Differentiating the impact of biomechanical forces of labor and delivery vs. the effect of a posterior tongue tie on neonatal and infant feeding dysfunction: a clinical evaluation

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ABSTRACT

A myriad of problems may cause feeding difficulties for the neonatal and infant population. However, the effect of mechanically induced stress, strain, and trauma on the infant and its impact on their ability to feed at breast or by bottle is poorly understood or researched and often goes unrecognized, and therefore, uncategorized. This commentary's aim is to evaluate mechanical trauma associated with the birth process as it contributes to feeding dysfunction as opposed to the current trend to consider most dysfunctional oral motor mechanics the result of a posterior tongue tie. The authors will also briefly review and summarize the relationship between mechanical craniovertebral dysfunction and/or posterior tongue tie as a cause for infant feeding dysfunction based on the best current research. The relevance of this discussion is to promote further observation and research to reach a clear diagnostic understanding of the infant's feeding difficulty as each, on its own, can disrupt oral motor function. Ankyloglossia, and the more recently delineated posterior tongue tie, and their accompanying compensations are hypothesized to result in a concomitant dysfunctional range of motion at the cranio-cervical junction and/or the cervical spine.

Key Words: pediatric chiropractic, cranio-cervical junction, birth trauma, feeding difficulty, breastfeeding difficulty, posterior tongue tie, tethered oral tissues (TOTs).

Introduction

Infants are subject to stress, strain, and trauma associated with the birth process.[1] The most frequent area of impact is to the head and neck with injuries ranging from mild to severe. This trauma has the potential of having a negative impact on range of motion of the head and neck as well as the trunk and extremities. Full and unrestricted range of motion of the head and neck is essential for a normal suck-swallow-breath pattern to occur while feeding at breast or on a bottle. Restriction and discomfort in other parts of the body may also result in difficulty feeding due to the pain that the infant feels when held in a specific feeding position and must be considered in a full evaluation. The authors' goal is to clarify as to whether infant birth stress, strain, or trauma can cause or contribute to infant feeding difficulty. To embark on answering this question, the definition of birth trauma, its prevalence and how it is classified will be explored. Beyond the scope of this paper, it would also be important for investigators to explore how the consequences of birth trauma are expressed or manifested in the neonatal period as well as the associated long-term ramifications.

Birth Trauma

In the United States, birth injuries are estimated to occur in 2.6 percent of births. Superficial and temporary, functional and cosmetic sequelae, disability or even death can result as a consequence of birth-related injuries.[2] The Agency for Healthcare Research and Quality (AHRQ) in the USA has determined seven categories of birth-related injuries, including:

- subdural /intracerebral hemorrhage
- epicranial subaponeurotic hemorrhage
- skeletal injuries
- injuries to spine and spinal cord
- peripheral and cranial nerve injuries
- other types of specified and non-specified birth trauma.[2]

The process of birth, whether spontaneous or assisted, is inherently traumatic for the newborn. Birth-related injuries encompass both mechanical and hypoxic-ischemic events.[2] The exact incidence of mechanical trauma at birth may be underestimated.[2] An incidence of 0.82 percent, prevalence has been estimated at 9.5 per 1000 live births.[3] Less than two percent of neonatal deaths result from severe birth trauma.[4] These statistics are based on the most severe outcomes from birth trauma. What are the consequences for the neonate who has less severe (mild or moderate) birth trauma? Neither the percentage of the infant population exposed to minor or moderate mechanical birth injuries, or their outcomes, appear to have been evaluated. Regardless of the reported incidence and prevalence of birth trauma, its true nature and long term sequalae are still poorly understood.[2]

The educational curriculum of pediatric chiropractors who work with the neonate should include the evaluation for the potential sequelae of birth injury or trauma. The evaluation should begin by obtaining a detailed gestational, labor/delivery and postpartum history. The chiropractor, with a clear understanding of the possibility of in-utero constraint, interventions, or manual manipulations utilized can better understand the mechanism of injury or restriction of the fetus during the pregnancy or birth process. The chiropractor will utilize palpation, as well as neurologic and muscle testing, to formulate a differential diagnosis to help understand the cause of feeding dysfunction. This physical examination is comprised of observations of how the infant moves or does not move during feeding, palpation of the head, neck, mouth, and body, and an elicitation and observation for symmetry of primitive feeding reflexes to determine the status of neurologic function.[5,6] It is important that the chiropractor pursue post graduate education for themselves and in the case of breastfeeding difficulties, consider working collaboratively with a healthcare professional, like an Internationally Board Certified Lactation Consultant (IBCLC). The IBCLC should be able to evaluate the infant's competency at breast or on the bottle including recognizing aspects of dysfunctional breastfeeding mechanics (preferred postures, restricted ranges of motion) and when to make appropriate referrals to chiropractors and osteopaths for adjustment or other manual mobilizations or therapies.[7] Seeking professionals who are trained in performing a functional evaluation of the lips and tongue to rule out connective tissue tethering or "ties" is paramount.[7,8] It is the authors' experience that there may also be other individuals, such as a speech and language pathologist or occupational therapist, who may focus on feeding difficulties. If your dyad's goal is to breastfeed, it is important to communicate and ensure that they have specific expertise, knowledge, and a goal of breastfeeding as a focus on compensations, as the substitute of bottle, cup, and spoon feeding are often immediately implemented.

According to Chaturvedi, et al,[2] the following could be potential red flags that the infant has been subjected to mechanical birth stress, strain, or trauma to the head and neck, thus potentially impacting their ability to suck, swallow, and breathe:

- Malposition (Breech; Transverse)
- Fetal macrosomia
- Maternal diabetes and small pelvis
- Malpresentation (Asynclitic; Occiput posterior)
- Prolonged pushing phase
- Premature rupture of membranes
- Shoulder dystocia or a dystotic labor (60 seconds or more passes between the delivery of the head and torso)
- Augmented or Induced delivery (Pitocin etc.)
- Assisted delivery (Vacuum or forceps, hand assisted, fundal pressures)
- Nuchal cord
- Surgical delivery (Emergency C-section)

The authors have found that birth trauma is typically described in the literature as severe in nature, leaving the clinician or physician to only consider trauma having occurred if there is an obvious deficit or damage as described by Chaturvedi, et al.[2] However, they admit that little is still known about the spectrum of mechanically associated birth trauma and that it is often underestimated. This comment resonates with the authors' clinical experience. In practice, the authors have documented injuries occurring on a spectrum ranging from mild, moderate to severe. As a professional community, chiropractors, or other physicians, recognize that infants can sustain what is considered a minor injury from the birth process (for example, accidental traction on the mandible during manual extraction by either the obstetrician's or midwives' hands or by forceps application) that can impact their ability to feed, grow, and develop optimally. So, how can health care professionals, especially chiropractors and osteopaths (and other practitioners of manual medicine who work with this population), recognize the infants who need attention or care but do not fall in one of the major categories of birth trauma as cited by Chaturvedi, et al?[2]

With the medicalization of birth and the "biomedical tendency to pathologize otherwise normal bodily processes and states,"[9] the introduction of interventions like the use of forceps and vacuum suction has the potential to produce obvious or subtle signs of trauma or strain. Currently, the forceps birth modality is utilized for .05 percent of births and the vacuum extraction birth modality is utilized for 2.5 percent of births in the United States.[10] Moreover, are we able to clinically link biomechanical dysfunction or cranio-vertebral subluxation to different presentations or interventions? First, we must acknowledge that the medical definition of subluxation differs from that of the chiropractic definition.[11-16] In chiropractic journals, we read how the subluxation complex can have an adverse effect on the surrounding nervous system.[17] Nevertheless, the subluxation complex can occur in a variety of presentations and degrees of severity, regardless of the definition, at the atlantooccipital (cranio-cervical) junction. For example, a malpresentation or asynclitic presentation may result in a pressure wound (caput succedaneum) on the top of the head and could result in a cervical spine strain and sprain injury due to a buckling of the spine while under excessive and/or prolonged compressive loading.[18] Additionally, is there an association with the traction or compression of a nuchal cord during delivery with upper cervical subluxation or a suboccipital muscle strain? The prevalence of nuchal cord deliveries is reported to occur between 10-29 percent of deliveries.[19] Studies have shown that traction forces of 8 lbs. usually separate the placenta from the uterus. Tensile strength of umbilical cord indicates that the average load required to break the cord is around 10—14 lbs.[19] In addition, vacuum assisted delivery may also be associated with strain and sprain of the cervical spine due to the recorded forces applied to effectively complete this procedure. This makes biomechanical sense given the average clinician applied forces used to perform a vacuum delivery range between 10 and 32 pounds-force.[1,20] It is recommended that this procedure is not attempted any longer than 20 minutes nor repeated more than two attempts.[21] This excessive amount of force over a prolonged period can potentially disrupt the normal osteoligamentous integrity of the craniovertebral junction. Moreover, chiropractors and osteopaths have historically attributed the cause of hypothesized cervical spine subluxation complex to abnormal physical stressors being applied to this region.[22-24] Several have published papers discussing how these mechanisms are related to breastfeeding dysfunction.[20,25,26,27]

Research has investigated the amount of force required to buckle (subluxate) the adult and pediatric spine.[18,28] Marchand et. al, found that the osteoligamentous sub-catastrophic load (for an infant cadaver from 0-12 months)[28] is 50 newtons or 12 pounds of tensile traction force.[18,28] Panjabi, et al. found that the average critical load of the osteoligamentous cervical spine, excluding muscular support, in an adult (weighing 70 Kg) is 10.5 N or 2.36 pounds-force.[18] It was discovered that the osteoligamentous spine contributes approximately 20 percent to the minimally needed mechanical stability of the cervical spine, while the rest, nearly 80 percent, is provided by the surrounding neck muscles while under gravity.[18] Keep in mind that we are extrapolating this data to a neonatal spine. The neonatal spine is arguably much less stable under the same amount of pressure, especially when the cervical spine's postural stabilizing muscles are not developed and cannot support the load force during prolonged labor through the cervix or extracted from the birth canal. Observe the normal and acceptable forces applied during common assisted and surgical obstetric procedures in Figure 1, below.

When these figures, ranging from 17–308 newtons are compared with that of the mean chiropractic clinician forces used during a sustained contact on a neonate, 1-20 newtons,[28] there are appreciable differences between the forces used in routine labor and delivery as compared to the forces used in the routine neonatal or infant chiropractic adjustment.

Forces are applied to the neonatal presenting part (head and neck) during an uncomplicated birth as well as when interventions are employed. Excessive forces can be observed during a difficult delivery, including, but not limited to, an asynclitic presentation, manual or assisted deliveries, inefficient or prolonged (> 2 hours) pushing by the mother during dysregulated uterine contractions under the influence of epidural analgesia, shoulder dystocia, occiput posterior presentation, a nuchal chord, or a dystotic uterus. It is also important to note that the pressure gradient will vary due to female body habitus and strength during the pushing phase of a vaginal delivery (with and without neuraxial epidural or anesthesia). The question is, is it possible to calculate the force distributed across the head and neck of a neonate over the period of 1-2 hours during the second stage or pushing phase of labor and delivery or when the obstetrician applies traction or rotation to the head and neck with their hands? Also, consider the force exerted by the vacuum or forceps applied to assist the delivery and potentially save the neonate's life. It seems fair to hypothesize that abnormal forces applied to the head, neck, and associated soft tissues and nerves that are recruited for normal feeding might be injured and might result in feeding dysfunction and craniovertebral pain syndromes.

Unit Comparisons	**Normal Spontaneous Delivery (Grimm/Obrien)**	**Forceps Delivery (non-rotational) (Obrien)**	**Vacuum Device (Mean peak clinician force)**	**Ranges of Traction force with vacuum Ext. @600mmHg**	**Recommended Mean Peak Clinician Force with Adjustment (0-23 mos.) Marchand /Todd)**
Newtons	129	251-309	129-145 (Obrien) 17-99.89 (Grimm)	157-308	Max: 20 Mean: 7.7 <12 wks.: 1-2
Pounds	29	56-69	3.8-32.59 Pop-off > 70	35-69.24	4.4 1.73 .44

Figure .1[1,20,28,29,30]
Pop off: indicates how much pounds-force is required to break the seal between the suction cup and the cranium of the fetus.

Relevant Clinical Anatomy

To better understand this relationship, we need to review the relevant clinical anatomy of the upper cervical spine and feeding system. Eating and swallowing are complex behaviors including both volitional and reflexive activities involving more than 30 nerves and muscles.[31] Subjecting the cranio-cervical junction to abnormal amounts of pressure will result in the subsequent disturbance of the normal alignment between the cranium (C0) and the atlas (C1). The following structures in proximity will be at risk of compromise: the superior cervical ganglion, hypoglossal nerve, genioglossal nerve, and Vagus nerve.[32] How can these structures be negatively impacted by craniovertebral subluxation?

It has been cited in scientific literature that the most common area of cervical spine subluxation occurs at C1, C2 and C3.[33,34] In the authors' clinical experience, this presentation has often been observed. Furthermore, the biomechanical implication must be considered when diagnosing a cause for infant feeding dysfunction, especially when there is evidence of mild to severe mechanical birth stress, strain, or trauma. The architectural concept of "form follows function" is mirrored in the human body by Wolff's Law in degenerative changes.[35] But clinically, we also know that function follows form. When there is a change in cranial or spinal shape, alignment or mobility or range of motion, there will be a subsequent alteration in its function. Normal shape, alignment and mobility or range of motion (form) lend to normal function. Abnormal shape, alignment or mobility or alteration in range of motion is a red flag for abnormal functional performance, and for the purpose of this paper, a red flag for abnormal feeding function.

Overall, sprain, strain, or trauma to this region theoretically hinders the function of the neuro-biomechanical system at the craniovertebral junction. Biomechanical compromise at this level may result in dysregulation of the cranial nerves,[36] as well as restricted (or excessive) joint range of motion and altered muscular activities that are required for safe and efficient feeding, regardless of the perceived severity of the stress, strain, or trauma. In addition to mechanical dysfunction, it is likely and possible that infants with these injuries and noxious stimuli will suffer from craniovertebral myofascial pain syndromes. "In this context, nociceptive fibers that travel with the motor fibers which innervate a particular muscle are possibly involved in pain sensation of the involved muscle and its associated fascia."[3,28] Nociceptive stimuli plays its own role in elevating sympathetic tone and interfering with relaxed, normal feeding.[7,36,37,38]

Oral Ties

A full discussion of ankyloglossia and tethered oral tissues ("anterior" and "posterior" tongue ties, lip ties and buccal ties) are beyond the scope of this commentary but anatomically refer to ligamentous frena that restrict the range of motion and therefore function of the tongue and lips.[39,40] These restrictions have been considered significant in a number of issues other than feeding including but not limited to reflux,[41-44] airway dysfunction,[42] orthodontic issues[45] and articulation difficulties.[46] To breastfeed successfully, the gape must be wide requiring full range of motion of the temporomandibular joint and the cervical spine and the mandible must be free to hinge (drop) and translate forward (allowing for a "cycling" motion as it comes back up), the lips must create a secure passive seal (with the extended tongue) on the tissue of the breast and the tongue needs to extend, elevate, trough around the nipple and undulate smoothly and rhythmically in a peristaltic wave which is essential for swallowing without risk of aspiration of liquid into the lungs.[47,48]

Restrictive frena are taut ligamentous bands of tissue between the floor of the mouth and the underside of the tongue, between the midline of the lips and gum or the cheek and gum. These restrictive frena alter the mobility of the structures that determine efficient removal of milk from breast or bottle. The ability of the mandible to move freely, separate from the tongue (changing gape width/height) or the tongue moving separately from the mandible (changing the ability of the tongue to elevate the breast tissue to the palate without the mandible following and forcefully compressing the breast tissue) is affected by a tongue tie. Efficiency of milk transfer will be affected by the quality of the seal of the lips on the breast tissue. This seal is poor when there is an inability to passively flange the lips due to the presence of taut connective tissue bands between the gum and cheek (buccal ties) or midline frena between the upper or lower lip and gum. When the seal is insecure, there is a greater risk of aerophagia (swallowing air), leakage, and poor milk transfer from the positive pressure of the full breast to the negative pressure of the oral cavity.[8,47,48] An infant may compensate by recruiting the orbicularis oris to hold the breast tissue resulting in "milk blisters" in the midline of the lip or cobbling or cross striations of the entire lip occurring either on one or both of the lips.

A tongue tie may present anteriorly at the tip of the tongue causing a characteristic indentation or crease in the midline or have a more posterior presentation and can be visible upon elevating the tongue or be hidden, embedded in the mucosa and may cause a central indentation or persistent retraction of the tongue. Based on its point of attachment and its "flexibility" (which is dictated by composition of elastin and collagen), both anterior and posterior tongue ties may affect the tongue's ability to extend, elevate or lateralize and often causes a "humping" or retraction of the tongue which will decrease, at best, the efficiency of transfer of milk and at worst, decrease the patency of the pharyngeal aperture (potentially causing airway obstruction) or create poor channeling of milk (increasing the risk of choking/ aspirating).[40]

Any or all interference with latch and efficient milk transfer (using less energy/calories to extract the milk than the energy/calories contained in the milk itself) will result in a sympathetic response in the infant. Due to their efficient neural plasticity, a quick adaptation and reorganization from their "preprogrammed" neurology that guides feeding, the infant may develop a compensatory sequence of motions. This can become evident when the infant recruits accessory muscles that in turn risk compromising other muscles responsible for diverse physiologic functions. This cascade can affect everything from swallowing and breathing, to posture and joint range of motion, increased flexor tone, retained fetal posture, a head tilt with or without rotation or other preferential postures. These compensatory postures or compensatory muscle actions are often the root of the segmental dysfunction or subluxation that can be addressed by the chiropractor or osteopath. The importance of recognizing both issues lie in the fact that treating one or the other exclusively may not have an optimal outcome.

If the subluxation is a result of the aberrant oral motor activity dictated by the presence of tethered oral tissues like a tongue tie, then one would be repeatedly addressing the subluxation secondary to compensatory muscular recruitment without resolution until, perhaps the infant is no longer feeding at breast or on bottle.

On the other hand, surgically intervening by releasing the taut frena will not necessarily result in improved oral motor function if the subluxation (segmental motor dysfunction) is interfering with the infant's ability to gape widely or extend at the base of the cranium.

The authors would also like to point out that there are certainly other unexplored areas of consideration including the epigenetic effects of ankyloglossia or other tethered oral tissues, in-utero constraint resulting in fascial restriction and potential segmental dysfunction on the fetus as well as the epigenetic effects of birth trauma and dysfunctional oral motor function on the neonate.

It is critical for inter-collegial discourse and professional development of an inclusive evaluation and differential diagnosis so that the treatment planning and goals are prioritized and collaboratively delivered to have the best outcome for the dyad.[7,36,37,38]

Discussion

Over the past five years, the lead author has worked in a breastfeeding medical office and has cared for more than 2,000 neonates and infants in a multidisciplinary and collaborative setting with IBCLCs, nurses and a medical physician. A birth history was obtained from the parents of each infant. Every one of these parents reported a chief complaint associated with structural issues in the head and neck while also having feeding difficulties. Some had been previously diagnosed with an anterior tongue tie, or posterior tongue tie (or other oral frena restricting the normal action of the lips, tongue or cheeks), as well as some having no apparent tongue or other oral frena restricting oral motor function, yet were experiencing oral motor dysfunction.[39,48] Some had undergone a surgical procedure that released the tethering oral tissues but had no pre or post-surgical manual or chiropractic care and experienced no improvement in breastfeeding.

There is much debate on the prevalence and incidence of posterior tongue tie.[49-52] Based on published observations, the current research and the author's clinical observation, there is an unexplored incidence of mild to severe mechanical birth stress, strain, and trauma in the infant population which might explain the rise in infant feeding difficulties that can occur with or without other comorbidities like a posterior tongue tie or other tethered oral tissues.[20,38]

Based on these observations, it is critical to differentially diagnose the reasons for breast feeding difficulties. A biomechanical injury to the head and neck should not be confused with a "posterior tongue tie" or any other anatomical restriction of the oral structures by ligamentous structure.[20,26,53,54,55,56] There is mounting research[40] and clinical evidence that a significant cause of infant feeding dysfunction can occur due to abnormal forces during labor and delivery on the cranium, hyoid bone, and cervical spine, which can often masquerade as a "posterior tongue tie." The hyoid, for example, when restricted by a nuchal cord, can result in a change in the muscular action of the muscles of the floor of the mouth, the neck and the tongue, as well as the muscles that influence the range of motion at the craniocervical junction.[36] The position and range of extension and elevation of the tongue can be reduced as a result of hyoid displacement. This may give the appearance of a tongue tie but is actually a "faux tie" (as coined by Hazelbaker)[57] and the hyoid should be mobilized before assessing tongue function. Failure to assess and address biomechanical dysfunction can lead to an unnecessary or premature surgery and/or poor surgical outcome, resulting in continued feeding dysfunction.[7,36,37,38]

Many health professionals interfacing with these infants are not trained how to assess breastfeeding mechanics or appropriately refer infants with biomechanical dysfunction contributing to breastfeeding dysfunction for treatment. Chiropractic physicians are well positioned to educate the public and professional communities on this topic. A literature review of chiropractic care for breastfeeding newborns was performed in 2015 which briefly touched on the topic of birth trauma as a contributing factor.[25] Further investigation and a review of the literature on the topic of birth trauma and associated infant feeding dysfunction is warranted.

Just as there is much debate on the prevalence and incidence of posterior tongue tie and safety and necessity for their surgical release,[40,58,59] there also seems to be a large debate on the necessity, safety, and efficacy of infant chiropractic care.[60,61] (One must remember to compare the forces of labor and delivery to the forces used during the infant chiropractic adjustment which is recommended to be performed with 1/10th of the force used for adult manipulation.)[28]

Furthermore, the adjustment is an appropriate therapeutic intervention to treat an upper cervical strain and sprain injury or subluxation complex.[28,30,60,61] It is apparent that without adequate care and early intervention, these upper cervical "conditions" resulting from postural loading mechanisms are not self-limiting and continue as an adaptation from normal. These spinal and cranial structural adaptations will potentially perpetuate into other sequela thus leading to less than optimal neural and structural function and in the infant, potentially compromise their development.[62-66]

Mechanical stress and strain to the cranium and vertebral column needs to be considered in the top differential diagnosis when considering the cause of feeding dysfunction or when considering a tethered oral tissue as the primary diagnosis not only for the preservation of the breastfeeding relationship but in consideration of the infants overall development.

Conclusion

Based on the current research and the authors' clinical experience, there seems to be higher than reported prevalence and incidence of mild to moderate and moderate to severe mechanical birth stress, strain, and trauma in the infant population. A potential rise in birth stress, strain, and trauma, with or without ankyloglossia, may be another explanation of the increasing number of infant feeding difficulties and should not be misdiagnosed or mistreated as a posterior tongue tie. This misdiagnosis or the failure to recognize a concomitant situation could result in a less than optimal outcome. Due to the paucity of research available on both topics, the question remains unanswered as to whether there is a current exponentially growing number of children with the structural occurrence of posterior tongue tie or if there is a failure to recognize mild to moderate birth trauma sequelae like (breast) feeding dysfunction. Without reaching a collaborative consensus, there is the risk of normalizing anatomical variants or mechanically induced dysfunction interfering with breastfeeding instead of creating an avenue of support for the breastfeeding dyad.

Further research and investigation on the mechanism of mild to moderate mechanical birth stress, strain, and trauma's (as well as the posterior tongue tie's) effect on infant feeding function and overall development is warranted.

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