骨化核对发育性髋关节脱位术后股骨头缺血性坏死的影响研究

全文二维码

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【摘要】 **目的**　探讨股骨头骨化核对6～24月龄发育性髋关节脱位（developmental dysplasia of the hip，DDH）患儿治疗后发生股骨头缺血性坏死（avascular necrosis of femoral head，AVN）的影响。 **方法**　回顾性分析2018年1月至2022年1月期间在昆明市儿童医院接受石膏固定术治疗的6～24月龄DDH患儿的髋关节临床资料。依据末次随访时患髋股骨头是否坏死分为：AVN（+）组（Kalamchi-MacEwen分型Ⅰ～Ⅳ型）、AVN（-）组（Kalamchi-MacEwen分型未见坏死）；根据股骨头是否出现临床坏死分为临床AVN（+）组（Kalamchi-MacEwen分型Ⅱ～Ⅳ型）、临床AVN（-）组（Kalamchi-MacEwen分型Ⅰ型或未见坏死）；根据手术年龄分为6～12月龄组、12～18月龄组和18～24月龄组。比较AVN（+）组与AVN（-）组患儿性别、患髋骨化核状态、侧别、手术年龄、手术方式、术前国际髋关节发育不良协会（International Hip Dysplasia Institute，IHDI）分型、术前髋臼指数（acetabular index，AI）值、外展角度，采用二元Logistic回归分析评估DDH术后发生AVN的独立影响因素，基于独立影响因素绘制受试者操作特征（receiver operating characteristic，ROC）曲线评估其对DDH术后发生AVN的诊断效能。对比临床AVN（+）组与临床AVN（-）组患髋的骨化核状态，分析骨化核状态对临床AVN的影响。对比6～12月龄组、12～18月龄组、18～24月龄组患髋AVN发生率、临床AVN发生率、再脱位发生率、残余髋臼发育不良（residual acetabular dysplasia，RAD）发生率。 **结果**　本研究共纳入221髋。AVN（+）组54髋，AVN（-）组167髋。患髋中有骨化核者AVN发生率为18.1%（27/149），无骨化核者ANV发生率为37.5%（27/72），有骨化核者AVN发生率显著低于无骨化核者（$P=0.002$）。多因素Logistic回归分析发现，骨化核状态（$OR=3.064$，95% CI：1.486～6.319）、外展角度（$OR=1.184$，95% CI：1.110～1.264）、术前IHDI分型（$OR=3.821$，95% CI：1.465～9.968）是DDH术后发生AVN的独立影响因素（$P<0.05$）。ROC曲线分析显示外展角度预测DDH术后发生AVN的最佳截断值为63.5°，曲线下面积（area under curve，AUC）为0.752，灵敏度为0.500，特异度为0.934。有骨化核者临床AVN发生率为14.1%，无骨化核者临床ANV发生率为26.4%，有骨化核者临床AVN发生率显著低于无骨化核者（$P=0.026$）。6～12月龄组、12～18月龄组、18～24月龄组AVN发生率分别为20.0%、31.7%、46.1%，临床AVN发生率分别为11.3%、25.0%、26.1%，再脱位发生率分别为1.7%、8.3%、13.0%，RAD发生率分别为27.0%、45.0%、54.3%；3个手术年龄组间比较，AVN发生率差异均无统计学意义（$P=0.224$），但临床AVN发生率、再脱位发生率和RAD发生率差异均有统计学意义（$P<0.05$）。 **结论**　骨化核状态、外展角度、术前IHDI分型是DDH患髋术后发生AVN的独立影响因素。骨化核出现对股骨头具有保护作用，可显著降低AVN及临床AVN的发生率，但随着年龄增大，临床AVN发生率、再脱位发生率和RAD发生率增高，会导致相对不良的预后，因此建议在有复位指征时尽早进行DDH治疗，无需等待骨化核出现。

【关键词】 发育性髋关节脱位；股骨头缺血性坏死；外科手术；儿童
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Effect of ossification on avascular necrosis of femoral head after operation for developmental dysplasia of the hip

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【Abstract】 **Objective** To explore the effect of ossified nuclei on avascular necrosis of femoral head (AVN) in children aged 6 – 24 month with developmental dysplasia of the hip (DDH) and examine whether or not DDH therapy should be deferred until the emergence of ossified nuclei. **Methods** The clinical data of hip joint in children with DDH aged 6 to 24 months who received plaster fixation in Kunming Children's Hospital from January 2018 to January 2022 were retrospectively analyzed. According to the necrosis of the hip head at the last follow-up, it was divided into: AVN (+) group (Kalamchi-MacEwen type Ⅰ ~ Ⅳ), AVN (–) group (Kalamchi-MacEwen type no necrosis), The femoral head was divided into clinical AVN (+) group (Kalamchi-MacEwen type Ⅱ to Ⅳ) and clinical AVN (–) group (Kalamchi-MacEwen type I or no necrosis) according to whether clinical necrosis occurred, and were divided into 6 to 12 months of age group, 12 to 18 months of age group and 18 to 24 months of age group according to operative age. The ossified nucleus status, gender, side, age, mode of operation, preoperative IHDI classification, preoperative AI value, and abduction Angle of the affected hip were compared between the AVN (+) group and the AVN (–) group, and the independent influencing factors of postoperative AVN were evaluated by multivariate Logistic regression analysis. receiver operating characteristic curve (ROC) was drawn based on independent influencing factors to evaluate its diagnostic efficacy for postoperative AVN after DDH. The status of ossified nucleus of hip in clinical AVN (+) group and clinical AVN (–) group were compared to analyze the influence of ossified nucleus status on clinical AVN. The incidence of AVN, clinical AVN, redislocation and residual acetabular dysplasia (RAD) of the affected hip in the 6 – 12 months age group, the 12 – 18 months age group and the 18 – 24 months age group were analyzed. **Results** A total of 221 hips were included in the study. The AVN (+) group had 54 hips and the AVN (–) group had 167 hips. In all affected hips, the incidence of AVN with ossified nucleus was 18.1%, and the incidence of ANV without ossified nucleus was 37.5%. The incidence of AVN with ossified nucleus was significantly lower than that without ossified nucleus ($P = 0.002$). Multivariate Logistic regression analysis showed that the status of ossified nucleus ($OR = 3.064$, 95% CI: 1.486 – 6.319), abducting Angle ($OR = 1.184$, 95% CI: 1.110 – 1.264), preoperative IHDI classification ($OR = 3.821$, 95% CI: 1.465 ~ 9.968) were independent influencing factors for postoperative AVN after DDH ($P < 0.05$). ROC Curve analysis showed that the best truncation value of abduction Angle for predicting AVN after DDH was 63.5°, the Area Under Curve (AUC) was 0.752, the sensitivity was 0.500, and the specificity was 0.934. The incidence of clinical AVN in patients with ossified nucleus was 14.1%, and the incidence of clinical ANV in patients without ossified nucleus was 26.4%. The incidence of clinical AVN in patients with ossified nucleus was significantly lower than that in patients without ossified nucleus ($P = 0.026$). The incidence of AVN in 6 – 12 months, 12 – 18 months and 18 – 24 months age groups was 20.0%, 31.7% and 46.1%, respectively. The clinical incidence of AVN was 11.3%, 25.0% and 26.1%, and the rate of redislocation was 1.7%, 8.3% and 13.0%, respectively. The RAD rates were 27.0%, 45.0% and 54.3%, respectively. There was no significant difference in the incidence of AVN among the three operative age groups ($P = 0.224$), but the incidence of AVN and redislocation were clinically significant. **Conclusions** The status of ossified nucleus, abduction Angle and preoperative IHDI type were independent factors for postoperative AVN in DDH affected hips. The appearance of ossified nucleus has a protective effect on the femoral head and can significantly reduce the incidence of AVN and clinical AVN. However, with the increase of age, the incidence of clinical AVN, the rate of re-dislocation and the rate of RAD will increase, which will lead to a worse prognosis. Therefore, it is recommended that DDH treatment should be performed as soon as possible when there are indications of reduction, without waiting for the appearance of ossified nucleus.

【Key words】 Ossified Nucleus of Femoral Head; Developmental Dysplasia of The Hip; Surgical Procedures, Operative; Child

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发育性髋关节脱位(developmental dysplasia of the hip, DDH)是儿童常见髋关节畸形,严重者可引起股骨头坏死,影响患儿及其家庭生活质量[1]。对于6~24月龄DDH患儿,一般建议首先采用闭合复

位术，闭合复位失败者行单纯切开复位术治疗，治疗目的在于恢复髋关节稳定及减少并发症发生。股骨头缺血性坏死（avascular necrosis of femoral head，AVN）是 DDH 术后最严重的并发症，其发病率为 6%~48%，股骨头一旦发生坏死，严重者将导致髋关节疼痛和严重功能障碍[2]。DDH 治疗时骨化核是否出现与 AVN 发生的关系日益受到重视，虽然多年来 DDH 治疗遵从“早发现、早治疗”的原则，但有研究人员认为骨化核对股骨头具有保护作用，可降低股骨头坏死率，应等待骨化核出现再行 DDH 治疗，为此不少研究者对 DDH 的治疗时机选择存在顾虑[3-5]。目前，骨化核出现是否可降低 AVN 发生率仍存在争议。Gornitzky 等[4]研究认为等待骨化核出现再行 DDH 治疗可降低 AVN 发生率；Niziol 等[6]则认为骨化核的出现不会降低 AVN 发生率；Yilar 等[7]研究表明，骨化核的存在虽然降低了 AVN 的发生率，但等待骨化核形成时患儿年龄增大，此时行 DDH 治疗会显著增加术后并发症发生率，因此建议尽早手术。基于是否应延迟 DDH 治疗这一争论，本研究围绕 6~24 月龄 DDH 患儿术后 AVN 的影响因素，分析骨化核与 AVN 的关系，探讨 DDH 治疗是否应等待骨化核出现。

资料与方法

一、研究对象

回顾性分析 2018 年 1 月至 2022 年 1 月期间在昆明市儿童医院接受石膏固定术治疗的 6~24 月龄 DDH 患儿临床资料。病例纳入标准：①手术年龄 6~24 个月；②2018 年 1 月至 2022 年 1 月期间于本院行闭合或单纯切开复位石膏固定术；③随访时间≥12 个月。排除标准：①影像学资料不完整；②存在脑性瘫痪、多关节挛缩、神经肌肉疾病等引起的病理性髋关节脱位；③接受过吊带或支具治疗。符合以上纳排标准者共 221 髋，治疗时年龄（11.06±4.21）个月，随访时间（44.06±18.62）个月。本研究经昆明市儿童医院伦理委员会审核批准（2024-05-005-K01），患儿家属均知情同意。

二、治疗方法

闭合复位石膏固定术：在全身麻醉下进行闭合复位。患儿屈髋屈膝，双髋外展进行手法试复位，如果外展受限，则于大腿内侧行内收肌离断术，复位稳定后将髋关节行人类位石膏固定。闭合复位失败者，行单纯切开复位石膏固定术，患儿取仰卧位，全身麻醉后常规消毒、铺巾。选择内侧 Weinstein 入路，于大腿内侧行内收肌离断术，于耻骨肌和股鞘肌间隙进入，关节囊行“T”型切开，清除髋臼内脂肪垫，切除圆韧带、横韧带，复位股骨头，缝合切口各层。再次复位髋关节，用髋关节人类位石膏固定。

三、资料收集及随访

收集患儿手术年龄、性别、侧别、手术方式等。在 X 线正位片上，观察有无股骨头骨化核、测量术前髋臼指数（acetabular index，AI）、术前股骨头脱位程度[根据国际髋关节发育不良协会（International Hip Dysplasia Institute，IHDI）方法进行分型]、AVN 分型（Kalamchi-MacEwen 分型Ⅰ~Ⅳ型）、临床 AVN 分型（Kalamchi-MacEwen 分型Ⅱ~Ⅳ型），评估残余髋臼发育不良（residual acetabular dysplasia，RAD）和再脱位[8-11]。在术后 MRI 上测量髋关节外展角度。

四、统计学处理

采用 SPSS 25.0 进行数据整理与分析。对于性别、侧别、手术方式、骨化核状态、术前 IHDI 分型、手术年龄、AVN、临床 AVN、再脱位、RAD 等计数资料以频数（%）表示，组间比较采用 χ^2 检验（样本量均大于 40，无一数值为 0 的单元格及数值小于 5 的单元格占比均低于 20%）。对于外展角度，随访时间、术前 AI 值等服从正态分布的计量资料以 $\bar{x} \pm s$ 表示，组间比较采用两独立样本 t 检验。DDH 术后发生 AVN 的独立影响因素采用二元 Logistic 回归，绘制受试者操作特征（receiver operating characteristic，ROC）曲线分析 DDH 术后发生 AVN 的最佳截断值、曲线下面积（area under curve，AUC）、灵敏度、特异度等。$P<0.05$ 为差异有统计学意义。

结　果

共纳入 221 髋，其中 AVN（+）组 54 髋、AVN（-）组 167 髋；男性 26 髋、女性 195 髋，左侧 126 髋、右侧 95 髋，行闭合复位术 127 髋、行单纯切开复位术 94 髋；术前脱位程度根据 IHDI 分型：Ⅱ型 68 髋、Ⅲ型 92 髋、Ⅳ型 61 髋，所有患髋随访时间（42.08±17.97）个月。AVN（+）组与 AVN（-）组患儿性别、患髋侧别、手术年龄、手术方式、术前 AI 值、随访时间差异无统计学意义（$P>0.05$），骨化核状态、术前 IHDI 分型、外展角度差异有统计学意义（$P=0.029$）。有骨化核的患髋 AVN 发生率明显低于无骨化核者（$P=0.002$）。见表 1。

表 1　影响 DDH 术后发生 AVN 的单因素分析

Table 1　Single factor analysis of AVN after DDH operation

变量	AVN(+)组($n=54$)	AVN(−)组($n=167$)	χ^2/t 值	P 值
骨化核状态[髋(%)]			$\chi^2=9.874$	0.002
有	27(18.1)	122(81.9)		
无	27(37.5)	45(62.5)		
性别[髋(%)]			$\chi^2=0.029$	0.864
男	6(23.1)	20(76.9)		
女	48(24.6)	147(75.4)		
侧别[髋(%)]			$\chi^2=0.062$	0.803
左	30(23.8)	96(76.2)		
右	24(25.3)	71(74.7)		
术龄[髋(%)]			$\chi^2=2.992$	0.224
6~12 月龄	23(20.0)	92(80.0)		
12~18 月龄	19(31.7)	41(68.3)		
18~24 月龄	12(26.1)	34(73.9)		
手术方式[髋(%)]			$\chi^2=2.538$	0.111
闭合复位术	26(20.5)	101(79.5)		
单纯切开复位术	28(29.8)	66(70.2)		
术前 IHDI 分型[髋(%)]			$\chi^2=7.110$	0.029
Ⅱ型	11(16.2)	57(83.8)		
Ⅲ型	21(22.8)	71(77.2)		
Ⅳ型	22(63.9)	39(36.1)		
术前 AI 值($\bar{x}\pm s$,°)	36.50±6.07	36.60±5.51	$t=1.947$	0.911
外展角度($\bar{x}\pm s$,°)	62.57±7.87	56.98±4.77	$t=4.943$	<0.001
随访时间($\bar{x}\pm s$,月)	40.00±16.48	42.75±18.42	$t=-0.997$	0.330

注　DDH:发育性髋关节脱位; AVN:股骨头缺血性坏死; AI:髋臼指数; IHDI:国际髋关节发育不良协会

Logistic 回归分析结果显示,骨化核状态、外展角度、术前 IHDI 分型是 DDH 术后发生 AVN 的独立影响因素($P<0.05$),见表 2。

ROC 曲线分析显示:外展角度预测 DDH 术后发生 AVN 的最佳截断值为 63.5°($P<0.001$),AUC 为 0.752;灵敏度为 0.500,特异度为 0.934。见图 1。有骨化核的患髋临床 AVN 发生率明显低于无骨化核者($P=0.026$)。见表 3。

三个月龄组比较,AVN 发生率差异无统计学意义($P=0.224$),但临床 AVN 发生率、再脱位发生率与 RAD 发生率差异有统计学意义($P<0.05$)。见表 4。

表 2　影响 DDH 术后发生 AVN 的多因素 Logistic 回归分析

Table 2　Multivariate Logistic regression analysis of AVN after DDH operation

因素	β 值	SE 值	OR 值	OR 值 95% CI	P 值
骨化核状态	1.120	0.369	3.064	1.486~6.319	0.002
外展角度	0.169	0.033	1.184	1.110~1.264	<0.001
术前 IHDI 分型	1.340	0.489	3.821	1.465~9.968	0.006

注　IHDI:国际髋关节发育不良协会; DDH:发育性髋关节脱位; AVN:股骨头缺血性坏死

表 3　骨化核状态与 DDH 术后发生临床 AVN 的关联性分析[髋(%)]

Table 3　Relationship between ossified nucleus status and clinical AVN after DDH operation[n(%)]

骨化核状态	临床 AVN(+)组($n=40$)	临床 AVN(−)组($n=181$)	χ^2 值	P 值
有	21(14.1%)	128(85.9%)	4.950	0.026
无	19(26.4%)	53(73.6%)		

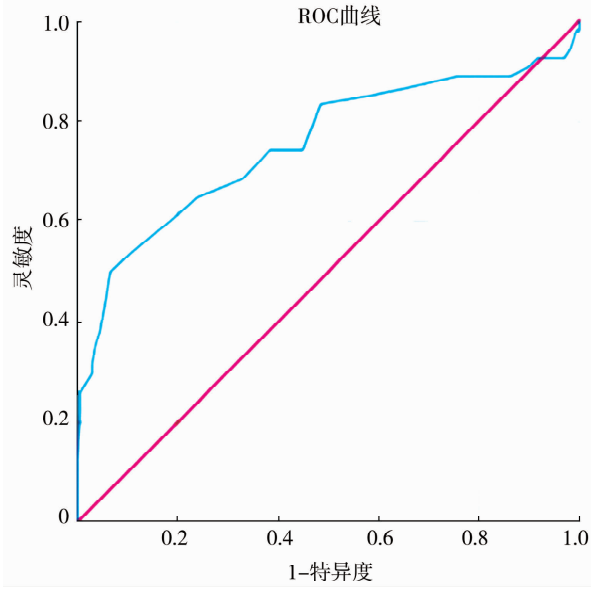
注　AVN:股骨头缺血性坏死; DDH:发育性髋关节脱位

表 4　不同手术年龄组 DDH 患儿预后比较[髋(%)]

Table 4　Prognostic comparison of DDH children of different operative age groups[*n*(%)]

分组	再脱位		临床 AVN 状态		AVN 状态		RAD	
	是	否	(+)	(-)	(+)	(-)	是	否
6~12 月龄组 (n=115)	2 (1.7)	113 (98.3)	13 (11.3)	102 (88.7)	23 (20.0)	92 (80.0)	31 (27.0)	84 (73.0)
12~18 月龄组 (n=60)	5 (8.3)	55 (91.7)	15 (25.0)	45 (75.0)	19 (31.7)	41 (68.3)	27 (45.0)	33 (55.0)
18~24 月龄组 (n=46)	6 (13.0)	40 (87.0)	12 (26.1)	34 (73.9)	12 (26.1)	34 (73.9)	25 (54.3)	21 (45.7)
χ^2 值	8.478		7.489		2.992		12.458	
P 值	0.014		0.024		0.224		0.002	

注　AVN:股骨头缺血性坏死; RAD:残余髋臼发育不良; DDH:发育性髋关节脱位



注　DDH:发育性髋关节脱位; AVN:股骨头缺血性坏死; ROC:受试者工作特征

图 1　外展角度影响 DDH 术后发生 AVN 的 ROC 曲线图

Fig. 1　ROC curve diagram of abduction angle affecting AVN after DDH operation

讨　论

DDH 的治疗目的在于恢复髋臼和股骨头同心圆复位,恢复其正常的生长发育[12]。目前,闭合复位术或单纯切开复位术仍是早期 DDH 的主要治疗方法[13-14]。为降低 RAD 发生率,一些机构设定选择手术方式的相应标准为:首先进行闭合复位术,根据术中髋关节稳定性和造影结果评判闭合复位术是否成功,若闭合复位术失败则行单纯切开复位术,本研究也根据本机构设定的选择手术方式标准来实现 DDH 治疗[11,15]。AVN 可能与骨化核、年龄、脱位程度、手术方式及外展角度等有关[16-18]。近年来,各种研究强调骨化核与 AVN 的关系,但骨化核出现后再行 DDH 治疗是否可降低 AVN 发生率至今存在争议[19-20]。

本研究根据 Kalamchi-MacEwen 分型法进行股骨头坏死测定,结果显示 AVN 发生率为 24.4%;临床 AVN 发生率为 22.8%,与文献报道相符[20]。既往研究表明髋关节切开复位可能造成旋股内动脉的损伤,增加股骨头坏死的风险,但也有研究得出相反结论[21-22]。本研究中,虽然单纯切开复位术的 AVN 发生率高于闭合复位术,但差异无统计学意义(P=0.111),分析本研究随访时间较短可能对结果有一定影响。Wu 等[23]研究认为股骨头高度脱位和骨化核缺失为 DDH 治疗后发生 AVN 的危险因素,本研究中影响 DDH 术后发生 AVN 的单因素分析显示,有骨化核的患髋 AVN 发生率明显低于无骨化核的患髋,术前 IHDI Ⅳ型的患髋 AVN 发生率最高,发生 AVN 的患髋平均外展角度大于未发生 AVN 的患髋,多因素 Logistic 回归分析也显示骨化核状态(OR=3.064,95% CI:1.486~6.319)、外展角度(OR=1.184,95% CI:1.110~1.264)、术前 IHDI 分型(OR=3.821,95% CI:1.465~9.968)是 DDH 术后 AVN 发生的独立影响因素(P<0.05)。

本研究在骨化核状态对 DDH 术后发生 AVN 的影响分析中,显示有骨化核者 AVN 发生率为 18.1%,无骨化核者 ANV 发生率为 37.5%,AVN 发生率相差约 20%,有骨化核者 AVN 发生率显著小于无骨化核者(P=0.002),表明骨化核出现后对股骨头具有保护作用,可使 AVN 发生率降低,表 3 显示有骨化核的患髋临床 AVN 发生率为14.1%,无骨化核的患髋临床 ANV 发生率为26.4%,有骨化核的患髋临床 AVN 发生率显著低于无骨化核者(P=0.026),Roposch 等[24]曾研究得出骨化核出现可降低股骨头坏死发生率的结论,这可能与骨化核出现

时股骨头血供增加和骨化核抗机械应力增强有关[25-26]。一些研究结果支持骨化核对股骨头具有保护作用的观点,Trueta[10]对46例胎儿和婴儿尸体标本进行了股骨近端动脉的血液灌注形式研究,发现儿童期不同阶段股骨头血供有较大差异,早期每条血管所供应的软骨骺区不一致,它们不相吻合,待患儿5~7月龄时股骨头二次骨化中心在X线片上可见到,此时期股骨干骺端血供发生较大变化,终末小动脉之间开始吻合而不再供应单一区域,血流量明显增加。吴剑平等[27]也发现患侧股骨头中有骨化核者术后灌注较无骨化核者好,有骨化核的患髋AVN发生率较无骨化核者低。Wilkinson[28]的研究证实了股骨头骨化核出现前股骨头骨骺易发生压力性缺血性损伤,在相同的负荷下,完全未骨化的股骨头变形量是二次骨化中心占骨骺体积60%的股骨头变形量的两倍,这表明骨化核的存在增加了股骨头的机械强度,使供应骨骺血液的血管免受外部压迫。

本研究中,AVN(+)组与AVN(-)组的患髋术前IHDI分型差异具有统计学意义($P=0.029$),术前IHDI分型增高时AVN发生率增加,其中Ⅳ型患髋AVN发生率最高,为36.1%,与其他研究中高度脱位的髋关节更容易发生缺血性变化一致[29]。一方面,术前脱位程度越高,可能导致髋关节病理改变越严重、股骨头与髋臼匹配不良,复位后股骨头和髋臼压力突然增加,术后髋关节内部机械环境的变化可能导致AVN发生率增加;另一方面,脱位程度越高,虽然脱位时股骨头受到的压力较小,但血管的张力越大,越易发生坏死,且在复位时受到的创伤大,血管易受到损伤[30]。

本研究AVN(+)组的外展角度明显大于AVN(-)组($P<0.001$),AVN(+)组的平均外展角度为(62.57±7.87)°,AVN(-)组的平均外展角度为(56.98±4.77)°,ROC曲线分析显示外展角度预测DDH术后发生AVN的最佳截断值为63.5°,AUC为0.752,灵敏度为0.500,特异度为0.934,这表明当DDH术后髋关节外展角度大于63.5°时发生AVN的可能性明显增加,符合Schoenecker等[31]的动物实验研究结果,提示髋关节外展角度过大时股骨头的血流速率明显降低,这将导致股骨头的缺血变化,可能是外展角度过大时股骨头和周围血管受到较大压迫所致。以往研究认为髋关节的重塑潜力随着年龄增长而降低,延迟DDH治疗可能导致复位更困难,AI将难以恢复正常,髋关节可能有更糟糕的预后[20,32]。本研究结果也显示,随着手术年龄增大,DDH患儿预后变差。

综上所述,骨化核状态、外展角度、术前IHDI分型是DDH患髋术后发生AVN的独立影响因素。骨化核出现对股骨头具有保护作用,可显著降低AVN发生率、临床AVN发生率,但随着年龄增长,临床AVN发生率、再脱位发生率和RAD发生率增高,会导致相对不良的预后,因此建议在有复位指征时尽早进行DDH治疗,无需等待骨化核出现。

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