachycephaly is also the so-called "Top of the head" means the elevation of the cranial vault in the posterior part [9]. The third deformity is the scaphocephaly (Fig. 4), known as the narrow head. Scaphocephaly is characterized by a lateral flattening of the head, which consequently becomes longer and narrower. Compensatory changes in the structure of the skull consist in emphasizing the frontal and occipital areas. Scaphocephaly occurs with a frequency of 1: 2000 live births and is three times more common in boys. The main cause is premature overgrowth of the sagittal suture, which is one of the types of craniosynostosis. Another cause is that the baby's head becomes wedged under the mother's ribs during fetal life [10].
Cranial deformity is commonly considered a cosmetic defect,

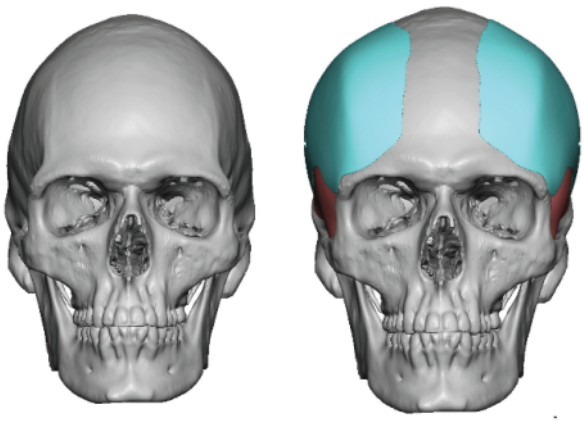


Fig. 4. Scaphocephaly including frontotemporal implant (source: https://skullreshaping.com/temporal-skull-surgery/)

but it can have psychosocial consequences for the developing child. The head in human development is an important element of social interactions. A patient with congenital or acquired facial differences or asymmetries may have problems establishing contacts with peers, fearing criticism, is at risk of greater psychosocial problems [11]. In everyday activities, failure to correct the deformation may lead to difficulties in fitting corrective glasses or sunglasses, e.g. due to craniofacial asymmetry or ear position asymmetry. The problem may be the adjustment of a protective helmet to a motorcycle, bicycle or snowboard, or the purchase of a cap due to excessive rotation or falling on one side of the skull [12]. In addition to the cosmetic aspects, there are also medical consequences. Asymmetry and disturbed biomechanics of the skull affect the bite, for example, vision may be impaired in the functioning of the muscles moving the eyeball – astigmatism [13].

Diagnostic evaluation

Deformation measurements can be made using the following methods: invasive (X-ray, CT, MRI) and non-invasive (3D scan of the head surface). Due to the need to repeat measurements, the methods of choice are non-invasive methods with an indication of a 3D scan. An additional ultrasound scan of the skull may be performed to check the degree of fusion of the skull sutures. Non-invasive methods are based on the measurements of angles and distances between individual bone points measured on digital photo printouts or in computer programs using a scanned child's head. Based on the measurements, calculations of parameters specific to a given deformation are performed. The length, width and diagonal dimensions of the skull are determined and the values of the cranial vault asymmetry index (CVAI) and the cranial index (CI) are calculated. The CVAI is used to assess the symmetry of the baby's head. It is calculated by dividing the difference between the long diagonal and the shorter diagonal by the longer diagonal and multiplying the result by 100 to obtain the percentage. For this purpose, two diagonals are used, which are inclined on both sides at an angle of 30° to the median sagittal plane (Fig. 5).

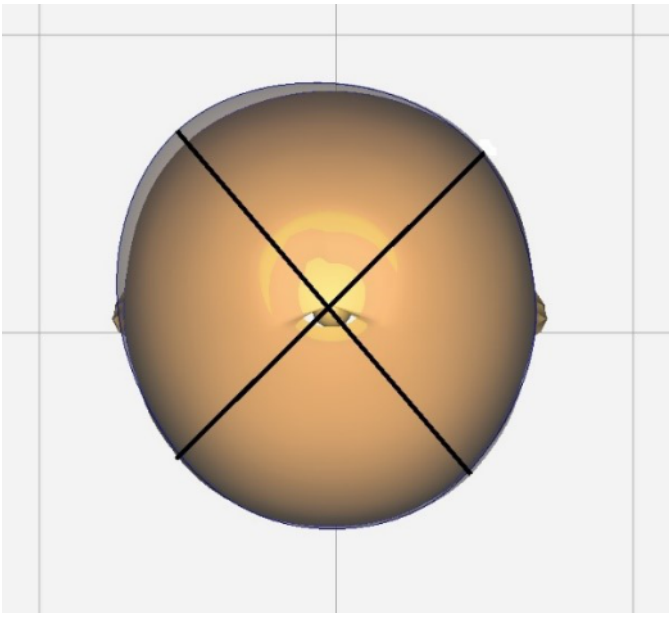


Fig. 5 Cranial vault asymmetry index (CVAI)

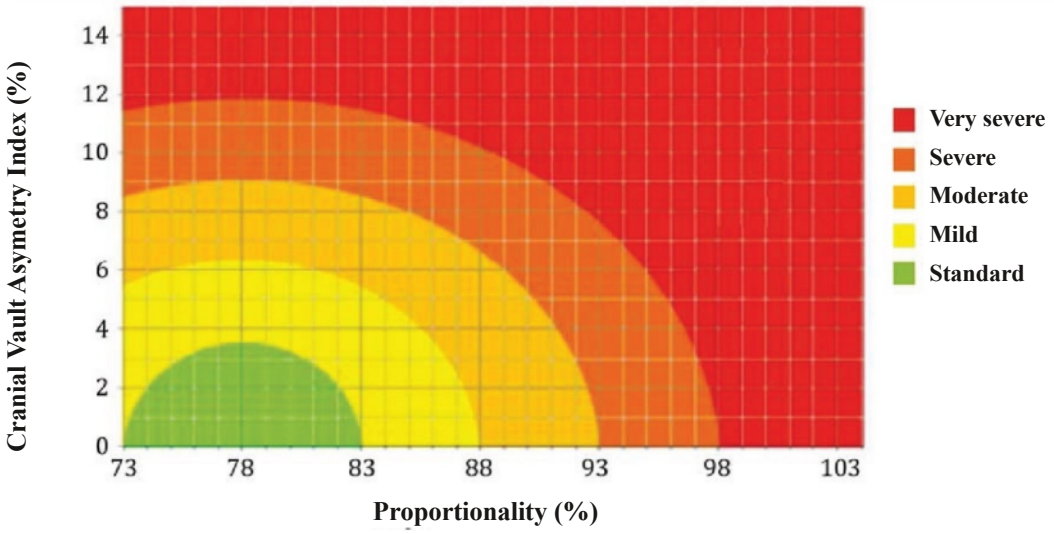
CVAI lower than 3.5% indicates normal cranial shape.

$$CVAI = \frac{\text{Long diagonal} - \text{Short diagonal}}{\text{Long diagonal}} \times 100$$

The cranial index is used to assess the proportionality of the head. Normally, the CI is within 78 ± 5%.

$$CI = ML/AP \times 100$$

where ML is maximum cranial breadth and AP is maximum cranial length. The analysis of the values of both indices allows to determine the type and severity of the distortion. Distortions (Fig. 6) are divided into: mild, moderate, severe and very severe [14].



Symmetrical positional brachycephaly – characterized by a symmetrical flattening of the occipital part of the skull, with a symmetrical frontal part. Pathology is characterized by an increase in the CI value and normal CVAI values. It is therefore a defect in the proportion of the skull. Positional plagiocephaly - is characterized by unilateral flattening of the occipital part of the skull, often with compensatory unilateral bulging of the frontal part, asymmetry of the position of the auricles and unilateral displacement of the ear and part of the face forward. The head is usually in the shape of a parallelogram. Pathology is characterized by abnormal CVAI values and normal CI values. It is therefore a defect in the symmetry of the skull. Positional dolichocephaly – characterized by lateral flattening and decreased CI values. It rarely occurs as a positional anomaly, more often it is seen as a sign of premature overgrowth of the sagittal suture. Positional asymmetric brachycephaly - this is the coexistence of positional plagiocephaly with brachycephaly. It is characterized by asymmetrical occipital flattening, unilateral bulging of the frontal part, asymmetrical position of the auricles and asymmetry of the face. It is characterized by increased CI and abnormal CVAI. It is therefore a defect of the symmetry and proportionality of the skull [14].

Differential diagnostic assessment

For the purposes of the differential diagnosis, it is necessary to distinguish between postural deformities of the skull and premature fusion of the cranial sutures – craniosynostosis. Craniosynostosis is a congenital defect in which one or more sutures of the skull grow prematurely. It leads to dysmorphic bone development and an increase in intracranial pressure. It occurs with a frequency of 1: 2,200 live births and is more common in boys [5, 10]. Craniosynostosis is an isolated defect or one of the features of various genetic syndromes (Aperta, Crauzona, Seathre-Chotzen). It is inherited in an autosomal dominant and recessive manner (15). Treatment of craniosynostosis is aimed at releasing the adhesives seams, preventing craniofacial deformities and restoring normal intracranial pressure [16]. The release of the stitches means a surgical intervention, and the duration of the operation depends on the age of the child at which the diagnosis is made. The best results are observed with treatments carried out at the age of 4-8 months. Surgical treatment is very effective for plagiocephaly with craniosynostosis, and various surgical methods are available. Currently, minor craniosynostosis can be operated endoscopically [17]. The advent of endoscopic synostectomy made early surgery possible in infants with craniosynostosis. Although diagnosis is often made at birth, endoscopic synostectomy is traditionally postponed until 3 months of age. There have been very few reports of this procedure being performed in the early neonatal period. Preliminary data suggest that early synostectomy before 8 weeks of age is safe and is not associated with increased complications compared to surgery performed between 3rd and 6th month of age. Helmet treatment after surgery such as craniotomy is beneficial. The use of a helmet after surgery does not limit the growth of the skull and shows excellent functional and cosmetic results in remodeling its shape. Postoperative helmet treatment can help the skull and brain develop properly. The mean duration of treatment is 6–12 months, and treatment is generally continued until the age of 12–18 months [2, 18].

Treatment of skull deformation

Regardless of the shape of an infant's skull, the general care recommendations are the same for all babies. These are cost-effective and effective measures that include educating and instructing parents on how to arrange their child: avoiding the favorite side, supporting the less favorite side, putting babies on their stomachs and observing (measuring the resting time), preventing sudden infant death [7]. In the first place, conservative treatment with the use of reposition is used to relieve persistent external forces in the affected area along with physiotherapy for the treatment of torticollis. It is recommended to lay the child on both sides or on the side not affected by the problem. Do not use pillows as a positioning aid. Existing mobility restrictions are eliminated – possible therapeutic approaches according to Bobath or Vojta. Physiotherapy should be started as early as possible, under 6 months of age. If the parameters of asymmetry have not improved after 4 months of therapy, it is recommended to start helmet therapy. Early initiation of treatment improves results. Moreover, immediate helmet therapy is recommended if the child

is over 7 months of age and there is a strong asymmetry of the head at the same time [3, 7].

Correction through helmet therapy

Correction as a result of applying helmet therapy occurs most quickly in younger patients, and the degree of correction slows down with age. This is for a number of reasons. Reconstruction of the shape of the skull is possible due to the dynamic growth of the brain in the first months of a child's life. It is estimated that the brain grows to about 200% of its original size at 6 months of age, and then only grows by an additional 50% over the next 24 months, reaching about 70% of the size of an adult brain at 24 months of age. Additionally, the progress in correcting the shape of the skull depends on the thickness of the bones. As the cranial bone thickens with age, the contouring process takes longer to correct the asymmetry of the skull [18]. Compared to positioning prophylaxis and physiotherapy, cranial orthoses reduce existing deformities more efficiently and faster. Correction in the helmet is based on a very precise adhesion of the soft skeleton in the compensatory convex places and the places developing the board, while ensuring free space in flattened places (Fig. 7). The snug fit of the helmet exerts a slight pressure (gravitational component) on the compensating ridges, thus slowing their growth. The simultaneous provision of space to flattened bones enables free and physiological bone growth according to a genetic pattern.

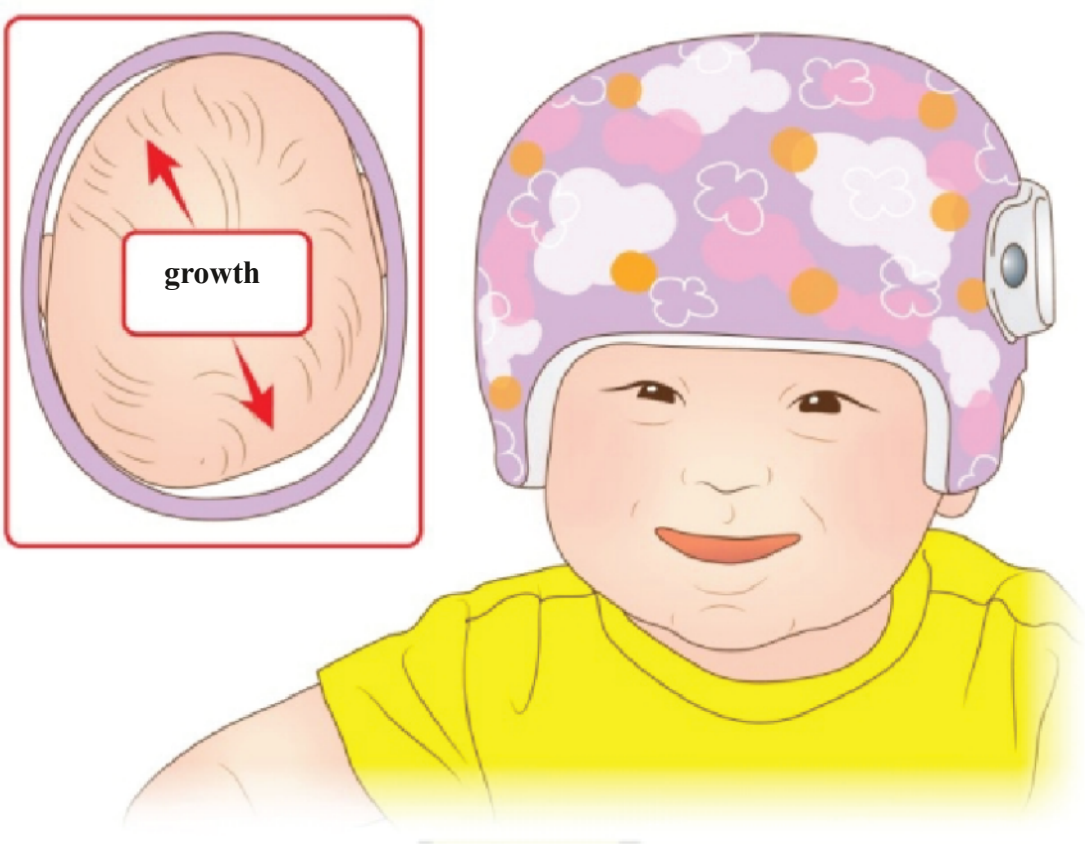


Fig. 7 Cross section of the helmet

Indications: Therapy can be started until the end of the first year of life, although such a late start of treatment may hinder therapeutic success. Considering the growth dynamics, previously untreated infants after 7 months of age with CVA > 12 mm or clearly visible deformation should be treated immediately with a cranial orthosis [19, 20]. Contraindications: The most important of these is the diagnosis or not of craniosynostosis. Another factor excluding/delaying the commencement of correction is insufficient strength of the muscles of the head and neck to support the head independently and reliably. This means that you are not ready to accept even a small axial load such as a helmet. The therapy is not introduced in children with untreated osteogenesis imperfecta due to the too high risk of damage to the limbs and spine when putting on and taking off the helmet. An important contraindication is purulent skin diseases and allergies to the materials used in the production of the helmet. Corrective glasses, hearing aids or hearing implants are not a contraindication to the use of a helmet. Side effects: The most persistent complications are pressure, abrasions, drooping and sliding of the helmet, and uncontrolled growth of the head through holes in the upper and ear parts of the helmet [21]. The image of the patient's head is acquired using the eye-safe optical scanner (Fig. 8) for diagnostic purposes and to create a head model.

Fig. 8. Direct scanning (source: rodin4d.com)

The helmet is designed in such a way that it covers the entire head. In some cases, half-open or open helmets are used at the top of the head. The helmet is made of hypoallergenic high-density medical foam. It has direct contact with the patient's body. The outer, hard shell of the helmet can be made of thermoplastic materials by vacuum forming, injection methods or using modern incremental methods, commonly known as 3D printing. The slit enabling the putting on and taking off the helmet is usually located on the side and runs from the top of the

head and ends in the recess above the ear. The opening is blocked with one Velcro strap or a specially designed buckle. Function is the most important role of the orthosis, but the appearance and aesthetics of the equipment as well as the comfort of use are also important. Getting used to the helmet and normalization of initial sweating is an individual factor and usually takes about 1-3 weeks. Ventilation openings are also useful during inspections, where they determine the free space or the degree of pressure. The task of the orthosis, apart from correction, is the possibility of its modification with the growth of the head, which will allow the use of one helmet during the entire therapy, because the National Health Fund in Poland does not refund the costs of helmet therapy. For parents of a child with a deformed head shape, it costs PLN 6000,00– 8000,00.

Summary

The cranial remoulding helmet is most effective when initiated before 5 months of age. Apart from positioning therapy, physiotherapy and the use of a skull brace shorten the treatment time and improve the results in severe cases of head asymmetry. Children less than 6 months of age with a CVA < 10 mm should initially be treated only with positional therapy and physical therapy. Treatment with cranial orthosis is very effective, but should be reserved for patients who are refractory to conventional physiotherapy and in cases of severe deformities or those diagnosed late [19, 20].

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