

# 骨化核与发育性髋关节发育不良闭合复位后股骨头缺血坏死相关性的研究进展



全文二维码

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**【摘要】** 发育性髋关节发育不良 (developmental dysplasia of the hip, DDH) 是常见的儿童肢体畸形, 早期筛查和诊断非常重要, 延误治疗或治疗不当将导致严重后果。股骨头缺血性坏死 (avascular necrosis, AVN) 是 DDH 闭合复位后严重且常见的并发症, 如何预防及避免 AVN 的发生一直困扰着小儿骨科医师。闭合复位前骨化核的存在似乎有助于降低 AVN 发生率, 避免 AVN 的发生与 DDH 早诊断、早治疗关系密切。本文就骨化核与 DDH 闭合复位后 AVN 相关性的研究进展进行综述。

**【关键词】** 发育性髋关节发育不良; 股骨头坏死; 病因学; 病理生理学

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## Research advances on the relationship of ossification nucleus with avascular necrosis of developmental hip dysplasia after closed reduction

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**【Abstract】** Developmental hip dysplasia (DDH) is one of the most common extremity deformities in children. Early screening and timely diagnosis are essential in the treatment of DDH. Delayed or improper interventions lead to serious consequences. Avascular necrosis (AVN) of the femoral head is the most serious and common complication after closed reduction of DDH. Practical difficulty of preventing and avoiding the occurrence of AVN has always perplexed pediatric orthopedic surgeons. The existence of ossification nucleus before closed reduction seems to be helpful to reduce the incidence of AVN. Waiting for the appearance of ossification nucleus means postponing treatment. Balancing the occurrence of AVN and the concept of early diagnosis and treatment of DDH are particularly important. This review summarized the relevant literature to further explore whether the existence of ossification nucleus before closed reduction affects the occurrence of AVN and discussed the influence of ossification nucleus on the timing of clinical treatment.

**【Key words】** Developmental Dysplasia of the Hip; Femur Head Necrosis; Etiology; Physiopathology

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发育性髋关节发育不良 (developmental dysplasia of the hip, DDH) 又被称为先天性髋关节脱位 (congenital dislocation of the hip, CDH), 是一种常见的儿童肢体畸形, 发病率约为 1%<sup>[1]</sup>。目前, 6~18 月龄 DDH 患儿的首选治疗方案是闭合复位加髋人字石膏外固定<sup>[2]</sup>。股骨头缺血性坏死 (avascular

necrosis, AVN) 是 DDH 保守治疗或外科干预后常见且严重的并发症, 发生率为 5%~48%, 闭合复位加髋人字石膏固定后 AVN 的发生率可能较其他治疗方案更高<sup>[3-6]</sup>。AVN 可导致患侧髋部疼痛、无法正常行走、肢体长度不一致、关节僵硬、持续性半脱位、髋外翻等后遗症, 这些变化会严重影响髋关

节功能,影响患儿生活质量,加速髋关节退行性病变,从而增加后续翻修、关节置换和姑息性手术的需求<sup>[7]</sup>。因此,如何预防 DDH 治疗后 AVN 的发生十分重要。目前,普遍认为 DDH 应该在早期诊断后及时治疗,因为髋关节生长和重塑的潜力在出生时最大,此后逐渐下降<sup>[8-9]</sup>。DDH 治疗前骨化核的存在可有效降低 AVN 的发生率,多数学者主张延迟复位,但一般不超过 13 月龄<sup>[10-12]</sup>。近年来越来越多的研究认为,骨化核的存在并不能有效降低 AVN 的发生率,不论骨化核是否出现,都应早期复位<sup>[13-17]</sup>。然而,不同地区 DDH 筛查和诊断水平存在差异,可能造成延迟就诊、漏诊等情况,因此大部分研究中患儿个体间月龄差异很大,很少有研究将不同月龄患儿进行分组分析<sup>[18]</sup>。在平均月龄较大的患儿中,AVN 的发生与骨化核的存在显著相关;而在平均月龄较小的患儿中,AVN 的发生与骨化核的存在无显著相关性<sup>[4]</sup>。

### 一、骨化核的正常发育及保护作用

#### (一) 股骨头的正常发育及血供

正常情况下从妊娠第 7 周开始,股骨近端开始骨化,股骨内侧在出生后 4~6 个月出现股骨头骨化核,并在 14~16 岁与股骨近端融合。当髋关节脱位时股骨头内的骨化核可能延迟出现<sup>[19]</sup>。股骨近端外侧的大粗隆骨化核大概在 4 岁时出现,并在 14 岁(女)和 16 岁(男)时与股骨近端融合形成大粗隆<sup>[20-21]</sup>。AVN 的危险因素包括骨折、激素或酒精中毒以及医源性因素等,但确切原因尚不清楚<sup>[22]</sup>。DDH 患儿发生 AVN 多由于复位后股骨头压力过大、阻碍其血液供应而引起<sup>[6]</sup>。Trueta 等<sup>[23]</sup>和 Ogden 等<sup>[24]</sup>对婴幼儿和青少年尸体标本的股骨近端血液供应进行解剖,发现还未骨化的股骨近端软骨骨骺内存在弥漫的管状血管网络,由终末微动脉供应血液,该时期内终末微动脉抵抗压迫的能力较差,易发生缺血坏死。骨化核出现后,股骨近端的主要血供模式也发生了改变,随着骨化核进一步发育成熟,参与其血供的侧支循环逐渐形成,此时股骨头抗压能力明显增强,理论上可以降低闭合复位后 AVN 的发生率。股骨近端的软骨骨骺和生长板由旋股深动脉的两个分支(股骨颈后内侧的旋股内侧动脉和股骨颈前外侧的旋股外侧动脉)供血,供血比例大致相等,血管发育的特点是圆韧带动脉供血减少、旋股外侧动脉系统退化以及旋股内侧动脉系统进化<sup>[21,24]</sup>。此后,旋股内侧动脉的后上支和后下支组成的骨骺外侧血管为股骨头提供主要的血供,其中后上支供血占比更大,这两个分支也为成年后的股骨头提供了最主要的血液供应<sup>[25-27]</sup>。10 岁以后,骨骺的血液供应少部分来自圆韧带动脉,大部分来自旋股内侧动脉。到骨骼成熟时,圆韧带、干骺端和骨骺的血管之间发生吻合,形成股骨头血管环。Dewar 等<sup>[28]</sup>对 10 例尸体的骨盆标本进行研究,量化了旋股内侧动脉、旋股外侧动脉对股骨头和股骨颈血供的相对贡献,通过聚氨酯和硫酸钡灌注后的 CT 三维重建数字减影图像,发现旋股内侧动脉对股骨头、颈部的供血占比分别达到 82% 和 67%,是股骨头、颈部的主要供血动脉<sup>[29]</sup>。

#### (二) 骨化核的保护作用

动物研究表明,骨化核的存在增加了股骨头骨骺的机械

强度,可能会减少复位时和复位后对股骨头血运的影响,Segal 等<sup>[30]</sup>在猪模型中发现,骨化核的结构刚度随骨化核的大小呈指数增加,当骨化核占骨骺体积的 40% 时,旋股内侧动脉后上支区域的压缩应变平均降低 54%。因此理论上认为,在未成熟软骨性股骨头内存在的骨性骨化核可能会减轻股骨头受压程度,从而避免或减少 AVN 的发生。在 DDH 治疗中,强迫外展位是导致 AVN 的最常见原因,在股骨头血供逐渐向旋股内侧动脉过渡的阶段,股骨头骨骺和生长板的前段及外侧段血管更容易受到损伤,而旋股内侧动脉的起始走行在髂腰肌和内收长肌之间<sup>[31]</sup>。复位年龄、性别、脱位程度、石膏类型、术前牵引和支具治疗与 AVN 的发生无关<sup>[16-17,32-34]</sup>。Salter 等<sup>[35]</sup>通过对幼猪髋关节施加持续的外展应力,发现其股骨头骨骺软骨管内的血管发生缺血坏死,这一研究结果验证了复位后强制外展髋关节会增加股骨头的机械应力,从而影响股骨头的血供,造成 AVN。

### 二、延迟复位的潜在风险

#### (一) 基于理论依据的临床研究

Segal 等<sup>[10]</sup>对 49 例(57 髋)12 月龄以内的 DDH 患儿进行闭合或切开复位,发现有骨化核组与无骨化核组的 AVN 发生率分别为 4% 和 53%。该研究认为,在进行闭合或开放复位前,骨化核的存在可能会降低 AVN 的发生率。Carney 等<sup>[11]</sup>也认为骨化核的存在可能会降低 AVN 的发生率,建议在骨化核未出现时延迟闭合复位。Clarke 等<sup>[12]</sup>的一项前瞻性研究表明,对于未接受治疗的 DDH 患儿,延迟治疗直到骨化核出现是必要的,骨化核的存在是预防 AVN 的一个重要因素,特别是在晚期闭合复位后。该研究认为,延迟复位并不会使患儿丧失闭合复位的机会,因为无论是否出现骨化核,最晚应在 13 个月时进行闭合复位,但二次手术概率增加。该研究中虽然 AVN 的发生率并不高,闭合组与切开组分别为 7% 和 14%,但分别有 57% 和 41% 的患儿需要二次手术,随着随访时间延长,这一比例还将继续增加,可能与错过了髋关节发育和重塑的最佳时间有关。

然而,即使骨化核的存在可能会降低复位后 AVN 的发生率,但在脱位或半脱位的髋关节中,骨化核出现的时间往往要晚于正常髋关节,一味地延迟治疗可能会避免 AVN 的发生,但很可能会错过髋关节重塑的最佳时期,导致接受二次重建手术的风险升高。近年来越来越多的学者不赞成延长闭合复位的时间。Luhmann 等<sup>[14]</sup>针对 124 例(153 髋)DDH 患儿的研究表明,DDH 复位时骨化核的存在与 AVN 的发生无关,治疗时无需考虑骨化核是否出现,其后通过随访发现,DDH 复位时间延迟到骨化核出现后会错过髋关节重塑的最佳时间,使未来重建手术的需求增加一倍以上。

#### (二) 骨化核与不同程度股骨头缺血坏死的关系

大部分相关研究只关注复位后 AVN 是否发生,而忽视了 AVN 的严重程度以及不同严重程度 AVN 对髋关节的远期影响。Cooke 等<sup>[15]</sup>一项长达 11 年的研究表明,闭合复位时无论骨化核是否出现,都不会对 AVN 的发生和髋关节远期预后造成影响。Roposch 等<sup>[36]</sup>采用结论分析评估延迟复

位和早期复位对髋关节的远期影响,不仅考虑 AVN 发生与否,同时将 AVN 和残余髋关节发育不良可能导致的终生残疾考虑在内,结果显示,延迟复位比早期复位更有优势,导致终生残疾的可能性更小。但该研究所使用的数据均为其他作者已报道的回顾性研究数据,缺乏相应的临床和随机对照证据。

部分研究认为, I 级 AVN 的影像学特征无异常,可认为 I 级 AVN 本质上并不属于 AVN。Roposch 等<sup>[37]</sup>通过 Meta 分析发现,对闭合复位的患儿而言,骨化核的存在使 AVN 的发生率降低了 60%,而切开复位则没有该作用。随后的研究发现,无论影像学上 AVN 的分级如何,骨化核的存在均没有保护作用<sup>[16]</sup>。Niziol 等<sup>[38]</sup>和 Chen 等<sup>[39]</sup>于 8 年后发表了关于此内容的 Meta 分析,纳入的文献更多,证据等级更高。这项新的研究表明,无论对于哪个分期的 AVN,骨化核均无保护作用,因此,该研究不建议为了降低 AVN 发生率而延迟复位。虽然大部分研究表明,复位时年龄与 AVN 的发生无明显相关性,但 Sllamniku 等<sup>[40]</sup>研究发现,在初始治疗年龄≤10 个月的患儿中,AVN 发生率与骨化核是否存在无明显相关性,该研究主张 DDH 治疗应该尽早进行,而无需考虑骨化核是否存在。

总体而言,复位前股骨头骨化核的存在通过血供模式的改变以及机械应力的增加,在一定程度上增加了复位后股骨头抵抗缺血坏死的能力,但单纯以骨化核存在与否作为延迟复位的标准仍不可取,还应该考虑患儿的整体预后情况和生存质量。如果单纯为了降低 AVN 的发生率而延迟治疗,可能会增加二次重建手术的概率。减少 AVN 发生的同时不影响治疗质量、不增加二次手术的风险并不是绝对矛盾的,这需要更多的随机对照研究量化骨化核大小、月龄与 AVN 的关系,但目前不建议因骨化核未出现而延迟 DDH 的治疗。

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