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Original article

Anterior cruciate ligament tears in children: Management and growth disturbances. A survey of French Arthroscopy Society members

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ABSTRACT

Background: Anterior cruciate ligament (ACL) tears are becoming more common and occurring at earlier ages in the paediatric population. The surgical indications and the optimal time for surgery, technique, and graft type remain controversial in skeletally immature patients. Growth disturbances have been reported after ACL reconstruction, further complicating treatment decisions. The primary objective of this study was to describe current practices of French Arthroscopy Society (*Société Francophone d'Arthroscopie*, SFA) members regarding ACL tear management in skeletally immature patients. The secondary objectives were to determine the incidence, type, and severity of growth disturbances after ACL reconstruction.
Hypothesis: Recent publications support early surgical reconstruction and the further development of transphyseal techniques, even in pre-pubertal patients.
Material and methods: An email invitation to complete a 52-item questionnaire was sent to all SFA members. Participation was voluntary and replies were kept confidential. The data were collected automatically via the SurveyMonkey® tool. Descriptive statistics were computed.
Results: Of 1280 invited SFA members, 142 replied, yielding a participation rate of 11%. Among respondents, 14% recommended ACL reconstruction within 3 months for pre-pubertal patients, compared to 35% for pubertal paediatric patients. The preferred tibial tunnel was transphyseal for both pre-pubertal patients (44.4% of respondents) and pubertal patients (97.7% of respondents). The preferred femoral tunnel was epiphyseal for pre-pubertal patients (62.2% of respondents) and transphyseal for pubertal patients (55.5% of respondents). Growth disturbances after ACL reconstruction were reported by 7% of respondents.
Conclusion: No consensus exists to date about the surgical management of ACL tears in skeletally immature patients. Transphyseal tunnels are gaining in popularity, even for pre-pubertal children. Reports of significant growth disturbances, although relatively rare, warrant the implementation of technical precautions.
Level of evidence: IV, descriptive epidemiological survey.

1. Introduction

Anterior cruciate ligament (ACL) tears are becoming more common and occurring at earlier ages in the paediatric population [1–5]. The reasons for these trends can be found in the ever younger ages at which children are enrolled in sporting activities, combined with the earlier hyperspecialisation of youth sports [6].

The surgical indications, best time for surgery, and optimal technique including graft type selection remain controversial in skeletally immature patients. Deferring ACL reconstruction until growth is complete is associated with higher rates of damage to the cartilage and menisci, as well as with a higher risk of early osteoarthritis [7]. A consensus seems to exist in the literature that surgery is required, and this approach is further supported by reports of conservative treatment failures [8].

Growth disturbances have been reported [9,10], raising concern about selection of the optimal treatment method. In the classical practice survey conducted by Kocher et al. [11] in 2002, the proportion of respondents advocating early surgery was 16% for 8-year-olds and 34% for 13-year-olds. Most of the 15 reported cases of growth disturbance were ascribable to technical errors such as interference screw placement across the physis, excessive graft

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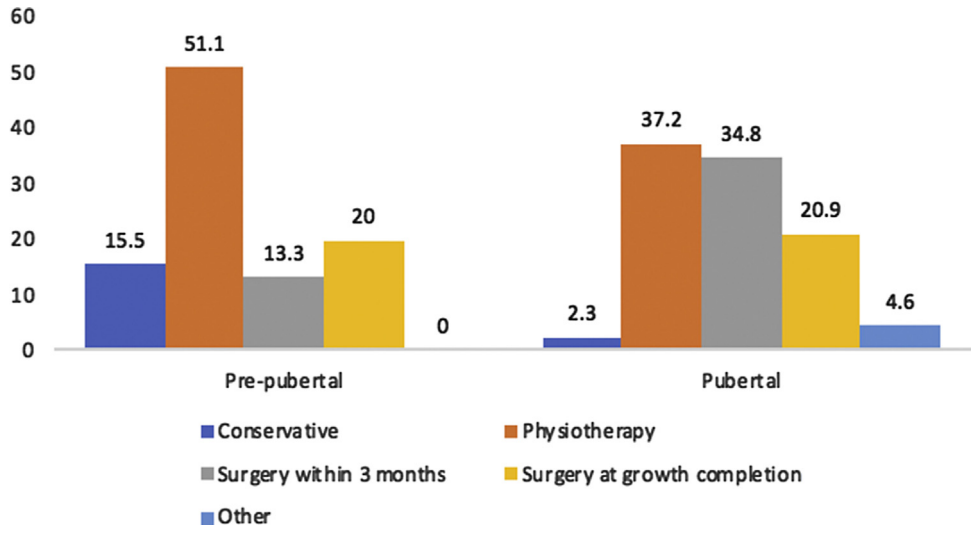

Fig. 1. Distribution of management strategies used by the respondents. Conservative treatment was defined as symptom alleviation and restriction of sporting activities. Physiotherapy was defined as active treatment by a physiotherapist with a gradual return to sports after 3 months and surgery in the event of failure.

tension, and tunnels that were too wide and positioned near or across the physis. At the 2006 SoFCOT symposium, Chotel et al. [12] reported the results of a similar practice survey done in 2004 among members of the SoFCOT and SOFOP.

The primary objective of this study was to describe current practices of French Arthroscopy Society (*Société Francophone d'Arthroscopie*, SFA) members regarding ACL tear management in skeletally immature patients. The secondary objectives were to determine the incidence, type, and severity of growth disturbances after ACL reconstruction. The working hypothesis was that recent publications support early surgical reconstruction and the further development of transphyseal techniques, even in pre-pubertal patients.

2. Material and methods

A 52-item questionnaire was prepared by an orthopaedic surgeon (FA) and edited on the free online survey tool SurveyMonkey® (https://www.surveymonkey.com/). The items, which were derived from those used by Kocher et al. [11], and collected information on the respondent's experience, therapeutic indications, and preferred surgical techniques for pre-pubertal and pubertal skeletally immature patients. Items at the end of the survey asked about observed growth disturbances, with their type and severity. The relevance of the questionnaire was validated in a group of 10 paediatric orthopaedic surgeons.

An email invitation to participate in the survey was sent to all 1280 SFA members. Non-respondents received a reminder after 1 week then again 1 week later. Participation was voluntary and the data were kept confidential. Descriptive statistics were computed on the results.

3. Results

The participation rate was 11%, i.e., 142 of the 1280 invited SFA members. Among them, 8% performed only paediatric orthopaedic procedures and 72.5% were specialised in sports injuries. The number of ACL reconstructions in paediatric patients was none for 59 (41%) respondents, more than 10 per year for 37 (26%) respondents, and more than 20 per year for 13 (9%) respondents. Mean age of patients managed surgically for ACL tears was 11.5 years (range, 5–16 years).

Surgery within 3 months after the injury was reported to be the preferred treatment by 13% of respondents for 8-year-olds (pre-pubertal children) and 34.8% for 13-year-olds (pubertal children) (Fig. 1). For 13-year-olds, most respondents preferred a transphyseal tunnel at the tibia (97.7%) and femur (55.5%). For 8-year-olds, 64.4% of respondents used a transphyseal tibial tunnel; whereas at the femur 62.2% preferred an epiphyseal tunnel, 26.6% a transphyseal tunnel, and 11.1% the over-the-top position (Fig. 2). An autologous hamstring graft was preferred for both pre-pubertal (84.4%) and pubertal (86%) patients, followed by the ilio-tibial band (6.6% and 4.4% for pre-pubertal and pubertal children, respectively). None of the respondents reported using allografts. In pre-pubertal patients, a cortical button was the most widely used fixation method at the tibia (40%) and femur (66.6%). Preferred fixation methods for pubertal patients were an interference screw at the tibia (51.1%) and an endobutton at the femur (68.8%). Finally, 47.7% of participants used fluoroscopy guidance during the procedure.

Growth disturbances defined as greater than 1-cm limb length discrepancy (LLD) and/or more than 5° of malalignment were reported by 7% of participants. Significant growth disturbances were uncommon. A single patient experienced growth arrest with greater than 2 cm of LLD, i.e., type A in the classification developed by Chotel et al. [13]. In addition, 2 patients had more than 10° of valgus malalignment and 1 patient had more than 10° of recurvatum deformity. Among the respondents, 72% routinely obtained long-leg radiographs before the procedure and 53.3% continued to monitor their patients until growth was completed. A standardised physiotherapy protocol was advocated by 68.8% of respondents before surgery and 84.3% after surgery. Finally, 31.1% of respondents reported using an extension splint to immobilise the knee after surgery.

4. Discussion

Primary ACL reconstruction does not seem to be gaining ground for the treatment of ACL tears in paediatric patients, disproving our working hypothesis. By separately assessing practices in 8-year-olds and 13-year-olds, we were able to show a preference for the transphyseal tunnel, notably at the tibia, for pre-pubertal patients, which had not been identified by Kocher et al. [11]. Although concern about growth disturbances continues to exert a major influence on treatment decisions, this adverse effect is not routinely sought during follow-up. Thus, only about half our respondents

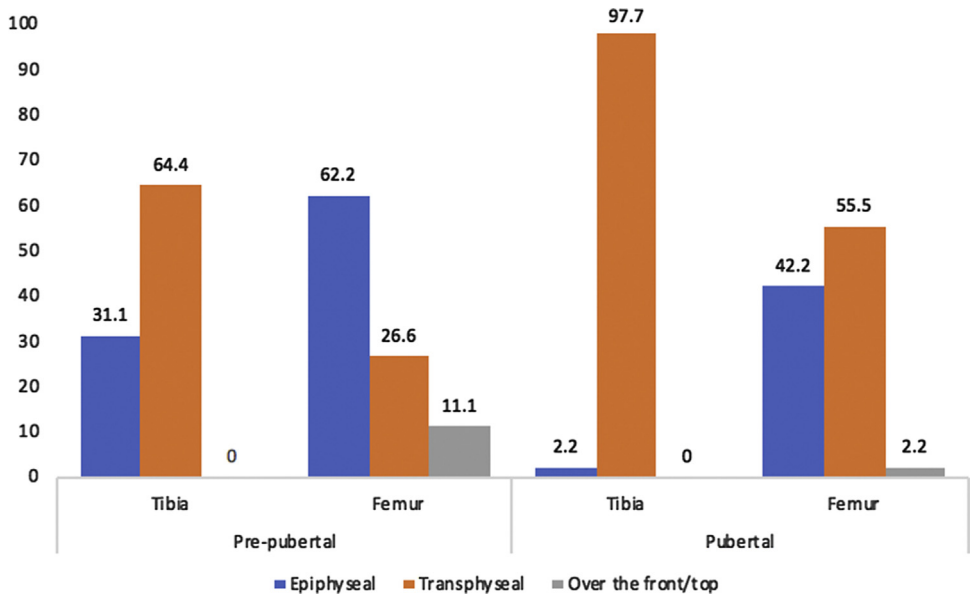

Fig. 2. Distribution of the tunnels used by the respondents.

monitored their patients until the end of growth. Although only 7% of respondents reported growth disturbances, these were probably underestimated.

In their practice surveys, Kocher et al. [14] and Chotel et al. [12] found growth disturbance rates of 11% and 3%, respectively. A recent literature review by Collins et al. [15] identified 39 patients with growth disturbances, of which 25% were LLDs and 47% malalignments related to the use of physis-sparing techniques. Similarly, a meta-analysis by Frosch et al. [16] found a 1.8% rate of growth disturbances, with a considerably higher risk in patients managed using physis-sparing techniques compared to transphyseal techniques (5.8% vs. 1.9%). In a systematic literature review by Pierce et al. [17], in contrast, the incidences of growth disturbances and re-rupture were similar with physis-sparing and transphyseal techniques. Longo et al. [9] also found no significant differences across various techniques in terms of growth disturbances, which occurred in 2.6% of patients.

Evidence suggests that physeal disruption followed by the formation of a bony bridge after physeal drilling is not always followed by growth disturbances. Of 43 patients who underwent ACL reconstruction using the transphyseal technique in a study by Yoo et al. [18], 5 (11.6%) had magnetic resonance imaging evidence of a physeal bony bridge yet were free of growth disturbances. The main limitation of this study is the small amount of residual growth, as mean age at surgery was 14.8 years (range, 12.4–16.5). A surgically induced physeal bridge may persist without causing adverse clinical effects in children near the end of growth, whereas in younger children the bridge may rupture when exposed to the forces generated by physeal expansion [19].

An alarming finding from our practice survey is the limited attention directed to detecting growth disturbances. Routine pre-operative long-leg radiographs and routine clinical and radiographic follow-up until growth completion were reported by only 62.2% and 53% of respondents, respectively. The limited follow-up offered to nearly half the patients suggests that the low rate of reported growth disturbances may constitute an underestimation of the true rate.

Kocher et al. [11] reported that 79% and 58% of respondents used transphyseal tunnels at the tibia and femur, respectively, but did not provide information on differences according to age. Among the SoFCOT members surveyed in 2004 by Chotel et al. [12], 25% used a transphyseal tunnel at the femur and 9% at the tibia in 8-year-olds. A 2015 practice survey among ESSKA members by Moksnes et al. showed a marked increase in respondents using transphyseal tunnels, to 91% at the tibia and 67% at the femur. We found a similar marked preference for transphyseal tunnels among SFA members. Although to date no technique has been proven superior over the others, the most recently published data support the use of transphyseal tunnels. Several studies in animal models [20–22] demonstrated that transphyseal positioning of a soft-tissue allograft prevented bony bridge formation across the physis. In an experimental study in rabbits done by Janarv et al. [23], an unfilled transphyseal tunnel did not induce growth disturbances provided its size did not exceed 7% of the physeal surface area.

Of the Herodicus Society and ACL study group members surveyed by Kocher et al. in 2002 [11], the proportion advocating primary surgery was 16% for 8-year-olds and 34% for 13-year-olds. Despite reports of failure of conservative treatment, notably with high rates of secondary meniscal lesions, the SFA members who responded to our survey do not seem to be increasing their use of primary surgery. Moksnes et al. [24] and Popkin et al. [25] reported far higher proportions of children managed surgically, i.e., 59% and 98% of 13-year-olds, respectively. These discrepancies may be ascribable to differences in practice patterns across scientific societies, to the only 8% proportion of respondents in our survey specialised in paediatric orthopaedic surgery, and to differences across training programmes and countries. Nevertheless, the overall body of available literature seems to support early ACL reconstruction in children. Thus, in a prospective study by Aichroth et al. [8], the 23 conservatively managed patients experienced a Tegner score decrease from 6.7 to 4.2 and a Lysholm score decrease from 78.6 to 52.4 after a mean follow-up of 4 years (range, 1–8 years). In addition, poor treatment adherence among paediatric patients and suboptimal follow-up of rehabilitation programmes contribute to the recurrence of instability episodes after conservative treatment, which eventually damage the cartilage and menisci, ultimately resulting in the early development of osteoarthritis [7].

Although hamstring grafts are still given preference, they do not seem to provide better functional outcomes when surgery is performed in skeletally mature patients [26–28]. A smaller graft diameter is associated with higher re-rupture rates [29,30] and poorer functional scores [31]. On the other hand, however, the

drilling of wide tunnels may increase the risk of growth disturbances [11].

The main limitation of this study is the uncertainty about whether the respondents were representative of the entire SFA membership. The questionnaire was sent to all SFA members. To limit selection bias, the first item of the questionnaire was designed to eliminate surgeons who did not perform ACL reconstructions in paediatric patients. The low participation rate of 11% is also a limitation and may have contributed to underestimate the rate of growth disturbances.

5. Conclusion

This practice survey shows a marked increase in the use of transphyseal tunnels over the last 15 years. Primary ACL reconstruction in skeletally immature patients has gained ground according to international practice surveys [24,25]. No similar trend was found, however, among our SFA members. Although rarely reported, severe growth disturbances were observed, indicating a need for preventive measures and close follow-up until growth completion.

Disclosure of interest

The authors declare that they have no competing interest.

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Contributions of each author

Gauthier Gracia: wrote the article.
Camille Thévenin-Lemoine: revised the article.
Pierre Laumonerie: revised the article.
Jérome Sales de Gauzy: revised the article.
Franck Accadbled: designed the study, collected the data, revised the article.

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