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Anterior Cruciate Ligament Injuries in Adolescents with Open Physis: The Effect of Different Conservative Treatments on the Risk of Meniscus and Cartilage Injuries

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Presenters' Financial Disclosure

We have no company affiliations and/or conflict of interest notifications, as noted in our Financial Disclosure Statement.

Introduction

- The treatment of pediatric and adolescent anterior cruciate ligament (ACL) injuries requires a different approach from adults due to their skeletal maturity.[1]

- Several studies have recommended early ACL reconstruction in patients with open physis to reduce the risk of meniscus and cartilage injuries when returning to sport.[2,3]

- In contrast, other studies have suggested conservative treatment and delaying reconstruction until skeletal maturity to prevent potential growth disturbances caused by surgery, making the management of ACL injuries in patients with open physis a highly controversial topic.[4]

The aim of this study was to investigate the effect of different conservative treatments on the risk of meniscus and cartilage damage in cases of ACL injuries in adolescent patients with open physis.

Subjects

- This study included 16 patients with open physis, each requiring more than six months to closure physis, who underwent ACL reconstruction.
- Patients continued sports activities during the time to surgery.

Mean age at surgery, y	14.3 ± 1.1 (12-16)
Gender, Male : Female, n	male 11 : female 5
Mean time to surgery, mo	22.3 ± 18.1 (6-57)
Participation in sports, n	basketball 6, soccer 6, athletics 2, Japanese archery 1, soft tennis 1

Expert group (E group; n=10):

- Began conservative treatment early after injury
- Treated by our hospital's ACL specialists

Standard group (S group; n=6):

- Referred to our hospital at least 3 months after injury
- Referred by non-ACL specialists

Physis closure was determined based on MRI findings, specifically the disappearance of the high-signal area in the central proximal tibial physis on T2 imaging (drop-out sign).[5]

Methods

Education for pediatric patients and their parents

- Initial explanations regarding the pathology, injury mechanism, and secondary meniscal and cartilage damage were provided to patients and their parents at our hospital.
- Additionally, specific activity guidelines were provided for preventing giving way, considering the reconsideration of sport-specific risk movements, limb positions, competition level, preferred play style, and playing position.
- Patients had medical consultations once a month for the first six months.

Conservative treatment during the preoperative waiting period

- Conservative treatment included not only standard rehabilitation exercises for knee function improvement but also core and hip muscle training, balance, and neuromuscular training (NMT), which were progressively implemented based on functional recovery and movement coordination.
- A functional pressure wear, a type of compression garment, was used to enhance knee joint and trunk stability during landing movements for patients who requested it.

Neomotion ACL®; NIPPON SIGMAX, JAPAN

Methods

Conservative management at a referring hospital

Cases	Brace	Progressive weight-bearing	Activity restriction	ROM exercises	Muscle strength	NMT
Case 1	○	-	-	-	Knee	-
Case 2	○	-	-	-	Knee	-
Case 3	○	-	Rest	-	-	-
Case 4	○	-	-	-	Knee	-
Case 5	-	○	-	-	Knee	-
Case 6	○	-	Return to play following improvement in knee function	○	Trunk Knee	○

- In 5 out of 6 cases, patients were advised to wear a brace and undergo muscle strengthening after ACL injury.
- Muscle strengthening was primarily focused on the quadriceps, and only one case received additional instruction in both core training and NMT.

Clinical Evaluations

Preoperative evaluations:

- Instrument-measured side-to-side differences of the anterior tibial translation (ATT)

  KS Measure KSM-100® (NIPPON SIGMAX, JAPAN)

- Peak isokinetic (60° /s) and isometric (80° of flexion) torque of the quadriceps and hamstrings

  CYBEX NORM® (CSMI, USA)

- International Knee Documentation Committee (IKDC) subjective score
- Tegner activity scale
- The average number of giving way episodes

Arthroscopic evaluations:

- Meniscal and cartilage lesions

Statistical Analysis:

The statistical comparison among the two groups were evaluated by using Mann–Whitney U test, Chi-squared test. For all analyses, statistical significance was set for $P < 0.05$.

Results: Patient Characteristics

(Mean ± SD)

	E group (n = 10)	S group (n = 6)	P Value
Age at surgery, y	14.1 ± 1.1	14.5 ± 1.0	0.59*
Gender, male: female, n	8 : 2	3 : 3	0.21†
Height, cm	169.1 ± 6.5	165.1 ± 7.4	0.28*
Weight, kg	59.3 ± 6.9	54.7 ± 3.6	0.45*
BMI, kg/m^2	20.8 ± 2.4	20.1 ± 1.7	0.66*
Time to surgery period, mo	20.1 ± 17.7	26.0 ± 19.7	0.63*
Time from injury to initial visit to our hospital, mo	0.4 ± 0.4	9.8 ± 8.3	<0.01*

* Mann–Whitney U test † Chi-squared test

- There was no significant difference in patient characteristics between the two groups, except for the time from injury to the initial visit to our hospital.
- During the preoperative waiting period for ACL reconstruction, only one case in the E group required lateral meniscal repair due to meniscus injury symptoms.

Results: Preoperative Clinical Evaluations

(Mean ± SD)

	E group (n = 10)	S group (n = 6)	P Value
ATT SSD, mm	5.2 ± 1.9	6.1 ± 1.0	0.48
Isokinetic strength*, %			
quadriceps muscle	97.1 ± 15.5	84.7 ± 11.8	0.13
hamstrings muscle	106.5 ± 30.8	104.7 ± 15.8	0.70
Isometric strength*, %			
quadriceps muscle	99.6 ± 16.8	91.7 ± 9.7	0.12
hamstrings muscle	97.6 ± 16.5	91.8 ± 8.7	0.75
IKCD subjective score	85.7 ± 3.7	78.2 ± 5.6	<0.01
Tegner activity scale	6.7 ± 1.1	5.8 ± 1.7	0.33
Giving way	1.6 ± 1.3	3.8 ± 1.3	0.01
Medial meniscal (MM) tear, %	20.0	83.3	0.01
Lateral meniscal (LM) tear, %	50.0	50.0	1.00
Cartilage lesions, %	10.0	33.3	0.25

SSD, side-to-side difference; *percentage of contralateral side

Mann–Whitney U test

Discussion

Effects of the preoperative waiting period after ACL injury on meniscal and cartilage damage

Author	Journal, year	n	Mean Age, y	Mean time to surgery	MM tear, %	LM tear, %	Cartilage lesion, %
Henry J, et al [2]	KSSTA. 2009	29 27	12.6 15.8	12.9 mo 30.3 mo	10.3 40.7	31.0 29.6	- 3.7
Anderson AF, et al [3]	Am J Sports Med. 2015	135	14.0	< 3 mo ≥ 3 mo	24.2 50.0	46.5 66.7	7.1 27.8
Gupta A, et al [6]	Orthop J Sports Med. 2023	173	15.0	5.0 wk 13.0 wk	21.8 30.6	64.5 53.1	Not reported

- Previous studies have suggested that a prolonged waiting period for ACL surgery is associated with an increased incidence of MM and cartilage damage.[2,3,6]
- Kluczynski MA et al.[7] reported that a greater frequency of giving way episodes is associated with an increased risk of MM tears after ACL injury.

Our study shows that beyond time-related factors, appropriate activity management during the preoperative waiting period and the prevention of giving way may also contribute to the incidence of MM tears.

Discussion

Conservative treatment for ACL injuries in patients with open physis

Author	Journal, year	n	Follow-up, mo	Brace	Activity restriction	ROM	Muscle Strength	NMT	MM tear, %	LM tear, %
Graf BK, et al.[8]	Arthroscopy. 1992	8	Minimum 24	○	-	-	Knee	-	87.5	50.0
Woods GW, et al [9]	Am J Sports Med 2004	13	Mean 16	○	No participation in pivoting sports	○	Knee	-	30.1	30.1
Madelaine A, et al [10]	Orthop Traumatol Surg Res. 2018	53	Mean 38	-	Return to play following improvement in knee and neuromuscular function	○	Trunk Hip Knee	○	9.4	7.5

- Bracing for ACL injury and knee muscle strengthening alone are insufficient to prevent giving way and meniscal injuries.
- Activity restriction, along with core and hip muscle training and NMT, is recommended.

Conclusion

- The rate of meniscus and cartilage injuries after ACL injury has been reported to increase with the lengthening of the preoperative waiting period.
- However, our results suggest that it is more closely related to appropriate earlier conservative treatment, thorough optimal education, and activity restriction for the affected patients, including their parents.

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