**Evidence-Based Care for Preventing and Treating Cranial Molding Deformities**

**in the Neonatal Intensive Care Unit**

**Introduction**

Cranial molding deformities develop as the result of excessive, consistent pressure places on a particular aspect of an infant’s head.1 The infant skull is soft and malleable in order to assist with passage thought the birth canal.1 Premature infants who have prolonged stays in the neonatal intensive care unit (NICU) are at increased risk of developing cranial molding deformities due to medical treatment and equipment, nursing care practices, prolonged positioning, and underlying muscle tone abnormalities.2 There are several different types of cranial molding deformities including plagiocephaly, brachycephaly, and dolichocephaly. Plagiocephaly is defined as unilateral occipital flattening of the skull.3 Severe plagiocephaly can result in ipsilateral frontal bossing of the forehead and anterior shift of the ipsilateral ear.3 Brachycephaly is defined as symmetrical occipital flattening.3 Dolichocephaly is defined as the bilateral flattening of the lateral skull resulting in an elongated anterior-posterior axis of the head.4 In the literature, these cranial molding deformities, when as a result of prolonged positioning, are commonly referred to collectively as ‘deformational plagiocephaly’ or ‘positional plagiocephaly’. For brevity, the term deformational plagiocephaly will be used for this literature review.

Premature infants in the NICU are at increased risk for developing deformational plagiocephaly due to the malleability of the neonatal skull, weight of gravity against the infant, and unnatural, sustained supine positioning in the NICU.4 Infants in the NICU spend more time in supine than their healthy peers because their medically unstable condition limits frequent repositioning and handling by nurses and caregivers.5 Deformational plagiocephaly, left untreated, can lead to disruptions in parent-child bonding, developmental delay, and motor asymmetries.3,5

While the prevalence of the deformational plagiocephaly in the NICU setting is well documented, there is no standard of care for preventing or treating deformational plagiocephaly in the NICU. Importantly, there has been clinical recognition of NICU patients being at higher risk for deformational plagiocephaly. This recognition has led to the development of many new positioning devices: water-bed mattresses, foam mattress, and gel pillows. These devices have been employed with inconsistent success and limited evidence.6 Nursing and caregiver education regarding frequent repositioning and physical therapy have also been used to prevent deformational plagiocephaly, again with low-quality evidence to support their efforts.6 There is a need for an evidence-based standard of care to prevent and treat deformational plagiocephaly in the NICU setting. This review will discuss the evidence regarding the interventions currently being employed to prevent and treat deformational plagiocephaly.

**Positioning Aids for the Body**

 Positioning aids for the body include nesting devices and mattresses that provide support and boundaries for the body, head, and extremities. There are several different infant body positioning aids being used in NICUs including the Frederick T. Frog (Philips), Flo Fluidized Neonatal Positioner (Molnlycke), Dandle ROO (Dandlelion Medical), and Nurture Rest NICU Baby Sleep Positioner (Neonatal Loving Kare); however, very little research has been conducted regarding the safety and efficacy of these products.

In a survey of NICU clinicians, the Dandle ROO, a containment device that positions the infant in supine and allows movement of the extremities while maintaining the head in midline and slight flexion, was identified as the “ideal method of neonatal positioning” by 62% of neonatal nurses and 86% of therapists.7 It was also deemed the easiest method of infant positioning in the NICU by neonatal nurses and therapists.7 The Dandle ROO has been deemed feasible for use in the NICU, but more research needs to be conducted in order to determine if the Dandle ROO is effective in preventing and treating deformational plagiocephaly.7

**Positioning Aids for the Head**

Positioning aids for the head include pillows, orthotics, and bumpers. As with body positioning aids, there are many different head positioning aids sold commercially and used in NICUs including the Gel-E Donut (Philips), the Fluidized Utility Positioner (Molnlycke), the Tortle Midliner (Tortle), the Tortle Air (Tortle), and the Crown Cradle (Dandlelion Medical). Research regarding safety, feasibility, and efficacy of preventing and treating deformational plagiocephaly in the NICU has been conducted on several, but not all, of these products.

The Gel-E Donut is a round, gel-filled pillow manufactured by Philips. The Gel-E Donut is designed to promote skin integrity and prevent cranial molding deformities due to prolonged immobility in the NICU. A study conducted by McLane et al. comparing the interface pressures of various pediatric support surfaces found that the Gel-E Donut with a foam overlay produced the lowest occipital pressures in infants less than 2 years of age.8 Cranial measurements were not taken.

The Fluidized Utility Positioner is a pillow-shaped device that supports the infant’s head, neck, and shoulders while in supine, side-lying, or prone. A randomized single-blinded study conducted by DeGrazia et al. in 2015 compared the use of the Fluidized Utility Positioner to another cranial device called the cranial cup in the NICU setting.6 The results of this study showed that 46% of infants using the moldable positioner had abnormal head shapes at hospital discharge; whereas, only 19% of infants using the cranial cup device had abnormal head shapes at hospital discharge.6 This suggests that the cranial cup is more effective in treating the deformational plagiocephaly. Unfortunately, initial head measurements and number of infants with cranial abnormalities in each group at enrollment were not reported in the article, making determining an accurate effect size impossible.6 DeGrazia does note that initial head abnormalities were evenly distributed between the two groups with a p-value=0.22.6

The cranial cup, now sold commercially as the Crown Cradle by Dandlelion Medical, is an orthotic device that contains a concave portion for the head in order to encourage normal cranial development. The concave cranial cup design was originally studied by Rogers et al. as custom-made orthotic.9 In a prospective, nonrandomized trial conducted by Rogers et al., an orthotist made a cranial cup individualized for the infant’s head shape.9 The orthotist was then required to widen and deepen the depression of the cranial cup every one to two weeks to accommodate the infant’s head growth.9 Rogers et al. demonstrated that the costume-made cranial cup was superior to parent education regarding repositioning and cervical stretching for the treatment of deformational plagiocephaly.9

Custom-made orthotics are expensive and take a significant amount of time to produce making this version of the cranial cup not feasible for prevention of deformational plagiocephaly in the NICU. The premanufactured Crown Cradle comes in two mattress sizes and has foam overlays for the concave portion that can removed in order to grow with the infant’s head. Multiple small studies have been performed on premanufactured Crown Cradle, and it has been found to be financially feasible, safe, and an effective way to prevent and treat deformational plagiocephaly in the NICU setting.6,10

Originally, the cranial cup was designed for infants weighing 1 kg or more, and studies reviewing the safety and efficacy of the cranial cup excluded patients weighing less than 1 kg until they reached the appropriate weight.6,10 At that point, NICU clinicians experienced difficulty fitting the infants to the smallest version of the cranial cup due to their already abnormal head shape.5 This further demonstrated that premature, low birth weight infants are at increased risk for developing deformational plagiocephaly. To combat this, Knorr et al., designed the preemie orthotic device (POD) for extremely low birth weight infants.5 Like the cranial cup, the POD is a mattress with a concave portion for the head. The POD has foam overlays that allow the device to accommodate infants weighing 0.5 kg to 1.7 kg.5 In a prospective study conducted by Knorr et al., 10 extremely low birth weight infants used the POD in the NICU immediately following birth.5 Infants were positioned on the POD for an average 21.2 hours per day, and no adverse events were reported.5 Five of the 10 infants had normal cranial measurements at study completion, compared with only 1 infant at study enrollment.5 This study found the POD to be feasible, safe, and effective in preventing and treating deformational plagiocephaly in extremely low birth weight infants despite the few patients enrolled in the study.5

**Frequent Changes in Body/Head position**

An increase in the prevalence of deformational plagiocephaly was detected after the American Academy of Pediatrics (AAP) launched the “Back to Sleep Campaign” in 1994 to prevent Sudden Infant Death Syndrome (SIDS) and suffocation.11 While the number of infant deaths related to SIDS and suffocation decreased, cranial molding deformities increased as infants spent increased time lying supine on firm surfaces.11 NICU standards regarding repositioning of infants vary, and no controlled studied have been performed with repositioning as the sole independent variable. Several studies have been performed including repositioning with other interventions such as positioning devices; however, repositioning is rarely well-defined.5,6,9-11 More research with needs to be conducted to determine appropriate repositioning standards in the NICU.

Despite the lack of controlled research, many authors report repositioning as a crucial first line preventative measure and treatment intervention of deformational plagiocephaly.2,12-15 Infants have immature musculoskeletal systems that are highly influenced by positioning.13 Infants in the NICU are often limited in their positioning options due to critical medical status and intolerance to position changes.13 Prolonged positioning has been associated with torticollis, plagiocephaly, and reduced movement quality.12 Infants need to experience and be supported in a variety of positions including supine, prone, and sidelying.2

Sweeney and Gutierrez provide detailed recommendations on appropriate infant positioning in the NICU.13 In supine, the infant’s head should be supported in midline.13 Support should be provided under the shoulders and upper extremities to prevent shoulder retraction and facilitate hands to chest and hands to mouth.13 A positioning device or towel roll should be placed under the knees and against the lateral thighs to promote hip flexion and prevent excessive hip abduction and external rotation.13 Infants positioned in prone should have a roll placed under the hips to promote flexion, lateral thigh supports to prevent excessive hip abduction, hip external rotation, and foot eversion.13 The head should be rotated side to side to avoid prolonged pressure on one side of the face.13 Prone positioning is often indicated in the NICU to decrease an infant’s stress, promote sleep, increase oxygenation, and improve feeding.2 Sidelying requires support under the head and neck and between legs to maintain spinal alignment.13 The infant may need to be swaddled to prevent shoulder retraction.13

Varying positions opposes the AAP’s recommendations for supine sleeping, but infants in the NICU are continuously monitored decreasing the risk of SIDS.2 However, all infants should be transitioned to sleep supine prior to discharge, and parents should be encouraged to comply with the AAP’s recommendations.2 Discharge education for caregivers should emphasize the need to vary positions for playing, feeding, and carrying in order to prevent deformational plagiocephaly.14

**Nursing Education**

Neonatal nurses play a crucial role in designing, implementing, and teaching positioning strategies that promote head shape integrity. Neonatal physical therapists play a crucial role in educating nurses on these positioning strategies.12,13 The literature lacks research regarding the effects of nursing education programs on repositioning in neonates but does include some research on older infants. In a systematic review conducted by Baird et al., nursing education alone was found to be insufficient in preventing and treating plagiocephaly in infants 7 weeks and older.11 Nursing education included repositioning, tummy-time, safe handling, and varying feeding positions.11 Nursing education in conjunction with physical therapy sessions that included cervical stretching and facilitation of movement into the non-preferred side was more effective than nursing education alone.11

**Parent Education**

In the NICU, parents are encouraged to care for their infants and will be the primary caregivers following discharge from the hospital.14 Parents, too, require education regarding repositioning, tummy-time, safe handling, and varying feeding positions. Currently, education for parents is not standardized, and delivery of education varies. Parents may receive education from nurses, physical therapists, occupational therapists, or developmental therapists. They may receive one-on-one education, group classes, written materials or a combination. Presently, only one study has been conducted regarding common parental education practices in NICUs and their effectiveness in regards to prevention and treatment of deformational plagiocephaly.15 A case report conducted by Dusing et al. in 2012 evaluates the development and implementation of new parent education program regarding infant positioning.15 The education program included a therapy introductory letter, bedside programs for parents, one-on-one discussions of assessments and treatments, discharge education, a written brochure, and evening parent groups.15 Implementation of this program along with several administrative changes allowed therapists to be more efficient with their time in the NICU, to be available for parent meetings, and to collaborate more regularly with nursing staff.15 Therapists, other healthcare staff, and parents had such positive reviews of the parent education program, that statewide recommendations to support parent education prior to NICU discharge were developed based on the program.15

 Unfortunately, specific education materials and topics were not outlined in this study.15 Sweeney et al., recommends parent education topics include varying the side-to-side rotation of the head during sleeping, positioning the head in midline in car seats and swings, limiting use the of infant seats and replacing that time with tummy-time, and varying positions for playing, feeding, and carrying.13

**Conclusion**

 Infants in the NICU are at increased risk for plagiocephaly. Current practices for preventing and treating deformational plagiocephaly in the NICU vary widely and some common practices are not supported by evidence. The optimum prevention and treatment regimen is unknown but likely includes a combination of the practices discussed above. Ultimately, more and higher quality research needs to be conducted in order to develop an evidence-based standard of care for prevention and treatment of deformational plagiocephaly in the NICU.

**Literature Review Table:**

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| **Author** | **Level of Evidence** | **Participants** | **Intervention** | **Results** | **Clinical Implications** |
| **Positioning Aids for the Body** (i.e. nesting devices) |
| Zarem, 2013 | 4 | 76 neonatal nurses and neonatal speech, physical and occupational therapists  | Survey regarding participants perceptions of positioning for preterm infants in the NICU  | 62% of nurses and 86% of therapists found the Dandle Roo positioning device as an ideal positioning device for infants in the NICU. | NICU clinicians find the Dandle Roo by Dandle-Lion easy to use and effective for positioning infants in the NICU. |
| **Positioning Aids for Head** (i.e. pillows, bumpers, and devices) |
| McLane, 2002 | 4 | 21 children ranging in age from infancy to 6 years  | Comparison of interface pressure under the occiput for infants to children under 6 years  | Standard hospital mattress yielded the highest interface pressure. Delta foam overlay alone or in combination with Gel-E Donut pillow yielded lowest pressure | Delta foam overlay alone or in combination with Gel-E Donut pillow by Philips is effective in reducing occiput pressure. |
| DeGrazia, 2015 | 2b | 62 infants with length of stay greater than 14 days in the hospital | Comparison of the Fluidized Utility Positioner alone to the Fluidized Utility Positioner in combination with cranial cup | 46% of infants using Fluidized Utility Positioner alone exhibited abnormal cranial measurements 19% of infants using Fluidized Utility Positioner in combination with the cranial cup exhibited abnormal cranial measurements  | Combination of the use of the cranial cup with Fluidized Utility Positioner is feasible, safe, and effective for the prevention of deformational plagiocephaly.The Fluidized Utility Positioner alone is not an effective preventive measure for deformational plagiocephaly. |
| Knorr, 2016 | 4 | 23 infants with deformational plagiocephaly born at < 35 weeks, weighing greater than 1 kg | Infants used the Cranial Cup by for an average of 12.7 hours per day | At discharge, 19 infants had normal cranial measurements | The cranial cup with is feasible, safe, and effective for the treatment of deformational plagiocephaly. |
| Knorr, 2019 | 2b | 9 premature, critically ill infants weighing <1 kg. | Infants used Preemie Orthotic Device (POD) by Dandle-Lion for an average of 21.2 hours per day. | All infants had normal cranial symmetry at study enrollment and completion, and no device-related adverse events were reported. | POD was found to be feasible and safe for premature, extremely low birth weight infants. |
| **Frequent Changes in Body/Head Position**  |
| Hummel, 2005 | 5 | Expert Opinion | Infants need to experience and be supported in a variety of positions including supine, prone, and sidelying. Deformational plagiocephaly has increased with the American Academy of Pediatric’ Back to Sleep Campaign. All infants should be transitioned to sleep supine prior to hospital discharge to comply with AAP recommendations; however, emphasis should be placed on the need to vary positions for playing, feeding, and carrying in order to prevent plagiocephaly. |
| **Nursing Education**  |
| Sweeney and Gutierrez, 2002 | 5 | Expert Opinion  | Neonatal nurses play a major role in designing, modeling, and teaching positioning strategies to prevent deformational plagiocephaly. Neonatal nurses and parents should be instructed to vary the direction that the infant’s head is turned during sleeping, placed the head in midline position in car seats and swings, limit use of car seat time, and play in prone. |
| **Parent Education** |
| Dusing, 2012 | 4 | Case report regarding the development and implementation of new parent education program regarding infant positioning  | Education program included therapy introductory letter, beside programs, discussion of assessments, discharge education, brochure, evening parent groups. Interdisciplinary developmental staff work group, positioning rounds. | Implementation of this program along with several administrative changes allowed therapists to be more efficient with their time in the NICU, to be available for parent meeting, to collaborate more regularly with nursing staff, and have fewer missed visits in the NICU | Therapists, other healthcare staff, and parents had such positive reviews of the parent education program, that statewide recommendations to support parent education prior to NICU discharge were developed based on the program.  |
| Craig, 2015 | 5 | Expert Opinion  | Parents should be educated on providing supportive positioning and handling for their infant.  |

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