The Limbus and the Neolimbus in Developmental Dysplasia of the Hip

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Abstract The limbus and the neolimbus are both pathological lesions that form in response to a developmentally dislocated hip. An understanding of these structures is integral to treatment of developmental dysplasia of the hip (DDH). Yet, we believe the current peer-reviewed orthopaedic literature and orthopaedic textbooks commonly fail to correctly use or define these terms. The neolimbus is best defined as a hypertrophied ridge of fibrocartilage in the superolateral region of the acetabulum caused by pressure from the dislocated hip on this region. The limbus is the labrum that is hypertrophied with fibrous and fibrocartilaginous overgrowth, and is a potential block to concentric reduction of a dysplastic hip. We review the early and current literature in an attempt to clarify the use of the terms limbus and neolimbus and provide an overview of the importance and treatment of these abnormal structures associated with DDH.

Level of Evidence: Level V, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

While both the neolimbus and the limbus are distinct pathologic structures found in patients with DDH, these structures are often confused in textbooks and in the literature. The neolimbus, as described by Ortolani in 1976 [16], is a hypertrophied ridge of acetabular articular cartilage that forms in the superolateral aspect of the acetabulum in response to eccentric pressure of the femoral head (Fig. 1A–D).

The limbus is a pathologic structure that results when abnormal pressure from the femoral head on the labrum causes the fibrocartilaginous labrum to hypertrophy and form surrounding fibrous tissue. The limbus forms as a result of a secondary adaptive change that occurs with prolonged subluxation or dislocation of the hip [4]. The limbus is able to invert and evert, and is a potential block to concentric reduction of the dysplastic hip (Fig. 2).

We will describe the evolution of the limbus and neolimbus in the literature and clarify the definition, pathology and management of these pathologic structures.

The Limbus

The acetabular cartilage of the hip joint is composed of hyaline cartilage whereas the acetabular labrum is composed of fibrocartilage [21]. In 1946, Leveuf and Bertrand described the limbus as a hypertrophic labrum [11]. In 1976, Milgram and Tachdjian [12] proposed a mechanism for the pathologic changes that lead to the formation of the limbus. They suggested persistently dislocated hips mechanically stimulate the labrum, leading to labral hypertrophy. This may apply to the abnormal forces caused by subluxated hips as well. This hypertrophic labral tissue

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Fig. 1A–D (A) In this normal hip, the labrum [A] is located at the periphery of the cartilaginous acetabulum. (B) In the dysplastic reduced hip, note the hypertrophied labrum, now called the limbus [A]. The neolimbus [B], a hypertrophied ridge inside the cartilaginous acetabulum, is located at the periphery just beneath the limbus. (C) In this dislocated dysplastic hip, note how the limbus [A] is a block to reduction, and could invert or evert while the neolimbus [B] is not a potential block to reduction and cannot invert or evert. (D) Lateral view of the dysplastic acetabulum depicts the neolimbus [B] running from anterior to posterior beneath the limbus [A].

is generated by fibroblasts at the acetabular rim (Fig. 3). Many layers of this fibrous tissue extend over the cartilaginous labrum forming a new lip of fibrous tissue. The junction between the fibrous limbus and the fibrocartilaginous labrum is not a distinct margin. Although two distinct tissues comprise the margin, they merge without a discernable tissue plane [12]. The limbus generally forms on the superolateral aspect of the labrum, just as the neolimbus forms on the superolateral aspect of the acetabulum.

In 1990, Tachdjian [20] described the limbus as “a pathologic response to eccentric pressure” and “hypertrophic fibrous tissue with overgrowth of cartilaginous elements from the labrum.” This text also reports

mechanical stimulation from the dislocated femoral head leads to fibrous tissue formation over the labrum generated by fibroblasts at the acetabular rim [20].

The limbus has the potential to become inverted and obstruct concentric reduction of the hip. The inverted limbus can interpose itself between the femoral head and acetabular surface, thus preventing the femoral head from seating properly in the acetabulum. In 1948, Leveuf described the limbus as a “lesion” that only becomes an obstruction to reduction if it is “pushed down into the joint” [10]. In 1978, Ponseti described the limbus as a “hypertrophic labrum” that may or may not be inverted depending on whether the hip is truly dislocated or only

Fig. 2 An arthrogram of a patient with developmental dysplasia of the hip reveals how the labrum (arrow) can act as a barrier to reduction.

Fig. 3 In this photomicrograph of a limbus, note the fibrous structure covering the cartilaginous labrum and projecting toward the true joint cavity. Distinct tissue planes are lacking. (Stain, hematoxylin and eosin; original magnification $\times 9$) (Reprinted with permission from Herring JA. Tachdjian's Pediatric Orthopaedics, 3rd ed. Philadelphia, PA: WB Saunders; 2002. Figure 15-10, page 519. Courtesy of the Armed Forces Institute of Pathology, Bethesda, MD.)

subluxed [17]. Due to the spherical nature of the femoral head and the proximally oriented direction of the joint reactive forces, an inverted labrum can only exist in the presence of a frankly dislocated hip.

Some authors debate as to whether the limbus is partially composed of joint capsule. In 1962, Scaglietti and Calandriello [18] described a theory on the formation of the limbus. They believed that the dislocated femoral head everted the acetabular labrum and captured a piece of joint capsule between the labrum and the iliac surface. The labrum and the capsule, they felt, then adhered to one another and together became the so-called limbus. However, in 1976, Milgram and Tachdjian [12] reported the limbus did not appear to be formed by folded joint capsule

on the labrum; they found no evidence of such a double layer of fibrous tissue. They reported the formation of the limbus appeared to be locally induced by the presence of the dislocated femoral head placing abnormal pressure on the labrum causing hypertrophy.

The limbus can obstruct proper reduction of the dislocated hip. One study showed that the limbus likely disappears in 71% of patients by 5 years of age [5]. Therefore, much discussion has revolved around whether or not the limbus should be removed. In 1953, Somerville [19] wrote, "the inverted limbus is a very important, if not the all-important, cause of failure to achieve immediate and complete reduction of a congenitally dislocated hip." In his series of 23 open reductions of the hip, he completely excised the limbus in 21 hips and transversely cut the limbus in two other hips. This paper reported complete reduction and adequate outcomes, although there was no more than 3 years of followup.

As more has been learned about the growth and development of the hip joint however, alternative approaches to the removal of the limbus have been taken. Ponseti [17] pointed out that after prolonged joint displacement, cartilage degeneration may make it difficult to differentiate between the fibrocartilaginous limbus and the hyaline cartilage of the acetabulum. Some acetabular articular cartilage may therefore be excised unintentionally. The superior os acetabuli, an ossification center on the superolateral aspect of the acetabulum, contributes to normal coverage of the hip (Fig. 4) [21]. Because acetabular cartilage is epiphyseal cartilage, any of its removal may hinder hip growth and development [17].

Tachdjian, in 1990 [20], asserted the limbus, when it prevents or hinders concentric reduction of the hip, should

Fig. 4 Ossification center of the acetabular margin. (Reprinted with permission from Tönnis D. Congenital Dysplasia and Dislocation of the Hip in Children and Adults. Berlin, Germany: Springer-Verlag; 1987. Figure 2.2b, page 14.)

be excised cautiously without disturbing the acetabular cartilage responsible for growth. Others have reported this procedure is risky and is difficult to reliably accomplish in practice. In 2005, a report by Angliss et al. [1] looked at the long-term followup of nearly 150 patients who previously received open reduction for DDH. This article tried to determine early indicators that would help predict postoperative outcomes. They reported a worse outcome associated with excision of the limbus. In this study, although histological review of the excised specimen revealed fibrocartilage limbus tissue only, they believed that the hyaline cartilage of the acetabular rim was likely damaged by the removal of the limbus. This potential damage to the epiphyseal cartilage may lead to abnormal acetabular growth, thus resulting in poorer outcomes [1].

Removal of the limbus may also be disadvantageous as the limbus may be not only important for normal acetabular growth but also for hip stability. A study on dogs demonstrated that eversion of the acetabular labrum produced acetabular dysplasia [9]. Therefore, since the labrum is important in normal hip development, it is likely that the limbus is also important in deepening the hip socket, improving stability and therefore the likelihood of normal acetabular development. Radial splitting of the limbus has been proposed as an alternative that may avoid violating the acetabular epiphyseal cartilage [9].

In 1997, Tumer et al. [22] studied 56 developmentally dislocated hips in 37 children with an average age of approximately 11 months that underwent open reduction. They found that it was not necessary to remove the limbus in order to achieve concentric reduction and that such excision may lead to osteoarthritis development in later years.

The Neolimbus

Ortolani originally described the neolimbus as a ridge of cartilage within the superolateral aspect of the acetabulum that forms as a reaction to femoral head pressure in the dysplastic hip [16]. This is distinct from the limbus, which is a hypertrophic labrum with fibrous overgrowth. In 1978, Ponseti [17] described the neolimbus as a ridge in the acetabular articular cartilage and showed histologically that it was composed of hypertrophic acetabular fibrocartilage. Ponseti agreed that the neolimbus ridge was formed by pressure exerted on the periphery of the acetabular articular cartilage by the displaced femoral head [17].

Authors of chapters in modern textbooks including Tachdjian's *Pediatric Orthopaedics* [6] and Lovell and Winter's *Pediatric Orthopaedics* [23] concur with the early literature and confirm the description of the neolimbus as a hypertrophic ridge of acetabular cartilage.

The Ortolani sign, or "click of entry," is felt as the femoral head slides over the ridge of acetabular articular cartilage from a subluxated or dislocated position into the true acetabulum [16, 23]. When the Ortolani sign resolves, it is not known whether this occurs due to resolution of the neolimbus or subsidence of the normal newborn ligamentous laxity that is normal after 2 to 3 months. This most likely depends on the age of the child. Ortolani [16] described his maneuver in the 3- to 4-month-old child, not the newborn. The Barlow sign, or "click of exit," is felt as the femoral head slides from a reduced position in the normal acetabulum over the neolimbus out of the true acetabulum in a subluxable or dislocatable hip [2, 23]. Unlike the limbus, the neolimbus is not an obstacle to reduction [8, 17].

The neolimbus is not a fixed deformity and will eventually spontaneously resolve once the femoral head has properly been reduced [6, 17]. This is because the neolimbus contains the secondary center of ossification, which does not appear until a much later age. The neolimbus always contains acetabular cartilage, and therefore epiphyseal cartilage, which is involved in the growth and development of the older child's acetabulum. Therefore, the neolimbus should never be removed or it will disrupt acetabular development [15, 17].

Discussion

Current literature often confuses or fails to correctly describe the limbus and the neolimbus. An orthopaedic dictionary [7] from 1994 incorrectly defines the limbus as "a fibrous, resilient, sharp-edged, crescent-shaped tissue attached to the bony rim of the acetabulum and the transverse acetabular ligament. Its free edge cups around the head of the femur to increase the stability of the hip joint. Also known as the Acetabular Labrum." This is the definition of the labrum, not the limbus.

In the chapter describing the normal anatomy of the developing acetabulum from the textbook of Tönnis' et al., the authors describe the "labrum" or "acetabular labrum" that has "come to be preferred over the older terms 'limbus' and limbus articularis'" [21]. However, rather than an evolution of a term, this probably represents confusion of the limbus - a pathologic structure seen in dysplastic hips - with the labrum, a normal structure.

Wheless' *Textbook of Orthopaedics* [24], an online orthopaedic reference popular with orthopaedic surgical residents, refers to the "inverted neolimbus" as a "rare type of obstruction in DDH," and a "lip of hypertrophied fibrocartilage" that "may be infolded or everted." This would be an accurate description of the limbus not the neolimbus.

In a 2002 article discussing complications of failed open reductions in DDH, Chmielewski and Albinana [3] describe that osteonecrosis (ON) can occur secondary to increased pressure against the posterior acetabular rim as well as the neolimbus, referencing an article by Morcuende et al. [13] among others. However, Morcuende et al. actually state that it is the increased pressure against the posterior part of the acetabular rim as well as the limbus that may lead to ON [13].

Whether the comment by Chmielewski and Albinana [3] is a correction or a mistake, however, is not clear, since the referenced article by Morcuende et al. [13] itself does not consistently define the terms limbus and neolimbus correctly. For instance, these authors classify the “neolimbus” into three types, depending on whether it was inverted, everted, or neither. They also use the term “inverted neolimbus” three times. These authors must mean “limbus” and “inverted limbus” instead, as it is the fibrous, hypertrophied labrum (or limbus) and not the small ridge of acetabular cartilage (or neolimbus) that is able to invert and evert. Therefore, when they report that pressure of the limbus on the lateral physis of the femoral head may be responsible for ON, it is not clear whether they actually mean limbus or neolimbus. Probably either one could, at least in theory, be responsible.

Similarly, a 2005 article by Angliss et al. [1] describes an “inverted neolimbus” as a poor prognostic factor in the open reduction of DDH. These authors mean “inverted limbus,” as this is the entity with the potential to block reduction. An English text refers to the neolimbus as a block to reduction and discusses the possibility of radialization of this structure [14]; again substituting the term neolimbus for limbus (which according to some authors is the structure that may benefit from radialization).

Clearly the terms are often confused for one another in modern textbooks and peer-reviewed literature. It is therefore imperative these terms be clarified and used correctly in order to avoid confusion, especially since the presentation and management of these two entities are so different.

The limbus and the neolimbus are both important pathologic structures that occur in developmental dysplasia of the hip. Most accurately, the neolimbus represents a hypertrophic ridge of acetabular articular cartilage whereas the limbus is a hypertrophic labrum with fibrous and fibrocartilaginous overgrowth. The use of the term “inverted neolimbus” is not accurate and should be replaced with the term “inverted limbus.”

The neolimbus may at times cause the palpable “click” heard on clinical exam. It is not an obstruction to reduction and will spontaneously resolve assuming quick diagnosis and proper reduction. The neolimbus should never be excised.

The limbus can also resolve spontaneously in a reduced hip or can invert and cause obstruction to concentric reduction. There has been debate about its removal, although current reports argue that excision should be avoided.

Both the limbus and the neolimbus have been proposed as potentially causing or contributing to ON, though due to the confusion of terms in the literature it is not clear which of the two structures is being proposed as the offender. Most likely, both the limbus and the neolimbus are potential causes of ON due to pressure on the lateral femoral head and physis when the hip is positioned in forced abduction.

In conclusion, limbus and neolimbus are important terms for clinicians managing DDH. The hopeful future correct use of these terms in the literature and discussions will help clarify the surgical management of DDH.

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