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TIMING OF SURGERY INFLUENCES THE RESULT OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

VREME OPERACIJE UTIČE NA REZULTAT REKONSTRUKCIJE PREDNJEG UKRŠTENOG LIGAMENTA

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Abstract

Introduction. The study aimed to determine whether delaying reconstruction of the anterior cruciate ligament significantly affects return to sporting activity, surgical outcomes, and rates of associated knee injuries, and to identify reasons for delay. **Material and Methods.** The study included 1,020 patients of both sexes (80% men and 20% women); 67% were recreational athletes, and 51% were footballers. All patients filled out a questionnaire, which contained functional activity scales. Patients were divided into an early-operated group (n = 320, surgery between 3 weeks and 3 months after injury) and a delayed-operated group (n =700, surgery more than 3 months after injury). **Results and Discussion.** The mean preoperative Tegner score was 4.49, and the postoperative score was 5.72. The mean preoperative Lysholm score was 73.28, rising to 92.08 postoperatively. The longer the interval before diagnosis, surgery, and resumption of running, training and competing, the lower the resulting activity scores. Early reconstructions were associated with higher mean postoperative scores than delayed reconstruction on both the Tegner scale (6.2 vs 5.5) and the Lysholm scale (93.1 vs 91.6). The early-operated group also had a lower rate of medial meniscal injury (20% vs 26%), and less cartilage damage (12.2% vs 22.3%). Patients' own (subjective) reasons accounted for 61% of delays. **Conclusion.** The ideal timing for reconstruction is patient-specific and depends on resolution of swelling and restoration of knee range of motion and muscle strength. Delaying surgery beyond 3 months is associated with secondary injury to the medial meniscus and cartilage, and with poorer functional and sporting outcomes.
Key words: Anterior Cruciate Ligament Reconstruction; Treatment Outcome; Prognosis; Time Factors; Lysholm Knee Score

Sažetak

Uvod. Cilj studije predstavlja utvrđivanje da li odlaganje rekonstrukcije prednjeg ukrštenog ligamenta značajno utiče na: povratak sportskim aktivnostima, rezultat operacije, udružene povrede kolena i analizira razloge za odlaganje operacija. **Materijal i metode.** U uzorku dominiraju: 80% muškaraca, 67% rekreativnih sportista i 51% fudbalera. Svih 1.020 operativno lečenih pacijenata kost–tetiva–kost metodom preoperativno i 12 meseci postoperativno popunjavali su upitnik, koji je sadržao funkcionalne skale aktivnosti. Podelili smo ih u grupu 320 rano operisanih: između tri nedelje i tri meseca nakon povrede (prosečno 2,2 meseca) i grupu 700 odloženo operisanih (više od tri meseca, prosečno 14,8 meseci). **Rezultati i diskusija.** Ukupan prosečni Tegnerov skor (*Tegner*) pre operacije iznosi 4,49, a postoperativni 5,72. Prosečan preoperativni Lišolmov skor (*Lysholm*) je 73,38, a postoperativni 92,08. Što duži period vremena protekne do postavljanja dijagnoze, početka trčanja, treniranja i takmičenja, niže su vrednosti bodovnih skala. Rane rekonstrukcije imaju više prosečne postoperativne vrednosti od kasnih po pitanju Tegner skora (6,2 naspram 5,5), kao i Lišolmove skale (93,1 naspram 91,6). Rano operisana grupa ima manju učestalost povreda unutrašnjeg meniskusa (20% naspram 26%), kao i ređa oštećenja hrskavice (12,2% naspram 22,3%). Subjektivni razlozi pacijenata uzrok su odlaganja operacije u 61% slučajeva. **Zaključak.** Idealno vreme za rekonstrukciju prednjeg ukrštenog ligamenta je individualno i uslovljeno smanjenjem otoka i postizanjem zadovoljavajućeg preoperativnog obima pokreta kolena i mišićne snage. Odlaganje operacije duže od tri meseca nakon povrede dovodi do sekundarnih povreda unutrašnjeg meniskusa i hrskavice, kao i lošijeg nivoa životnih i sportskih aktivnosti.
Ključne reči: rekonstrukcija prednjeg ukrštenog ligamenta; ishod lečenja; prognoza; vremenski factor; Lisholm skor

Introduction

Reconstruction of the anterior cruciate ligament improves quality of life and allows a return to sporting activity [1–3]. Even so, fewer than half of patients (only 28-55%) return to their previous level of sporting activity 1 year after surgery [4–6].

Athletes, sports clubs and the health system often press for early diagnosis and surgery, raising the question whether this haste leads to worse outcomes in

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Abbreviations

ACL – anterior cruciate ligament
BPTB – bone-patellar tendon-bone
HT – hamstring tendons
BMI – body mass index

terms of pain, instability, complications, re-operations and delayed return to unrestricted activity [6–8].

In Canada, the average interval from injury to surgery is 9.5-11.5 months [7], whereas in the United States this interval is considerably shorter, at 3-5 months [8], as is the case in Scandinavian countries, at around 5 months [5].

In the absence of consensus on the ideal timing for surgery, this study aimed to determine the waiting time for surgery in our population, whether the interval between injury and ACL reconstruction affects the rate of associated injury and the surgical outcome (as measured by activity scores), and the reasons for delayed surgery in our sample.

Material and Methods

This multicentre study was conducted at the Clinic for Orthopaedic Surgery and Traumatology, Clinical Center of Vojvodina, in Novi Sad, and at the Department of Orthopaedic Surgery and Traumatology, Subotica General Hospital. It was designed as a descriptive, retrospective study, and was approved by the Ethics Committee of the Clinical Center of Vojvodina.

We surveyed 1020 respondents with ACL injury who underwent surgery between 1 January 2010 and 31 January 2019. To minimise variability arising from surgeon or technique, all patients were operated on by one of two surgeons (with around 6,000 and more than 500 prior surgeries, respectively), working at different institutions, using bone-patellar-tendon-bone (BPTB) graft [9] fixed with interference titanium screws, followed by an identical rehabilitation protocol [10].

Before surgery and 1 year after, patients completed a questionnaire covering circumstances of the injury, subjective complaints, and current knee function [11]. Data recorded for all patients included: age, sex, level of sporting activity; time intervals from injury to diagnosis, from injury to surgery, from surgery to resumption of running, training and competition.

The Tegner activity scale [12] ranges from 0 to 10. A score of 10 denotes competitive sports such as football at national and international level; 9, competitive sports at high intensity (e.g. lower league football, ice hockey, wrestling, gymnastics); 8, high recreational and competitive lower intensity sports (e.g. badminton, athletics [jumping], downhill skiing); 7, frequent recreational (e.g. football, squash, cross-country track) and competitive (e.g. tennis, athletics [running], motocross, handball); 6, recreational sports (e.g. tennis, badminton, handball, basketball, downhill skiing, jogging at least five times a week); 5, recreational (e.g. jogging at least two times a week on uneven ground), work (e.g. heavy labour, forestry), competitive (e.g. cycling, cross-country skiing); 4, recreational (e.g. cycling, cross-country skiing, jogging at least two times a week on even ground), work (e.g. moderately heavy physical work such as housework); 3, competitive and recreational sports (e.g. swimming, walking in rough forest terrain), work (e.g. light labour); 2, work (e.g. light physical work, walking on uneven ground); 1, work (e.g. walking on even ground, sedentary work); 0, disability due to knee problems.

On the Lysholm scale [13], a maximum 100 points are available: instability and pain together account for half of the total score (0-25 points each), with further points allocated for blocking/locking of movement (0-15), swelling (0-10), stairs climbing (0-10), and support, walking and squatting (up to 5 points each).

Patients were divided into two groups: an early-operated group of 320 patients who underwent surgery between 3 weeks and 3 months after the injury, and a delayed-operated group of 700 patients who underwent surgery more than 3 months after injury. We assessed the effect of surgical timing on associated meniscal and cartilage injuries using repeat clinical examination and on functional outcomes using the Tegner and Lysholm scales.

Associated meniscal and cartilage injuries were identified from operative records and compared between groups.

700 patients for whom time from injury to surgery was longer than 3 months were asked to identify the single most important reason for delay. The reasons offered were: a) broadly subjective factors (e.g. the end of a sporting career, fear of surgery [pain, infection and other complications], fear of surgery failure [e.g. continued knee dysfunction], educational commitments [high school or university], family commitments [e.g. pregnancy, childcare], occupational commitments [e.g. inability to take extended leave], voluntary delay in seeking an initial orthopaedic assessment, or other/unknown reasons); b) objective factors, such as excessively long waiting lists and delayed referral for MRI (and thus delayed diagnosis).

Our sample comprised 815 men (79.9%) and 205 women (20.1%). The youngest patient at the time of surgery was 15 years old, and the oldest was 56 years old; the mean age was 27.2 years. Preoperative body mass ranged from 49 kg to 176 kg, and height from 147 cm to 207 cm. Mean height was 179.6 cm in the early-operated group and 181.2 cm in the delayed-operated group. Mean body mass index (BMI) was 24.6 and was

Table 1. Associated injuries in groups of early and late operated patients

	Early surgery (N 320)	Delayed surgery (N 700)	Total (N 1020)
Medial meniscus	64 (20%)	182 (26%)	246 (24.1%)
Lateral meniscus	46 (14.4%)	107 (15.3%)	153 (15%)
Chondral lesion (grade III/IV)	39 (12.2%)	156 (22.3%)	195 (19.1%)

higher in men (25.21) than in women (22.26). Mean body mass was 80.5 kg in the early-operated group and 81.6 kg in the delayed-operated group.

Injury occurred during sporting activities in 985 patients (96.6%); the remaining 35 injuries occurred during road traffic accidents, at work, or during everyday activities. The most common causative sport was football (n = 519; 50.9%), followed by basketball (n = 174; 17.1%), handball (n = 102; 10%), martial arts (n = 61; 6%), skiing (n = 35; 3.4%), and volleyball (n = 33; 3.2%). Other sports, including American football (rugby), tennis, athletics and gymnastics, accounted for the remaining injuries (n = 61; 6%).

Most patients were recreational athletes (n = 679; 66.6%), with professional athletes (n = 306; 30%) competing at international, national, or regional level, and only (n =35; 3.4%) patients reported no sporting activities.

Data were analysed using IBM SPSS Statistics v. 23 and Microsoft Excel 2013. Numerical variables are presented as minimum, maximum, mean and standard deviation; categorical variables are presented as absolute and relative frequencies. Non-parametric methods were used throughout; correlations between numerical variables were assessed using Spearman's rank correlation, and categorical variables were compared using the χ^2 test. Statistical significance was set at $p<0.05$.

Exclusion criteria were: age under 15 years (as our institutions do not treat patients younger than 15 years); previous knee injury, surgery or re-operations; incomplete or unreturned questionnaires; and failure to complete rehabilitation.

Results

Across the whole sample, the mean interval from injury to surgery was 10.6 months. In the early-operated group, the mean interval from injury to diagnosis was under one month (28.6 days), and surgery was performed within 3 months of injury (mean 2.2 months). In the delayed-operated group, the mean interval from injury to surgery was 14.8 months, comprising 8.5 months of waiting for diagnosis and 6.3 months waiting for surgery.

Among the 700 patients who waited more than 3 months for surgery, the principal reason given was subjective in 427 cases (61%); the remaining 273 patients (39%) reported that they had wanted earlier surgery, but were delayed by the waiting list for surgery (n = 211; 30.1%) or for MRI (n = 63; 9%). There was no dominant subjective reason: educational commitments accounted for 93 cases (13.3%), the end of a sporting career for 60 (8.6%), voluntary delay in seeking initial orthopaedic assessment (for example consulting a chiropractor first) 55 cases (7.9%), fear that surgery would fail 49 (7%), fear of surgery itself 36 (5.1%), occupational commitments 22 cases (3.1%), and pregnancy or childcare for 15 (2.1%) cases. The remaining 96 (13.7%) patients could not identify a specific reason for the delay.

Isolated ACL injury occurred in 530 (52%) cases; 246 (24.1%) patients had a combined injury involving the medial meniscus; 153 (15%) of the lateral meniscus; and 195 (19.1%) had more severe articular cartilage damage (grade 3 and 4 chondromalacia). Eighty-four patients had combined damage to the ACL, meniscus and articular cartilage.

Table 1 summarises associated injuries by group. In addition to ACL reconstruction, partial meniscectomy of the medial meniscus was performed in 64 (20%) patients in the early-operated group, and 182 (26%) patients in the delayed-operated group.

Lateral meniscal injury occurred in 46 (14.4%) patients in the early-operated group, and 107 (15.3%) in the delayed-operated group.

Table 2. Patients categorised by Tegner score

Tegner score	Preoperative	Postoperative
0	40	1
1	127	5
2	82	32
3	112	92
4	205	189
5	84	83
6	149	178
7	81	156
8	95	36
9	45	150
10	0	98
Average	4.40	6.17

Table 3. Difference between groups in mean activity score

	Tegner		Lysholm	
	Preoperative	Postoperative	Preoperative	Postoperative
Delayed surgery	4.44	5.50	73.86	91.60
Early surgery	4.61	6.20	72.00	93.12
Average	4.40	6.17	73.28	92.08

Cartilage damage was significantly less common in the early-operated group than in the delayed-operated group (12.2% vs 22.3%).

Overall, medial meniscal injury and severe articular cartilage damage were both significantly more common in the delayed-operated group ($p<0.05$). The difference between groups in lateral meniscal injury was not significant ($p>0.05$).

Tegner scores are shown in **Table 2:** the mean preoperative score was 4.49, rising to 5.72 postoperatively. The early-operated group had a higher mean postoperative score than the delayed-operated group (6.2 vs 5.5) (**Table 3**).

Postoperative Tegner score correlated significantly with the interval from injury to diagnosis ($\rho=-0.239$, $p<0.000$) and from injury to surgery ($\rho=-0.348$, $p<0.000$).

Postoperative Tegner score also correlated negatively and moderately strongly with the interval from surgery to the resumption of running ($r=-0.449$, $p<0.000$), and training ($r=-0.341$, $p<0.000$), and strongly with the interval to the resumption of competition ($r=-0.505$, $p<0.000$).

Preoperative Tegner score correlated significantly with preoperative Lysholm score ($r=0.138$, $p<0.000$). The mean preoperative Lysholm score was 73.28 (SD 18.17), rising significantly to 92.08 (SD 7.92) postoperatively. Early reconstruction was associated with a slightly higher, though not statistically significant, mean postoperative Lysholm score than delayed reconstruction (93.1 vs 91.6) (**Table 3**).

The Lysholm score also correlated negatively with the interval from surgery to resuming running ($r=-0.222$, $p<0.000$), training ($r=-0.098$, $p=0.01$), and competition ($r=-0.129$, $p<0.001$).

The interval from injury to surgery correlated moderately strongly with the interval from diagnosis to surgery ($\rho=0.355$, $p<0.000$).

Preoperative Tegner score showed a very weak positive correlation with the interval from diagnosis to surgery ($\rho=0.081$, $p=0.031$). Tegner score differed significantly by level of sporting activity ($\chi^2(30)=281.732$, $p<0.000$): professional athletes had significantly higher postoperative Tegner scores than recreational athletes or non-athletes.

Discussion

Active athletes represent the population at greatest risk of ACL injury; in this study, they were 30 times more likely to be represented than non-athletes [1–6,14]. The incidence of ACL injury is about 0.03 in the general population but as high as 1.6 among active athletes [6,14]. The epidemiological importance of this injury is further underlined by recent evidence that 1 in 4 young patients who return to high-risk sport after ACL reconstruction sustains a repeat rupture of the same or contralateral knee during their career [15,16].

Three questions dominate modern sports-traumatology debate on ACL surgery: should every complete rupture be operated on; what is the ideal time to operate; and when is it safe to return to training and competition after surgery.

Since natural processes such as graft ligamentisation cannot currently be accelerated, some authors recommend a return to unrestricted sporting activities at 6 months after reconstruction [9,10], while others argue that 9-12 months after reconstruction is more appropriate, given the risk of graft failure and re-rupture [4–6]. A safe return to competition at 6 months is possible only in the absence of knee instability, pain, swelling, or other complications, and only once proprioception and at least 90% of muscle strength have been restored [2,9,16]. Although the graft strength can initially exceed that of the native ligament, it weakens during ligamentisation (the process by which the graft is remodelled into a ligament) [16]. The graft does not begin to resemble a native ligament until around 6 months, with final maturation at approximately 1 year after the operation [17]. Vascularisation occurs 4 to 6 weeks after surgery, during which period the graft is structurally weaker and more vulnerable to tearing forces [17]. Remodelling of the new ligament is complete by 30 weeks, with maximum collagen strength, resistance, and proprioceptive recovery reached at around 39 weeks (9 months) [16–18]. Accordingly, there is growing evidence that returning to competition before 9 months substantially increases the risk of re-injury. Each additional month of delay reduces the risk by about 50% [19], and returning at 6 months carries up to 7 times the risk of returning at 9 months [17]. It

would therefore appear more effective to shorten the wait for surgery while allowing a longer interval before returning to sports [4–6,16–19].

Whether every ACL injury warrants surgery remains a topic of debate among surgeons and patients alike. Patients without significant post-injury symptoms, such as functional limitations and instability, are termed "copers" [19]; "non-copers", by contrast, cannot resume high-level sporting activity. With rehabilitation, however, copers may become non-copers and vice versa over time, further complicating decisions about whether and when to operate [19]. This is why assessing each patient's level of physical activity (via the Tegner score) is useful: sports can be stratified by risk into level 3 (lower risk), comprising cross-country skiing, cycling, swimming, and gym exercises; level 2, comprising volleyball, martial arts, gymnastics, ice hockey, tennis, squash, alpine/telemark skiing, snowboarding, dance/fitness and aerobics; and level 1 (highest risk), comprising handball, football and basketball (owing to the high risk movements such as pivoting, landing and rapid changes of direction these sports involve) [14,19]. In our sample, 96% of injuries occurred during sport, with two-thirds occurring during level 1 activities. Physical demands also vary within a single sport: for example, between a professional footballer training twice a day with frequent matches, an active recreational athlete training five times weekly, and an occasional recreational athlete training less than once a week. Notably, our sample included no ballerinas, dancers, or ice hockey players; this is not because ACL injuries do not occur in these groups, but because such activities are less popular in Serbia than ball sports [1–3,14,16].

Age, sex, and BMI are important considerations when planning the timing of surgery, particularly in adolescents, women, and obese patients who participate in high-risk activities such as skiing and ball sports [14,20–22]. We did not use hamstring grafts in this study; in general, our choice of graft is guided by the patient's occupation to avoid anterior knee pain in those whose work activities involve kneeling (for example: clergy, car mechanics, and plumbers, as well as female athletes) for whom we favour a hamstring graft. For professional and active recreational athletes, we favour a BPTB graft, consistent with recommendations that these are used for patients engaged in demanding physical activities such as football, basketball, handball, volleyball and alpine skiing [23–26]. In older patients, and in those engaged in lower-risk activity, hamstring reconstruction remains the method of choice [24,25]. Miller and Gladstone, and McAleese et al. found rerupture within 5 years of surgery to be 4.6 times more frequent with hamstring tendon (HT) reconstruction than with BPTB reconstruction among patients in the high-risk category (level 1) (19.7% vs 4.3%) [24,25]. Other authors report that revision rates after BPTB autografts remain within an acceptable range of 2-5% [2,26], which is why we used this graft in our sample of primary reconstructions.

The waiting time between injury and surgery depends on numerous patient-related factors (e.g. time to presentation, fear of surgery, motivation for treatment, preoperative knee status, and family or occupational commitments), as well as physician-related factors (e.g. interval to correct diagnosis, institutional waiting lists, and the surgeon's experience with this injury) [27]. In our experience, professional athletes typically request the earliest possible surgery, accepting that they will still lose at least 6 months of their career. In contrast, female athletes more often delay surgery towards the end of their careers, and students more often schedule surgery during academic holidays to minimise absence from study. A further complication is that one surgeon may agree to a professional athlete's request, whilst the other one may decline it, as they believe it may be less safe for the athlete in the long term. There is also a paramedical dilemma: if one surgeon does not grant a professional athlete's wish, another will, even if it is less safe in the long term.

There is evidence supporting the safety of surgery within the first week after the injury [28]. In comparison of patients with high recreational activity levels (Tegner score > 6) operated on within the first week versus those operated on between 6 and 10 weeks after injury, no significant difference was observed at 3 months and at 6 months. The early operated group had significantly less thigh muscle atrophy, although this difference subsequently resolved between groups. However, delayed surgery was associated with significantly higher costs, owing to longer rehabilitation and absence from work (89 vs 57 days), making early surgery more cost-effective [28].

In our sample, subjective factors accounted for 61% of delays. In contrast, other authors [4] report that fear of surgical failure (in 80% of cases) outweighs motivation and life factors such as occupation, family commitments and education. Our patients' mean wait for surgery, at almost 11 months, is comparable with that reported in Canadian public hospitals [7]. In contrast, waiting times in the United States and Scandinavia are typically 3-5 months after injury [5,8]. As our study included only patients treated in state institutions, it likely under-represents Serbian professional athletes, many of whom are treated privately and may receive even quicker diagnosis and treatment than those in our study sample. In our

delayed-operated group, it took about 8.5 months on diagnostics alone.

Some authors [20] believe that the timing of surgery is as important to the outcome as the surgical technique itself, in keeping with the principle that the smart choose the right moment, the superstitious anticipate it, and the less smart ignore it.

There is now substantial evidence that waiting for longer than 6 months for ACL surgery leads to recurrent knee instability and secondary injuries to other knee structures that may otherwise have been avoided [20,21,29–31]. We similarly found that medial meniscus injuries and severe articular cartilage damage were significantly more common in the delayed-operated group ($p<0.05$). A Norwegian study [32] estimated that each month's delay between injury and surgery increases the risk of articular cartilage injury by 1%, consistent with our findings that 12 months' delay was associated with an 11% higher rate of chondral pathology. On MRI, traumatic chondromalacia typically presents as localised, deep, focal cartilage defects with sharp, well-defined edges, often accompanied by acute bone marrow oedema or other joint injuries (such as meniscal tears) [32]. Degenerative chondromalacia, by contrast, features diffuse cartilage thinning, a broad, "crabmeat-like" zone of fibrillation, and chronic arthritic features such as subchondral cysts or bone spurs [32]; the older patients in our study with cartilage lesions showed features consistent with degenerative chondromalacia.

An Italian study following patients with combined ACL and meniscal injuries [31] likewise reported a mean interval of 11 months from injury to surgery. It concluded that older age and delayed surgery were associated with meniscal damage, while sex and BMI were not [22,31]. ACL rupture removes the knee's principal stabiliser, increasing load on other structures, such as the meniscus, owing to non-physiological redistribution of forces [22]. Nonetheless, excessive haste may not be warranted: a Swedish registry study that followed 18,425 patients found that reconstruction within the first 3 months after injury was associated with a significantly higher rate of revision surgeries (2.61% vs 1.64%), but with fewer meniscectomies and less post-traumatic osteoarthritis at 10 years [29].

Thirty-five years ago, the principal concern with early reconstruction (within 3 weeks of injury) was postoperative arthrofibrotic contracture [34]; this was reported in 18% of operations performed within 7 days of injury, compared with 6% in those performed more than a month after injury [35]. It was subsequently shown that even surgery within the first week, combined with more intensive rehabilitation, can avoid this complication [28]. Current opinion holds that the preoperative state of the knee (swelling, effusion, hyperthermia, muscle strength) is a more important determinant of outcome than the timing of surgery itself [27,30,36]. There is also evidence that preoperative quadriceps weakness (below 20% of physiological strength) is associated with significantly worse outcomes at 2 years [36].

Alongside developments in surgical technique, preoperative and postoperative rehabilitation protocols have been refined in recent decades [30], with an emphasis on achieving full range of motion, minimal or no swelling, a physiological walking/gait pattern, and adequate strength and muscle control before surgery. As this process takes time, patients opting for delayed surgery (beyond 6 months) should be advised that an unstable, unoperated knee can lead to further meniscal and cartilage damage, as well as significant pain and swelling [30]. We believe that an exception should be made for combined ACL injury with a locked (incarcerated) meniscus, where preoperative rehabilitation cannot achieve a satisfactory range of motion. Conversely, premature surgery may not allow time for spontaneous healing of the collateral ligaments, particularly the medial collateral ligament (MCL), which has a greater capacity for healing than the ACL or meniscus [33]. Most isolated and incomplete MCL tears are therefore managed conservatively, whereas ACL and meniscal tears are more often treated surgically [2,9,33]. Considerable debate remains, however, around combined ACL and complete (grade III) MCL injuries [33]; Westerman et al. found that MCL repair or reconstruction was associated with worse patient-reported outcomes and lower activity levels than non-operative MCL management at 2-year follow-up [33]. Most surgeons currently favour non-operative management of MCL with bracing for at least 6 weeks, followed by delayed ACL reconstruction [2,9,33].

A study of a similar-aged population, dominated by footballers, reached a conclusion comparable to ours: nearly one in 5 young athletes already had significant cartilage damage [37]. In that study, medial meniscal rupture was significantly more common among patients reconstructed more than 3 months after the injury, and chondral pathology was more pronounced among those operated on more than 6 months after rupture [37]. The same authors noted that some athletes continue to participate in sport despite injury, thereby worsening knee pathology while paradoxically reducing the apparent incidence of isolated ACL rupture. Other studies have similarly reported significantly more frequent meniscal injury and degenerative change with delays beyond 1 year, and identify 3 weeks to 3 months after injury as the optimal surgical window [32,37,38].

The success of ACL reconstruction in our sample is further evidenced by the mean Tegner score, which rose from 4.5 preoperatively to 5.7 postoperatively, an improvement most pronounced in the early-operated group (6.2). Across groups, mean Tegner score was lower among patients who waited longer for surgery. As expected, professional athletes achieved significantly higher Tegner scores than recreational athletes and non-athletes, reflecting the scale's design [2,6,9,39,40].

Tegner scores depend on both the type of sport played and whether it is pursued competitively or recreationally. Some studies have included only professional footballers (mean Tegner score 9) as subjects, yet found that only 65% of operated patients returned to the same sport, and only 55% regained their former level of activity [6]. Our results cannot reach an average score of 9, given that the sample is dominated by recreational athletes (66%) with a maximum score of 6-7. A study following amateur footballers' Tegner scores also found an association between scores and a history of knee injury, with a 0.8 point decrease per decade of age and scores 0.7 points lower in women than in men [39]. Other authors recorded a mean score of 8.7 2 years after ACL reconstruction, significantly higher than the preoperative value of 6.9 [40]. A study comparing autografts and allografts [41] found outcomes ranging from 6.8 to 7.2, suggesting that the Tegner score may be influenced by reconstruction method – a variable we controlled for by using a BPTB autograft throughout. We found no significant difference by age and sex between groups, although other studies report these as significant factors: one found a mean preoperative score of 5.58 in patients under 25 years versus 4.28 in older patients, and a postoperative score of 5.83 in the younger group versus only 4.33 in the older group [42]. Our findings are consistent with this body of evidence [39–42], with the Tegner score rising significantly after surgery, indicating functionality and sporting outcomes. A further indirect indicator of surgical success is shown in **Table 2**: 40 patients considered themselves disabled and unable to run before surgery, compared with only one after surgery. Similarly, no professional footballer competed at national or first division levels before surgery, compared with 98 afterwards. Overall, the longer the interval before diagnosis, surgery, and the resumption of running, training and competition, the lower the patients' resulting activity scores.

The Lysholm score remains one of the most widely used scales for pre- and postoperative assessment of knee function, despite dating from 1982 [13]. Scores of 91-100 are considered excellent, 84-90 good, 65-83 satisfactory, and below 64 poor. As surgical outcomes have improved, these criteria have tightened, such that only scores of 95-100 are now considered excellent [43]. In both of our groups, mean scores exceeded 90, indicating that operated patients had no significant residual problems with pain or instability (which together account for half the total score) or with daily activities.

Lysholm score also depends on the timing of the assessment as knee function continues to improve over time [44]. In one study, mean scores were 79.6 at 3 months after ACL reconstruction, 84.8 at 6 months, 88.0 at 1 year, and 89.0 at 2 years. Conversely, scores in another cohort fell from 82 to 76 between 2 years and a later follow-up, which was attributed to osteoarthritis [45]. Outcomes may also vary by sport: in one comparison, weightlifters had lower preoperative scores than non-weightlifters (58 vs 63) but higher postoperative scores (87 vs 84), reflecting greater improvement among those who undertake resistance training [46].

An earlier study comparing Lysholm scores between BPTB and HT groups found no significant difference in outcome (94 vs 93 points). However, BPTB results were more consistent, while the HT group had more complications, including infection and re-rupture [9]. Other studies report good outcomes even after revision surgery, with a mean score of 88 [2]. A comparison of early and delayed ACL reconstruction found that 1-year Lysholm scores were slightly higher after early surgery (87.0-93.3) than after delayed surgery (88.0-91.6) [28,47], a pattern broadly consistent with our own findings (93.1 vs 91.6), albeit with a small absolute difference. Other studies, like ours, have shown better outcomes when ACL reconstruction is performed within 3 to 5 months after injury than after a year [47]. Other authors, however, maintain that evidence for the superiority of early over delayed reconstructions remains insufficient [48].

This study has several limitations. We did not examine the effect of early support or rehabilitation on final surgical outcome, nor the relationship between activity scales and quality of life. A further limitation is the subjective nature of patient-reported outcomes, as we did not use instruments to measure anterior tibial translation or proprioception, nor did we formally test thigh muscle strength before clearing patients to return to sports. Future research might usefully compare more homogeneous groups of athletes - for example, early- versus late-operated professional footballers, or recreational basketball or handball players matched for competitive level.

Conclusion

The longer the interval before diagnosis, surgery, and the resumption of running, training and competition, the lower the resulting activity scores.

Patients' own (subjective) reasons are the most common cause of delayed surgery.

The ideal time for anterior cruciate ligament reconstruction is patient-specific and depends on the resolution of swelling and achievement of satisfactory preoperative range of motion and muscle strength.

Delaying surgery beyond 3 months after injury is associated with secondary injury to the medial meniscus and cartilage, and with poorer functional and sporting outcomes.

Early diagnosis and surgery should be a priority for health systems, as they support an earlier return to work and sporting activities, particularly among young patients.

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