STARBAND CLINICAL CONNECTIONS

Deformational Dolichocephaly: Uncommon or Underdiagnosed?

INTRODUCTION AND OVERVIEW

The dolichocephalic skull is disproportionately long relative to the width. Dolichocephaly and scaphocephaly are used interchangeably in the medical literature although each present with unique and distinct clinical features. Specifically, dolichocephaly describes a long narrow head shape secondary to deformational molding while scaphocephaly describes a long narrow head shape associated with sagittal suture craniosynostosis. A simple mnemonic to keep the terminology consistent is to think of **d**eformational **d**olichocephaly and **s**ynostotic **s**caphocephaly. The purpose of this paper is to discuss the conditions that exist in the preterm population that require close monitoring of cranial head shape and growth throughout the first year after birth. This aids the medical team with the early identification, prevention, and/or treatment of skull deformities in this high-risk patient population.

PATHOGENESIS

Infant sleep position, sustained positioning, and the overall malleability of the infant skull affects head shape development in the first few months after birth. Most infants sleep 14–17 hours per day for the first three months, potentially creating 1200–1500 hours of sustained head positioning. Dolichocephaly is a common finding in premature infants, especially in those born less than 32 weeks of gestational age. Prone and side lying are the position of choice in NICU to support respiratory function with full-time monitoring of their condition (Figure 1). Premature infants are susceptible to dolichocephalic head molding as their cranial structures are even softer and more flexible than the heads of full-term infants. It should also be noted that breech positioning, with or without cesarean delivery, has also been associated with dolichocephalic head shapes.

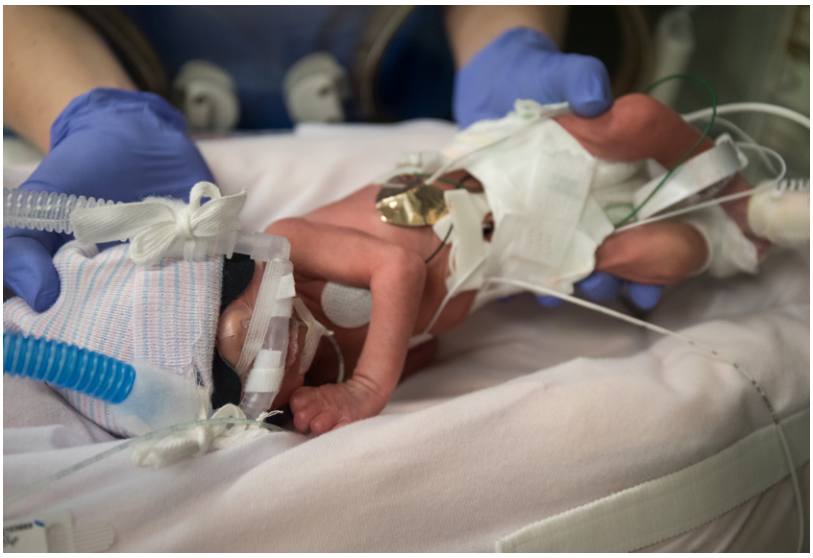


Figure 1. NICU care of premature infants with associated medical complications.

Despite the diligent work of the NICU staff to reposition the infants every 2–3 hours to prevent sore spots and negative cranial molding, this elongated head deformity is sometimes referred to as “NICUcephaly” (Figure 2). Still, it should be noted that

preventive care measures implemented in NICUs have likely decreased the number of infants acquiring severe forms of this head deformity prior to discharge. Other factors related to the development of the dolichocephalic deformity in premature infants may include but are not limited to:

- Delayed cervical muscle development and head control,
- Greater susceptibility to postnatal molding with increased proportion of collagen of the neonatal cranial structures,
- Mechanical disadvantage of weak neck muscles, further disadvantaged once elongation of the head shape begins,
- May be exacerbated by continuous positive airway pressure (CPAP) devices needed in the NICU,
- Impacts achievement of midline positioning of the head due to posterior occipital bossing, and
- Generalized hypotonia with greater gravity-dependent posture(s) creates localized pressures to the skull.

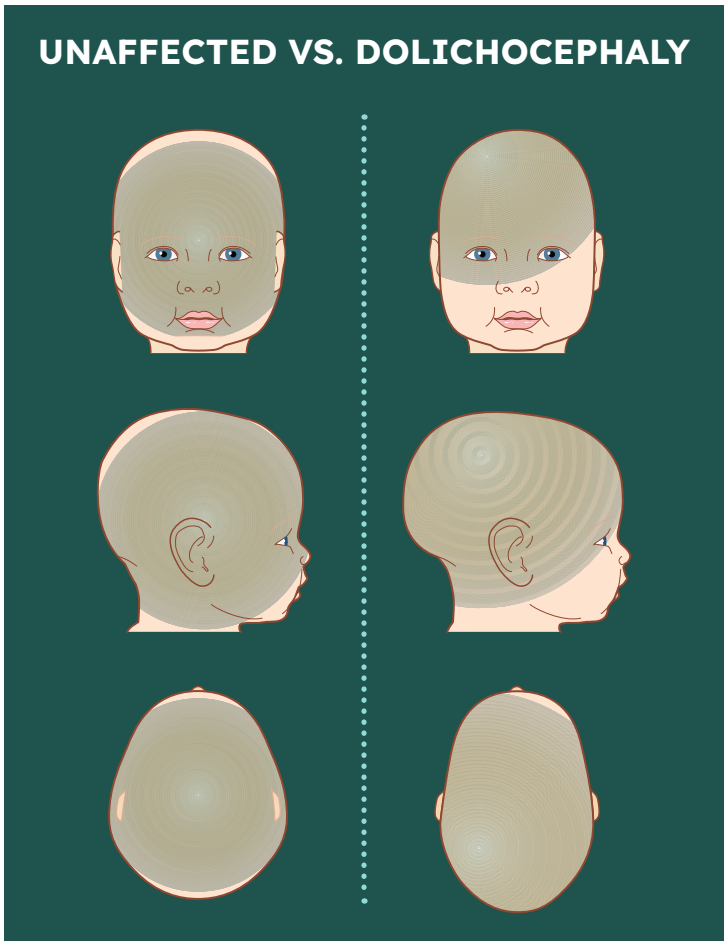


Figure 2. Compare the general features of the unaffected (left column) and dolichocephalic (right column) head shapes.

Currently, there is no standard of care for preventing or addressing dolichocephaly and other head shape deformities in the NICU. Premature infants have an elevated risk for deformational dolichocephaly due to limited mobility, sustained positioning, and inadequate bone mineralization. As infants become stable enough for discharge, the Back to Sleep program is recommended to parents. Unfortunately, a dolichocephalic head shape will make it difficult to position the head in any other manner than fully turned to the right or left. As parents are challenged with the care of this high-risk and fragile infant, the continued disproportion of the head shape may go unnoticed and the degree of dolichocephaly progresses.

Currently, there is no standard of care for preventing or addressing dolichocephaly and other head shape deformities in the NICU.

GESTATIONAL AGE

Newborns are classified into three groups of gestational age based on their stage of intrauterine development. These groups are:

1. **Pre-term —** Born before 37 weeks / 258 days of gestation
    - > **Moderate to late pre-term —** 32 to 36 weeks of gestation
    - > **Very pre-term —** 28 to 32 weeks of gestation
    - > **Extremely pre-term —** less than 28 weeks of gestation
2. **Full-term —** Born between 37 and 42 weeks / 259 to 293 days of gestation
3. **Post-term —** Born after 42 weeks / 294 days of gestation

Ifflaender et al. (2013) found that very preterm infants were at a higher risk of developing head deformities than late preterm infants. The most common deformational head shape found in this study was dolichocephaly followed by plagiocephaly, while brachycephaly was an uncommon finding in very preterm infants.

ADJUSTED OR CORRECTED AGE

Another consideration when working with premature infants is adjusted or corrected age. This is calculated by subtracting the number of weeks preterm from the number of weeks since birth. To determine the number of weeks preterm the baby was at birth, subtract the gestational age in weeks from 40 weeks. For example, if the baby was born at 32 weeks, then they were 8 weeks premature (i.e., 40 weeks – 32 weeks = 8 weeks) The 8 weeks of premature status is then subtracted from the chronological age since birth. Refer to examples in Table 1.

Patient Example	Age in Weeks Since Birth (Chronological Age)	Full-Term Pregnancy	Gestational Age	Weeks Preterm	Adjusted or Corrected Age
#1	16 weeks (4 months)	40 weeks	32 weeks	8 weeks	8 weeks or 2 months
#2	26 weeks (6 ½ months)	40 weeks	30 weeks	10 weeks	16 weeks or 4 months

Table 1. Calculating corrected age for preterm infants.

The significance of adjusted or corrected age relates to the continued repositioning and therapy efforts, along with CRO considerations and recommendations. The date of birth for patient #1 above reports the infant being four (4) months of age at initial evaluation. However, considering the 8 weeks of prematurity, the infant's corrected age is two months. This would indicate that repositioning and/or therapy would be the best course of treatment over the next 2 months or perhaps even longer. It would not be recommended to proceed with CRO treatment at this time

for this patient. The date of birth for patient #2 reports the infant being 6 ½ months of age. The 10-week preterm birth creates an adjusted or corrected age of 4 months. In this situation, an infant with a moderate head deformity may best benefit from continued repositioning and therapy, with another orthotic evaluation in 1–2 months. However, if this same patient presents with a severe head deformity, CRO treatment may be recommended immediately. As shown here, the strict use of chronological age may create the overutilization of CROs for some premature infants who would further benefit from continued repositioning and therapy prior to consideration of a CRO treatment program.

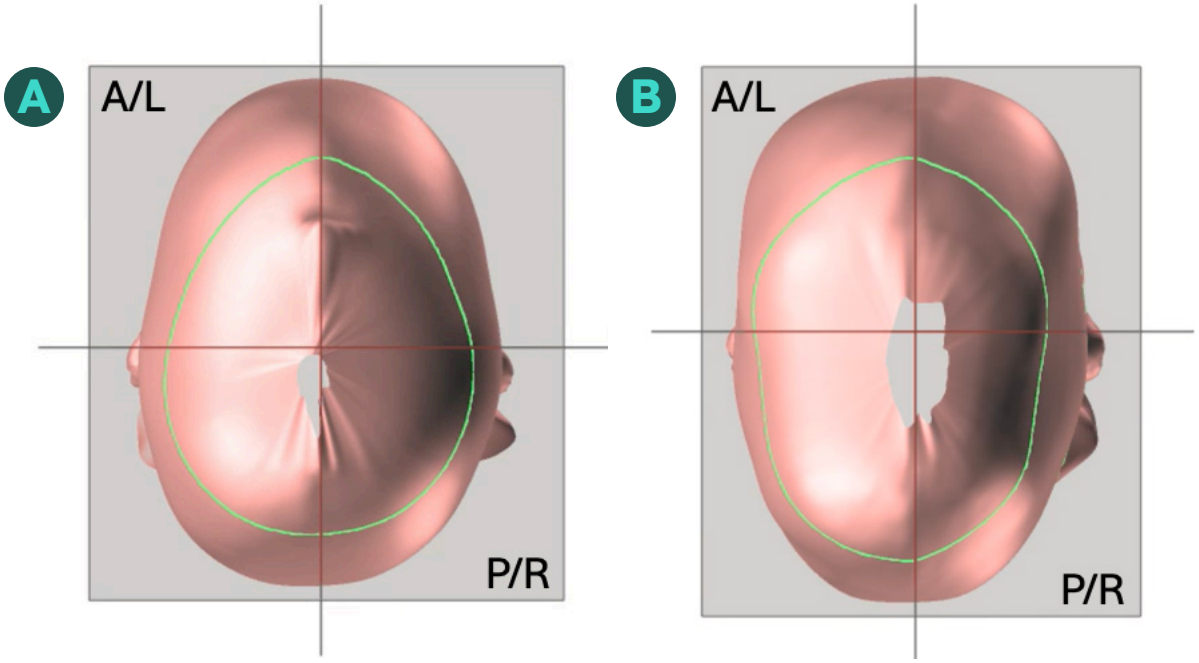
Provisional National Center for Health Statistics data suggests approximately 531,432 births in 2023 with preterm births affecting about 1 in every 10 births. A very high percentage of very preterm (< 32 weeks) and late preterm (32 to 36 weeks) infants are identified with moderate to severe dolichocephaly at term equivalent ages, 73% and 28% respectively in one study (Ifflaender et al. 2013). This suggests that a significant percentage of the annual premature births may have head shape anomalies that would benefit from ongoing repositioning efforts, clinical monitoring, early intervention of therapy, and/or a CRO.

PATIENT EVALUATION

Gathering important medical history and completing a thorough patient evaluation is needed for patients presenting with head shape deformities. Specific risk factors for dolichocephaly include but are not limited to prematurity, decreased cervical muscle development, hypotonia, low birthweight, increased length of time requiring respiratory support, and frequent and sustained prone and side-lying positions. Side-lying positions are important to help to reduce reflux, apnea, and bradycardia in this fragile patient population. Dolichocephaly has been associated with other medical challenges such as the acquisition of other head shape deformities (e.g., plagiocephaly), motor asymmetries, delayed reaching skills, decreased midline control, myopia, reduced flexibility in scapular retractors, tightness of spinal extensors, and shifts in cortical structures in the brain. It is important to note that the identification of dolichocephaly in preterm infants is correlated with higher rates of physical therapy referrals in the first 3-4 months after birth. Gathering this information from caregivers is important to understand the entire patient profile.

The baby's head will be evaluated with observation of head shape and alignment, overall posture, and palpation of sutures and fontanelles. The steps below are specific to dolichocephaly but can be adapted and generalized to other head shape involvements.

1. Observe the infant's overall posture in various positions (e.g., supine, prone and supported sitting) and note preferential head tilt and/or turning.
2. Observe the vertex view of infant's head noting general asymmetry and/or disproportion, ear position, and overall head shape.
    - Figures 3A and B compare the clinically observable features of deformational dolichocephaly to synostotic scaphocephaly.
    - Table 2 provides further details.
3. Observe and note any "bald spots" and/or neck folds that may suggest preferential positioning of the head.
4. Observe infant's active neck range of motion in various positions by moving a visually interesting object from side to side.
    - This can be evaluated during both supine and upright sitting positions.
5. Assess the infant's passive neck range of motion by gently rotating the head from side to side, up and down, and tilting the head to the right and left in various positions.
6. Palpate the sagittal suture, as well as the anterior and posterior fontanelles.
    - The width of the sagittal suture is about 5 mm at birth and narrows to half that width by 1 month of age.
    - The anterior fontanelle may begin to close between 9 and 24 months of age.
    - The posterior fontanelle may begin to close as early as 2 to 3 months of age.
    - Any full or partial ridging of the sagittal suture may indicate craniosynostosis and referral to a craniofacial team is required.



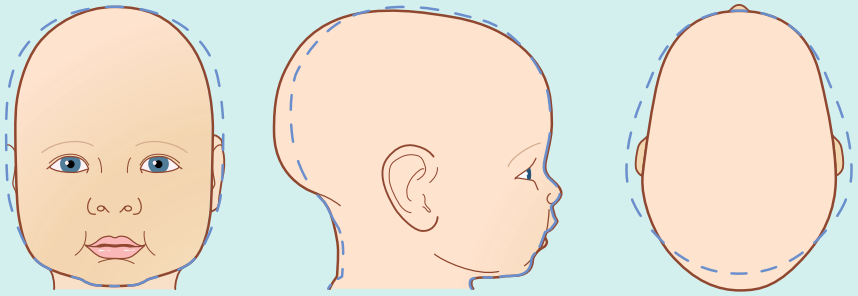
DEFORMATIONAL DOLICHOCEPHALY

SYNOSTOTIC SCAPHOCEPHALY

Figures 3A and B. General clinical features of deformational dolichocephaly and synostotic scaphocephaly.

DEFORMATIONAL DOLICHOCEPHALY

- Common in premature infants — up to 75% reported at initial hospital discharge
- **Least common deformational** head shape
- **CRO** for moderate to severe deformational head shapes resistant to early repositioning efforts



Long, narrow head shape

Minimal frontal bossing

Prominent occipital area

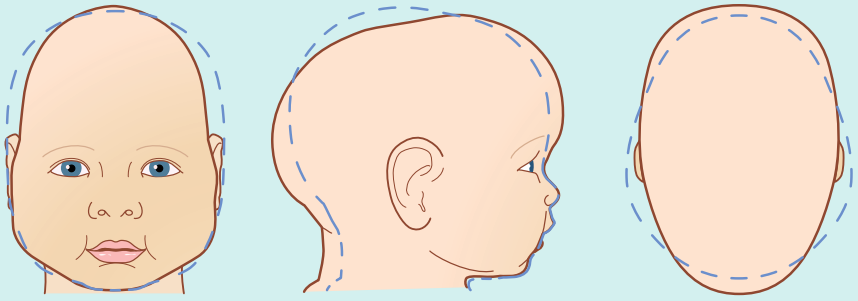
"Loaf of bread" or elongated

No sagittal suture ridging

Biparietal narrowing

SYNOSTOTIC SCAPHOCEPHALY

- Preterm delivery has been associated with sagittal and metopic craniosynostosis
- **Most common craniosynostotic** head shape — 40% to 55% of nonsyndromic cases
- Surgical intervention with **post-operative CRO** treatment programs



Long, narrow head shape

Bitemporal pinching

Significant frontal bossing

Significant occipital bossing (a.k.a., occipital bullet)

"Boat shaped" or keel shaped—wider anteriorly and narrower posteriorly

Sagittal suture ridging

Biparietal occipital/ parietal narrowing posterior to the anterior fontanelle

Table 2. Detailed comparison of deformational dolichocephaly and synostotic scaphocephaly. (Note that blue dotted line refers to normocephaly.)

INDICATIONS FOR REFERRALS TO CRANIOFACIAL SPECIALISTS

Most, if not all, infants experience fetal head molding during the birth process, and it occurs with both vaginal and cesarean deliveries. The infant skull is ideally designed to conform to the forces encountered in the birth canal and then become a more

rigid form to protect the brain. This process is referred to as configuration and may be a physiological or pathological process. After the forces of delivery are removed, there is a natural resolution of the skull shape that is referred to as reconfiguration. The initial reconfiguration is significant in the first week with a gradual and continued reconfiguration occurring over the next six to eight weeks.

The skull bones of the premature fetus are less ossified at the margins of the bony plates and the sutures are wider than those found in term infants. As a result, the interlocking mechanism of the skull plates is less effective in creating a rigid structure to protect the brain during delivery and resist deforming forces immediately after birth. It has been reported that the prevalence of deformational dolichocephaly remains high in preterm up to 6 months of corrected age. With an elevated risk of deformation and the poor predictability of reconfiguration and repositioning efforts in premature infants, consistent monitoring of head shapes of preterm infants should be a routine part of follow-up care programs.

HISTORY OF THE CEPHALIC RATIO (CR), CEPHALIC INDEX (CI), AND CRANIAL INDEX (CI)

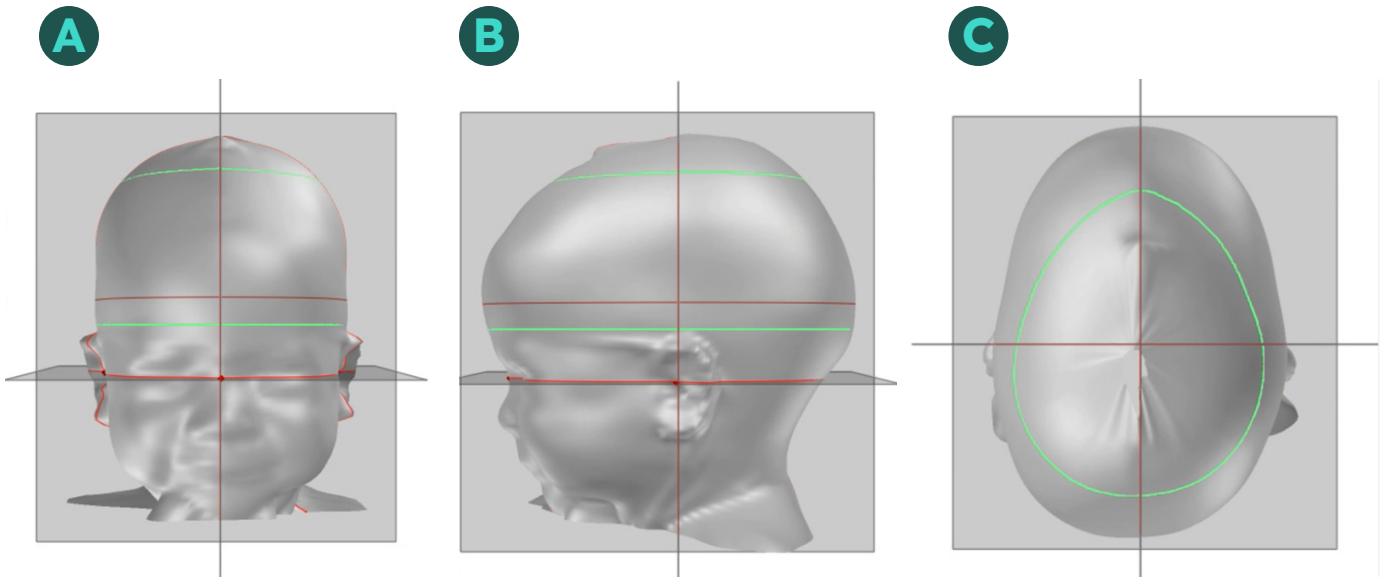
The most common anthropometric measurement used to document skull proportion and disproportion is the cephalic ratio (CR). This may also be referred to as the cephalic index (CI) for live subjects and cranial index (CI) for dry skulls. Anders Retzius is credited with proposing the CI in 1842, noting it as the ratio between cranial width and cranial length. Retzius arbitrarily defined dolichocephaly (long-headed) and brachycephaly (short-headed) from this calculation (Table 3). It is important to note that dolichocephaly and brachycephaly are descriptive terms of skull morphology and not dysmorphology. For cranial remolding programs it is the magnitude of the disproportion that denotes deformation, and there is general agreement in the medical literature that defines dolichocephaly as a CR of 76% or less.

Anders Retzius (1842)	**Cephalic index = (cranial width / cranial length) x 100%**	• **Dolichocephalic** (or long-headed) with a cranial index of 75% or less • **Brachycephalic** (or short-headed) with a cranial index above 75%

Table 3. Cephalic index introduced by Retzius in 1842 and associated head shape classification.

Various publications and research teams further defined the head alignment, anatomical landmarks, and severity for the classification of different head shapes. For the purposes of this document, the baseline alignment of the head is established by a plane determined by the sellion and right and left tragion — referred to as the sellion-tragion alignment and reference or Star plane (Figures 4A–C). The head is then divided into 10 equidistant

cross-sections from this reference plane to the vertex. Many two-dimensional (2D) measurements are obtained at Level 3, with default reporting of the greatest cranial width and greatest cranial length at that level. For more accurate representation of the magnitude of the disproportion, clinicians may also evaluate cranial width and cranial length measurements at Levels 2, 4 and 5 as indicated by the individual presentation. In some cases, the greatest width and length are found at different levels and should be accounted for as such in the CR calculation. Accurate scan alignment and measurement of the CR will be discussed in more detail.



Figures 4A–C. Star plane and deformational dolichocephaly: (A) anterior view, (B) lateral view, and (C) vertex view.

ANTHROPOMETRIC DATA

Initial measurements are obtained to document the current head shape and used for (1) comparison of progression or improvement of the deformity if monitoring the condition, and (2) for comparison with CRO treatment to support clinical outcomes. Consistent head alignment is needed for both manual and scanned measurements but differences in these two measurement methods may produce slightly different results. For example, many clinicians use a more “neutral” or Frankfurt horizontal plane alignment for manual measurements and the Star plane alignment for scanned images. Both methods hold significant clinical value but should not be directly compared as the findings may be quite different depending on the head shape. Table 4 outlines the manual and Starscanner measurements most often collected to assess deformational head shapes.

Manual measurements at equator	Starscanner measurements at selected level(s)
• Circumference	• Circumference

Manual measurements for disproportion	Starscanner measurements for disproportion
• Cranial width • Cranial length • Cephalic ratio (CR)	• Cranial width • Cranial length • Cephalic ratio (CR)

Manual measurements for asymmetry	Starscanner measurements for asymmetry
• Transcranial diagonal difference (TDD)	• Arc lengths • Cranial vault asymmetry at 30° (CVA) • Cranial vault asymmetry index (CVAI) • Radial symmetry index (RSI) • Oblique cranial maximum • Oblique cranial minimum

Manual measurements for volume disruptions	Starscanner measurements for volume disruptions
	• Anterior symmetry ratio • Overall symmetry ratio • Posterior symmetry ratio • Quadrant volumes • Vertex height

Table 4. Common manual and Starscanner anthropometric measurements used to document disproportion, asymmetry, and volume disruptions.

For manual caliper methods, cranial width is measured from the most projecting points above and behind the ears, known as the biparietal eminences. The eurion is poorly defined in the medical literature, is challenging to consistently locate on an unaffected head, and even more so on an affected infant head. Displaced eurion have been noted in many disproportional head shapes such as severe deformational brachycephaly and dolichocephaly, as well as synostotic scaphocephaly. Manually measuring the greatest width with a consistent head alignment allows the clinician to monitor growth in this dimension as changes occur in the dolichocephalic head shape. Cranial length is measured from the glabella to the most projecting point of the occipital region. Starscans follow this same approach with greatest cranial width and length initially displayed at the default Level 3. Clinicians should view cranial width and cranial length at Levels 2, 4 and 5 to identify any greater linear distances that would best represent the magnitude of the deformity. For example, the greatest cranial width might be found on Level 4 while the greatest cranial length is found on Level 3. Cranial width is divided by cranial length and multiplied by 100% to produce the CR.

A series of two- (2D) and three-dimensional (3D) measurements best documents deformations and changes in a 3D infant head. Orthomerica's Starscanner Clinician Manual details the alignment and measurement processes that were specifically developed for the clinical documentation of two- (2D) and three-dimensional (3D) scanned images of growing infant heads (Figure 5). These procedures are based on anthropometric data available with the Starscanner laser data acquisition system. This clinical reference manual provides key information for clinicians to assess and compare infant skull deformities over time in clinical practice as well as for research efforts.

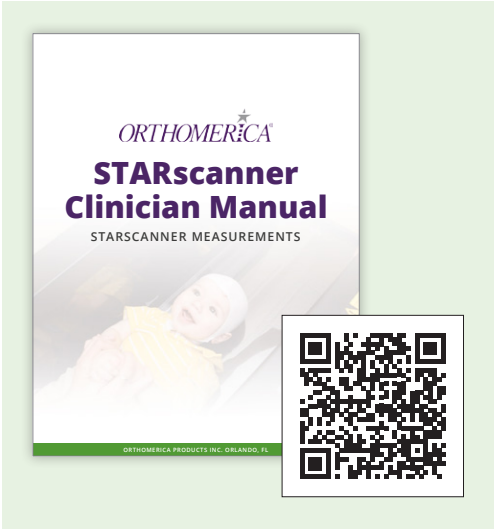


Figure 5. Orthomerica's Starband Clinician Manual—Starscanner Measurements

SEVERITY SCALES FOR DOLICHOCEPHALY

There are numerous severity scales for dolichocephaly reported in the medical literature. Unfortunately, some publications fail to distinguish differences between deformational dolichocephaly and synostotic scaphocephaly and the use of one scale for both conditions has never been validated. Table 5 presents several severity scales developed, reported, and/or referenced by different research teams. The lack of a professional consensus will continue to confuse and delay identification and effective management of this infant head shape deformity.

Cohen's classification	
Dolichocephaly	75.9 or less
Mesocephaly	76.0–80.9
Brachycephaly	81.0–85.4
Hyperbrachycephaly	85.5 or higher

Ifflaender et al. (2014)	
Mild CI	10th to 25th percentile
Moderate CI	3rd to 10th percentile
Severe CI	< 3rd percentile

(according to Wilbrand data)

Nam et al. (2021)	
Mild	79.6–82.4
Moderate	77.3–79.5
Severe	77.2 or less

Farkas et al. (2005)	
Ultradolichocephalic	X–64.9
Hyperdolichocephalic	65.0–69.9
Dolichocephalic	70.0–74.9
Mesocephalic	75.0–79.9
Brachycephalic	80.0–84.9
Hyperbrachycephaly	85.5 or higher
Hyperbrachycephalic	85.0–89.9
Ultrabrachycephalic	90.0–X

Likus et al. (2014)	
Dolichocephaly	Up to 75.9
Mesocephaly	76.0–80.9
Brachycephaly	81.0–85.4
Hyperbrachycephaly	85.5 or above

(according to Cohen & Maclean, 2000)

Santander et al. (2021)	
Mild	74% to 77.5%
Moderate	70.3% to < 74%
Severe	< 70.3%

Ifflaender et al. (2013)	
Mild CI	10th to 25th percentile
Moderate CI	3rd to 10th percentile
Severe CI	< 3rd percentile

(according to Wilbrand, 2012)

APTA (2021)	
Within normal limits	76%–80%
Mild	73%–75%
Moderate	69%–72%
Severe	< 68%

Orthomerica's Starscale (2023)	
WNL	> 76% and < 90%
Mild	69.5% - 76%
Moderate	65% - 69.4%
Severe	< 64%

Table 5. Severity scales for dolichocephaly.

There are limitations in attempting to classify the severity of a 3D infant head deformity with a single linear measurement, such as the CR (Fish, Hinton & Barrios, 2023). It should also be noted that dolichocephaly may present not only with disproportion, but also with asymmetry and volume disruptions. Measures such as the cranial vault asymmetry (CVA), cranial vault asymmetry index (CVAI), radial symmetry index (RSI), and volumetric measurements (e.g., anterior symmetry ratio (ASR), posterior symmetry ratio (PSR), and overall symmetry ratio (OSR)) yield significant clinical information.

MODELING AND REMODELING CONCEPTS

There are significant differences between pediatric modeling and adult remodeling. Modeling presumes growth and is used in pediatric orthotic care programs such as the treatments for clubfeet and scoliosis. In a similar manner, CROs work with the natural bone modeling process as the skull grows in close synchrony with the brain to allow for an increase in intracranial volume. The increase in skull area is accomplished primarily by bone accretion at the sutures to produce directed growth perpendicular to the suture lines. Additional growth occurs by resorption on the inner surfaces of the bone plates and accretion on the outer surfaces. These coordinated physiological processes create changes in the shape, thickness, and contour of the bones. CROs capitalize on directed natural growth to correct asymmetry, disproportion, sloping, and volume displacement that results in an overall improvement in head shape.

Remodeling is a lifelong process used in adult orthotic care programs such as fracture management. In adults, new bone matrix replaces old bone matrix on the same surface. Up to 10% of the adult skeleton is remodeled annually but the overall shape, thickness, and contour of the bone does not change.

Babies are NOT simply small adults and cannot be treated as such! The orthotic care program to correct head shape deformities has a time-limited opportunity to optimize head shape and maximize clinical outcomes. As the baby ages and growth slows, changes in head shape take longer with less favorable clinical outcomes.

CRO DESIGN CONSIDERATIONS

The primary objective in correcting deformational dolichocephaly is to address and improve the disproportion. This is accomplished by maintaining the cranial length while directing natural head growth into the lateral dimensions to

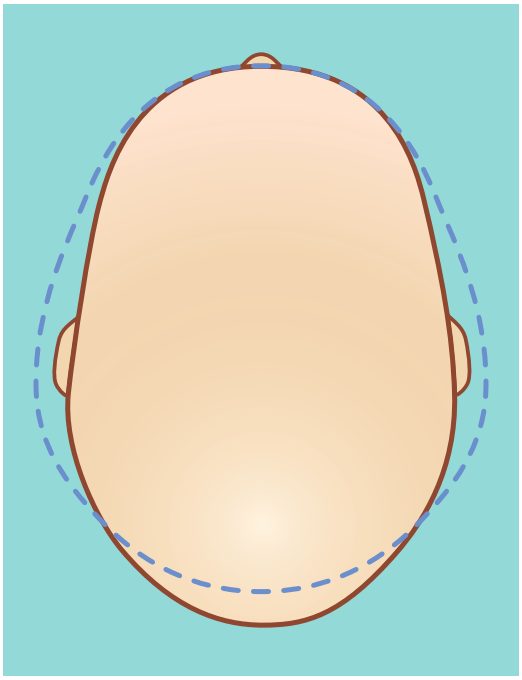


Figure 6. Dolichocephalic head shape compared to normocephaly (blue dotted line).

increase cranial width. Figure 6 demonstrates the dolichocephalic head shape compared to normocephaly, shown by the blue dotted line. Keep in mind that the cranial length will not decrease during CRO treatment as the orthosis does not apply compression forces to the head. Instead, the CRO is designed to maintain total contact over the frontal and occipital areas to resist further growth in those dimensions while providing void space over the lateral regions to allow directed growth. The result is a maintenance of cranial length, an increase in cranial width, and an increase in the CR. Any secondary asymmetry can be addressed concurrently with the CRO.

Post-operative orthotic correction of synostotic scaphocephaly varies in orthotic design and clinical technique as there is slight compression applied to the frontal and occipital areas once the fused suture has been removed. The primary goal to direct natural head growth into the lateral dimensions remains, as well as to address any secondary asymmetry concurrently. Since these infants are very young and their heads are growing even faster than most deformational cases, consecutive post-operative CROs are often needed to complete the post-surgical orthotic program.

Orthomerica has developed seven (7) FDA-cleared CRO designs to address different head shapes and the needs of different clinical care programs. Table 6 highlights different Star family designs that are most often used for the correction of deformational dolichocephaly and synostotic scaphocephaly.

DEFORMATIONAL DOLICHOCEPHALY

Table 6. Star family designs commonly used for deformational dolichocephaly and synostotic scaphocephaly.

Lighter weight design is ideal for premature infants

STARBAND 3D

This is the most recent addition to the Star family of CROs. The lighter weight and lower profile design is ideal for premature infants with weaker neck muscles.

- Donning and doffing are easy for parents with the two shells
- Strategically maintains contact over the frontal and occipital regions to maintain cranial length
- Strategically promotes directed growth into lateral dimensions
- Custom fabricated
- 3D printed shell with polyethylene closed cell foam
- Bi-valve design with bilateral side openings
- Lightweight and lower profile
- Ventilated
- Ease of donning
- Adjustable zone padding specific to head shape
- Requires additional clinical training (Learn more: www.orthomerica.com/3d/)

Table 6. Continued

Table 6. Continued from page 12

Bi-valve design effective for dolichocephalic head shapes

STARBAND BI-VALVE

The inner foam liner allows for consideration of more severe deformities while still completing the treatment program with a single orthosis. Donning and doffing are easy for parents with the overlap design.

- Strategically maintains contact over the frontal and occipital regions to maintain cranial length
- Strategically promotes directed growth into lateral dimensions
- Custom fabricated
- Plastic shell with foam liner
- Overlap design
- Total coverage over the crown of the head

Bi-valve design effective for dolichocephalic head shapes

STARBAND PLUS

This lower profile option is further customized by liner selections. A slightly snugger initial fit may be achieved with a Plastazote liner. Donning and doffing is easy for parents with the overlap design.

- Strategically maintains contact over the frontal and occipital regions to maintain cranial length
- Strategically promotes directed growth into lateral dimensions
- Custom fabricated
- Multiple liner options
- Low profile, full coverage
- One-piece living hinge
- Easy donning and doffing
- Additional adjustability for moderate to severe deformities
- Total coverage over the crown of the head

SYNOSTOTIC SCAPHOCEPHALY

Commonly used for initial post-operative CRO

STARLIGHT PRO

The Starlight PRO was specifically developed and used exclusively for post-endoscopic CRO care programs. The clear plastic allows visual inspection of the surgical sites without removal of the orthosis. The Starlight PRO is often prescribed as the initial post-surgical CRO, and then other designs may be considered as needed.

- Strategically maintains contact over the frontal and occipital regions to maintain cranial length
- Strategically promotes directed growth into lateral dimensions
- Custom fabricated
- Clear plastic shell with foam pads
- One piece living hinge design
- Specifically designed for post-operative craniosynostosis release
- Total coverage over the crown of the head

Often used for consecutive post-operative CROs

STARBAND BI-VALVE

Table 6. Continued from page 13

The inner foam liner allows for consideration of more severe deformities while still completing the treatment program with a single orthosis. Donning and doffing are easy for parents with the overlap design.

- Strategically maintains contact over the frontal and occipital regions to maintain cranial length
- Strategically promotes directed growth into lateral dimensions
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- Total coverage over the crown of the head

Often used for consecutive post-operative CROs

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- Custom fabricated
- Multiple liner options
- Low profile, full coverage
- One-piece living hinge
- Easy donning and doffing
- Additional adjustability for moderate to severe deformities
- Total coverage over the crown of the head

Keep in mind that there are a variety of clinical techniques in the treatment of infant head deformities. Other Star family designs are equally successful in addressing infant skull disproportion when incorporated into a comprehensive orthotic treatment program. Clinician experience, preferences of the medical team, family dynamics, comorbidities, and other factors are considered in the final Star family design selection.

AGE RANGES AND NATURAL GROWTH PATTERNS

Early cranial growth does not occur in a simple, global manner but rather in focused areas and directions. Age ranges and natural growth patterns for unaffected infants are outlined in the top two rows of Table 7. There is an intentional overlap in the age ranges as all infants grow in unique manners, so these groupings are intended to provide a general overview of expected cranial shape changes in unaffected infants. In the first five months after birth, a significant increase in length, width, and circumference occurs along with global cranial growth. There is little growth in the occipital region during this time. Between four and eight months of age there is a continued increase in length, specifically with forehead and occipital region growth. Further increases in width,

especially in the posterior part of the temporal regions, occurs between six to 11 months of age. Finally, between nine and 17 months of age, increased cranial length is noted again primarily with growth in the occipital region.

Age Ranges

1 to 4–5 months	4–5 to 6–8 months	6–8 to 9–11 months	9–11 to 12–17 months
Natural growth patterns (Kuwahara et al., 2020)			
• Significant increase in length, width, and circumference • Global cranial growth except for occipital region	• Significant increase in length • Forehead and occipital growth	• Significant increase in width, especially in the posterior part of the temporal regions	• Increase in length again • Growth primarily in occipital region
Modification options for deformational dolichocephaly (Orthomerica cranial training programs)			
MODERATE deformities			
• For preemies, consider adjusted age and repositioning, therapy, measuring, and monitoring • Ideal time to hold length and direct global growth into lateral dimensions with CRO at 4-5 months • (Correct asymmetry) / correct disproportion	• Ideal time to hold length with CRO • (Correct asymmetry) / correct disproportion	• Good time to continue correction with CRO • (Correct asymmetry) / correct disproportion	• May need to continue to hold correction with CRO • (Correct asymmetry) / correct disproportion
SEVERE deformities			
• For preemies, consider adjusted age and repositioning, therapy, measuring, and monitoring • Ideal time to hold length and direct global growth into lateral dimensions with CRO at 4-5 months • (Correct asymmetry) / correct disproportion • Full correction*	• (Correct asymmetry) / correct disproportion • Full correction*	• (Correct asymmetry) / correct disproportion	• (Correct asymmetry) / correct disproportion

*(Correct asymmetry) / correct disproportion modification will focus on CR.
*Full correction should be used by very experienced cranial clinicians.

Table 7. Age ranges and natural growth patterns should be considered relative to the modification options and clinical fitting strategies.

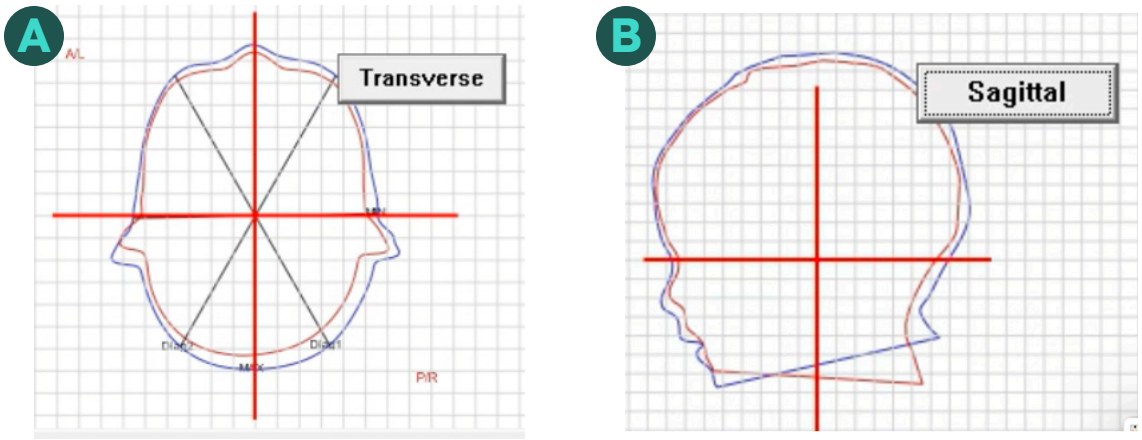
CRO MODIFICATION OPTIONS FOR DEFORMATIONAL DOLICHOCEPHALY

Modification options are related to premature or term status, natural growth patterns, and severity of the deformity. Repositioning, therapy, and monitoring may be the best course of action for the first age group, up to 4–5 months corrected age. Keep in mind that the chronological age of a premature infant may be five months since birth, but the corrected age might be three months due to eight weeks of prematurity. With these circumstances, the best course of action might be to continue to focus on repositioning and therapy efforts to address the abnormal head shape and neurodevelopmental aspects. Return visits for cranial evaluations can be made to measure the improvement or progression of head deformation. Documentation of the progression of the head shape deformity warrants consideration of a CRO at 4–5 months of corrected age. In contrast, a term infant presenting at 5 months of corrected age with a moderate or severe dolichocephalic deformity warrants an immediate recommendation for CRO treatment to capitalize on the greatest period of natural growth and optimize clinical outcomes.

In most cases, selecting the “correct asymmetry / correct disproportion” option during the ordering process is recommended. With the diagnosis of deformational dolichocephaly, the modification strategy will focus on correcting the CR and any secondary asymmetry will be addressed with the CRO modification and design. Pads may be added and/or material removed throughout the course of treatment to optimize fit and function of the orthosis, however, the original modification is often sufficient for many patients. Full correction is a modification option that is recommended for experienced cranial clinicians. This will produce a looser fitting CRO that will require padding to stabilize the orthosis and prevent tipping and tilting. This might be a good modification option on very young infants presenting with severe dolichocephaly. Full correction is not necessarily indicated on older infants with severe deformities as insufficient natural growth remains and the orthosis will be difficult to stabilize on the head.

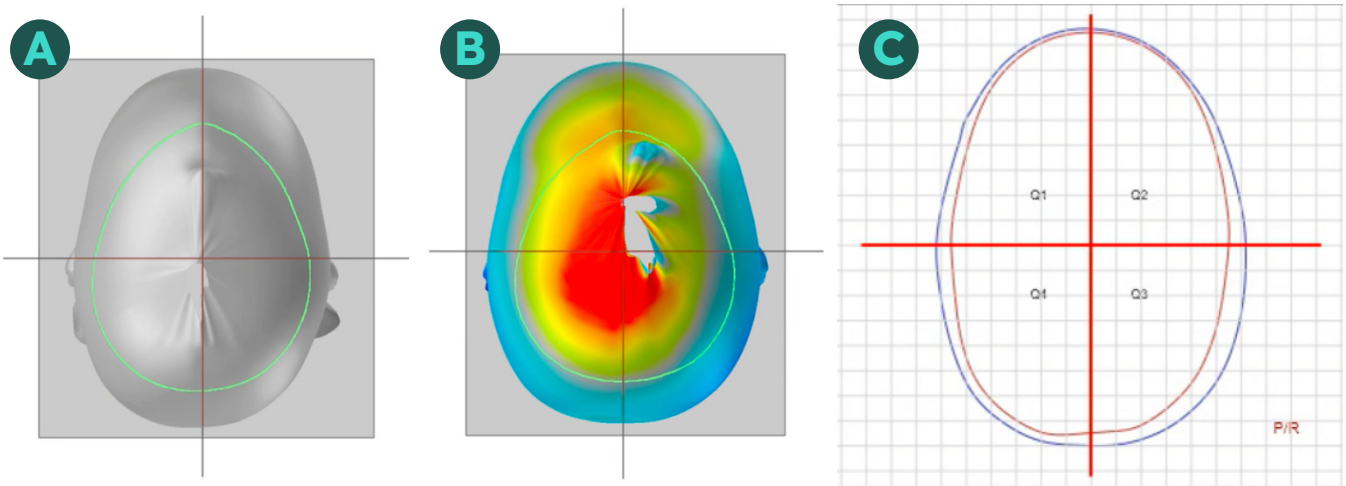
CASE PRESENTATIONS FOR DEFORMATIONAL DOLICHOCEPHALY

The images below provide an example of clinical outcomes for a patient treated for deformational dolichocephaly. Figures 7A and 7B relate to the Starscan alignment that uses the sellion and right and left tragion to establish a base plane for comparison of shape changes over time. The red line refers to the beginning of treatment scan data and the blue line refers to the end of treatment scan data. Figure 7A shows the transverse plane alignment based upon these three anatomical landmarks and reveals growth in both the viscerocranium and neurocranium. Figure 7B shows the sagittal plane alignment using the same landmarks.



Figures 7A and B. Starscan alignment for infant with deformational dolichocephaly.

Figure 8A shows the elongated head shape of the same infant with deformational dolichocephaly. The anterior and posterior rounding of the frontal and occipital regions along with the narrowing of cranial width represent the primary clinical features of deformational dolichocephaly. Figure 8B shows increases in growth dimensions throughout the neurocranium with the greatest amount of growth shown by the blue coloring. Figure 8C shows a transverse plane view at Level 3. Again, the red inner line represents the beginning of treatment head shape, and the blue outer line represents the end of treatment head shape.



Figures 8A, B and C. Beginning of treatment, end of treatment, and overlay at Level 3 for infant with deformational dolichocephaly.

Key measurements are outlined in Table 8. The circumference increased by 25.4 mm and improvements are noted in the cephalic ratio, radial symmetry index, cranial vault asymmetry, overall symmetry ratio, anterior symmetry ratio, and posterior symmetry ratio.

Measurement	Beginning of treatment	End of treatment
Cephalic ratio (CR)	69.2%	74.4%
Circumference	439.4 mm	464.8 mm
Radial symmetry index (RSI)	18.2	6.9
Cranial vault asymmetry	3.8	0.4
Overall symmetry ratio (OSR)	96.3%	99.9%
Anterior symmetry ratio (ASR)	99.4%	99.8%
Posterior symmetry ratio (PSR)	93.2%	100%

Table 8. Improvements in seven key measurements from scan comparison.

SUMMARY

Premature infants have an elevated risk for deformational dolichocephaly due to limited mobility, sustained positioning, and inadequate bone mineralization. Up to 75% of infants discharged from the NICU may have some degree of head shape deformity, with deformational dolichocephaly a common finding. The orthotic management of premature infant head deformities follows a similar clinical path as for term infants; however, special consideration must be given to the adjusted age, unique circumstances, associated medical conditions, and other factors. Often, repositioning and therapy are the initial treatments of choice for longer periods of time relative to the considerations of corrected age. Pediatricians, pediatric therapists, and pediatric orthotists should evaluate the infant's head shape at each follow-up visit and make recommendations for repositioning, therapy, evaluation by the craniofacial team, and/or CROs based upon clinical findings.

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