**Combined Anterior Cruciate and Anterolateral Ligament Reconstruction in the Professional Athlete: Clinical Outcomes from the SANTI Group in a Series of Seventy Patients With a Minimum Follow Up of Two Years**

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**Abstract**

**Purpose:** To evaluate clinical outcomes in professional athletes after combined anterior cruciate ligament (ACL) and anterolateral ligament (ALL) reconstruction, with a minimum follow-up of two years.

**Methods:** All professional athletes who underwent primary combined ACL and ALL reconstruction between January 2011 and March 2016 were included. A retrospective analysis of prospectively collected data from the SANTI Study Group database was performed. Patient assessment included physical examination, pre- and postoperative subjective and objective IKDC, Tegner activity scale (TAS) and Lysholm score.

**Results:** 72 professional athletes underwent primary ACL and ALL reconstruction, 70 (97%) were available with a mean follow-up of 3.9 years (range 2-7). The pre-operative side-to-side anteroposterior laxity difference was 7.1±1.4mm and this decreased significantly after surgery to 0.4±0.9mm (p<0.0001). Pivot-shift grade evolved from 16 grade I (22.8%) and 54 grade II or III (77.2%) preoperatively, to 66 absent pivot shift (94.3%) and 4 grade I (5.7). By one-year post-operatively, sixty athletes (85.7%) returned to professional sport with a mean time interval of 7.9 months (range 5-12). At final follow up the mean subjective IKDC was 90.5±7.6, Lysholm score 94.4±7.5, Tegner 8.8 ± 1.5. 11 Patients (15,7%) underwent a subsequent ipsilateral re-operation including 4 (5.7%) revision ACL reconstructions. Subgroup analysis of early graft failures (within one year or 3 months of first match post-operatively) in professional soccer players demonstrated a significantly lower rate in the current series (0%) when compared against published rates (7%), chi2 8.457 p=0.0036

**Conclusions:** Combined ACL and ALL reconstruction is associated with excellent outcomes in professional athletes with respect to graft rupture rates, return to sport, knee stability, and re-operation rates after injury. Subgroup analysis in professional soccer players demonstrates that combined ACL and ALL reconstruction is associated with significantly reduced graft rupture rates when compared to isolated ACL reconstruction.

**Level of evidence:** Level IV case series

**Keywords:** Anterior Cruciate Ligament (ACL), Anterolateral Ligament (ALL), professional athlete, Clinical Results, ACL-Rupture

**Introduction**

Despite a major focus on injury prevention the rates of ACL rupture have remained relatively unchanged over the last 25 years 1-3. ACL rupture continues to represent a devastating injury with potentially career-ending consequences for the professional athlete. Even for those individuals who return to elite sport, there is evidence that they may not be utilized by their team in competition as frequently, that their earning potential is significantly reduced and their overall careers may be shorter than age-matched controls 4,5. However, in contrast to the general population the rate of return to sport in professional athletes is very high 6 but this also means that they are at significantly greater risk of ACL graft rupture when compared to those with a sedentary lifestyle 7,8.

Walden, et al. highlighted that the rates of ACL graft rupture were unacceptably high in professional soccer athletes 9 and these concerns are mirrored in numerous reports of graft rupture rates between 18%-20% in high risk populations 10-13. Specifically, Walden et al. also reported that a large proportion of these injuries occur in the first year after ACL reconstruction, with 4% suffering a graft rupture before returning to match play and a further 3% suffering re-injury within 3 months after their first match appearance. The authors concluded that novel primary and secondary preventive measures are urgently needed in professional football 9.

Recently, Sonnery-Cottet et al. demonstrated that combined ACL and ALL reconstruction was associated with significantly reduced ACL graft rupture rates when compare to isolated ACL reconstruction 14. Furthermore, several systematic reviews have demonstrated that a lateral extra-articular procedure performed at the time of ACL reconstruction results in improved knee stability 15-17. This is consistent with the work of Guzzini et al. who reported no graft ruptures and excellent knee stability at medium term follow-up after combined ACL reconstruction and lateral extra-articular tenodesis, in a high-risk population of sixteen elite female soccer players 18. Although these results are promising, further study is required because of the small study population and the lack of applicability to professional athletes participating in other sports.

The aim of this study was to report the clinical outcomes of professional athletes in all sports, who have undergone combined ACL and ALL reconstruction in our institution with a minimum follow up of two years. The study hypothesis was that combined ACL and ALL reconstruction in professional athletes would be associated with good clinical outcomes and a lower than expected ACL graft rupture rate when compared to previously published data.

**Methods**

The study was approved by the hospital research and ethics committee and was performed in accordance with the Declaration of Helsinki ethical standards. Informed consent was obtained from all participants prior to enrolment in the study. A retrospective analysis of prospectively collected data was performed. The SANTI database was used to identify all professional athletes who had sustained a primary ACL rupture and had undergone combined ACL and ALL reconstruction. Patients were only excluded from the study if they met one of the following criteria: less than 2 years of follow-up data available, age < 15 years at the time of surgery, injury to the collateral ligaments of severity > grade 2, and any other ligament injury.

All procedures were performed by one experienced orthopaedic surgeon (\*\*\*blinded to first assessment) at a single institution between January 2011 and March 2016.

**Surgical Procedure**

Combined ACL and ALL reconstruction was performed as previously described 19,20. Concomitant intra-articular meniscal and chondral pathology was addressed in the standard manner. The procedure is briefly summarized here and illustrated in Fig 1: Hamstring tendon autograft is harvested. The gracilis tendon is detached and sutured to a tripled semitendinosus with its tibial attachment preserved. The ACL graft is then created using a tripled semitendinosus tendon and an additional strand of the gracilis tendon, the excess length of gracilis tendon forms the ALL graft. An outside-in femoral guide is placed proximal and posterior to the lateral epicondyle and at the femoral origin of the ACL and used to drill a tunnel of the same size as the graft diameter. For ALL reconstruction, a 4.5-mm drill is used to create a tibial tunnel. The combined graft is then routed proximally through the knee. The ACL portion of the graft is fixed with interference screws on tibial and femoral sides with the knee in 30 degrees of flexion. The ALL graft is then routed deep to the iliotibial band from the femur, through the tibial tunnel, and back under the iliotibial band to the anatomic origin of the ALL. The knee is placed in full extension and neutral rotation and the graft is secured to itself at this location with a previously placed non-absorbable suture.



Fig 1. ACL reconstruction combined with ALL (quadruple hamstring graft + ALL)

**Rehabilitation**

Patients were asked to mobilize brace-free, weight bearing with crutches immediately after surgery unless they underwent a meniscal repair, in which case they were instructed to remain partial weight-bearing and limit their flexion to 90° for 6 weeks.
Cycling was recommended at 1 month, jogging at 3 months, and return to competition at 6 to 9 months.

**Outcome Assessment**

Patients were reviewed at 3 and 6 weeks and at 3, 6, 12, and 24 months postoperatively and at their final follow up appointment. Patient assessment included pre-injury, pre- and postoperative subjective and objective IKDC, Tegner activity scale (TAS) and Lysholm score. Physical examinations were performed by a sports medicine physician, a surgeon or an author other than the primary surgeon. This examination included complete ligament examination following the instruction for the 2000 IKDC (International Knee Documentation Committee) knee examination form. Instrumented knee testing was performed before surgery and at final follow-up with the Rolimeter® Arthrometer (Aircast Europe). Any complications or ongoing symptoms were assessed by clinical examination and with further imaging if necessary. A record of whether the athlete underwent any subsequent knee injury or surgery was made, including revision ACL reconstruction or a contralateral ligament rupture. Furthermore, the level of competition before and after surgery, and the time taken to return to a competitive level after surgery were analyzed.

**Statistical Analysis**

All calculations were made with SAS for Windows (Version 9.4; SAS institute Inc.) unless otherwise stated. The level of statistical significance was set at p<0.05. Descriptive data (mean, median, range, proportion) are reported for the entire series and demographic variables (sex, age, BMI and follow-up) were examined. The paired student t-test was used to compare the pre- and post-operative IKDC subjective evaluation and Lysholm scores. The Mantel-Hantsel test was used to compare the pre- and post-operative pivot-shift test results, the laxity and the IKDC objective evaluation, because the Gaussian distribution was not verified. The signed rank test was used to compare the preinjury and postoperative Tegner evaluation and the laxity differential. The Kaplan-Meier method was used to estimate the cumulative survivorship with respect to both ipsilateral graft failure and contralateral ACL rupture. The stratified log-rank statistic was used to select predictors in univariate analysis of post-operative graft failure or contralateral ACL rupture. A univariate Cox model was used to estimate hazard ratio and 95% confidence limits. The Chi2 test was used to compare the early graft rupture rate in the subgroup of professional soccer players with rates previously reported by Walden et al. 9.

**Results**

Of the 72 professional athletes who underwent primary ACL reconstruction using the combined ACL + ALL reconstruction technique, 70 (97%) were available with a mean follow-up of 3.9 years (range 2-7). Two patients were lost to follow-up despite efforts to contact them. The mean age for the 48 men and 22 women, was 23.3 years (range 15 – 37). The mean delay between injury and surgery was 1.1 months (range 0.1 – 7). 39 patients presented with meniscal tears, 22 being medial and 31 lateral, including 14 bilateral lesions. Out of the 22 medial meniscal lesions, 19 could be repaired and 3 were treated by partial meniscectomy. 29 of the 31 lateral lesions were repaired and 2 were partially resected. The patient demographics are summarized in Table 1.

Table 1 Patient Demographics

|  |  |
| --- | --- |
|  | Patients (n=70) |
| Gender (%) | 48 male (68.6), 22 female (31.4) |
| Age, years (range) | 23.2 (15 – 37) |
| BMI (range) | 23.7 (19 – 36) |
| Follow-up, years (range) | 3.9 (2 – 7) |
| Time from injury to surgery, mo. (range)  | 1.1 (0.1 – 7)  |
| Meniscal tears n (%) | Medial meniscus 22 (31.9)Lateral meniscus 31 (45) |
| Meniscal surgery n (%) | Medial: repair 19 (86.4); meniscectomy 3 (13.6) Lateral: repair 29 (93.5); meniscectomy 2 (6.5) |

**Postoperative Outcomes**

The clinical outcomes are reported in Table 2. None of the patients experienced limitation of range of motion in flexion postoperatively.

Table 2 Clinical Outcomesᵅ

|  |  |  |  |
| --- | --- | --- | --- |
|  | Preoperative | Postoperative | *p* |
| IKDC subjective score | 56.1 ±13.3 | 90.5 ±7.6 | <0.0001 |
| IKDC objective score |  |  | <0.0001 |
| A |  | 65 (92.9) |  |
| B |  | 5 (7.1) |  |
| C | 39 (55.7) |  |  |
| D | 31 (44.3) |  |  |
| Tegner | 9.3 ±1 | 8.8 ± 1.5 | 0.0004 |
| Lysholm | 48.4 ±12.5 | 94.4 ± 7.5 | <0.0001 |
| Pivot shift (IKDC grade) |  |  | <0.0001 |
| 0 (equal) |  | 66 (94.3) |  |
| 1 (glide) | 16 (22.8) | 4 (5.7) |  |
| 2 (clunk) | 23 (32.9) |  |  |
| 3 (gross) | 31 (44.3) |  |  |
| Mean Instrumented anteroposterior laxity side-to-side, mm (range) | 7.1 ±1.4 (4 - 12) | 0.4 ±0.9 (-2 – 3) | <0.0001 |
| Laxity (IKDC grade) |  |  | <0.0001 |
| <3 mm |  | 69(98.6) |  |
| 3mm-5mm | 2 (2.9) | 1(1.4) |  |
| 6mm-10mm | 63 (90) |  |  |
| >10mm | 5 (7.1) |  |  |

ᵅValues are reported as mean ± SD (standard deviation) or n (%); IKDC, International Knee Documentation Committee

11 Patients (15,7%) underwent a subsequent re-operation and specific details are reported in Table 3.

Table 3 Indications for re-operation after the index procedure

|  |  |  |
| --- | --- | --- |
| Re-Operations | n (%) | Mean time (months) from index surgery to re-operation (range) |
| Total no. of reoperations | 11 (15.7) | 15.3 |
| Revision-ACLR | 4 (5.7) | 23.9 |
| Medial partial meniscectomy | 3 (4.3) | 14 |
| Lateral partial meniscectomy | 1 (1.4) | 18 |
| Cyclops removal | 1 (1.4) | 11.7 |
| Hemarthrosis | 1 (1.4) | 0.1 |
| Deep Infection | 1 (1.4) | 0.3 |
|  |  |  |
|  |  |  |

Graft rupture rates are reported in Table 4. In total only four patients sustained an ACL graft rupture and three of these occurred in professional soccer players. However, none of these graft ruptures occurred before, or within 3 months of the first match played after the index procedure. When compared to the series reported by Walden et al. this represented a statistically significant difference (Walden et al, early graft rupture rate 7% 9, current series early graft rupture rate 0%, mean difference 7%, chi2 8.457 p=0.0036).

Contralateral ACL rupture rates are reported in Table 5. Although 19 Patients had a contralateral ACL rupture prior to the end of the study period it is important to highlight that approximately half of these occurred before the index procedure.

Univariate analysis was performed in order to evaluate potentially important factors for an association with risk of graft rupture or a contralateral ACL rupture. None of the investigated variables showed a significant association (Table 6 and Table 7).

Table 4 The spectrum of occurrence of contralateral ACL rupture within the study population

|  |  |
| --- | --- |
|  | n (%) |
| Total no. of contralateral ACL rupture | 19 (27.1) |
| Before Index Procedure | 9 (12.8) |
| After Index Procedure | 10 (14.3) |
|  |  |
|  |  |

Table 5 Rates of contralateral and revision ACLR after index procedure stratified by gender distribution with Kaplan Meier Method.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Female (n=22) | Male (n=48) | p-value Log-Rank |
| Contralateral ACL (%) | 5 (22.7) | 5 (10.4) | 0.170 |
| Revision ACLR (%) | 3 (13.6) | 1 (2.1) | **0.048** |

Figure 2 shows the data from Kaplan-Meier Analysis of ACL graft failure, stratified by gender. This analysis shows a significantly greater risk of graft failure for female athletes (p=0.048).



Fig2. Survivorship data from Kaplan-Meier Analysis of ACL graft failure stratified by gender

Table 6 Univariate Analysis of Predictive Factors of Graft Failure

| Variable | Unadjusted HR | Unadjusted HR 95% Conf. Limits | p-value |
| --- | --- | --- | --- |
| Age | 1.470 | [0.188 ; 29.707] | 0.739 |
| >=20y vs. < 20y |  |  |  |
| Sex | 7.084 | [0.907 ; 143.225] | 0.090 |
| Female vs. Male |  |  |  |
| Type of sport | 1.669 | [0.178 ; 221.325] | 0.758 |
| Contact vs. Non-contact |  |  |  |
| Laxity pre-op | . |  | 0.310 |
| (6mm-10mm) vs. (3mm- 5mm) | 0.234 | [0.023 ; 31.466] | . |
| >10mm vs. 3mm-5mm | 1.200 | [0.064 ; 175.119] | . |
| Meniscal lesion | . |  | 0.705 |
| LM vs. No Lesion | 0.260 | [0.002 ; 2.68] | . |
| MM vs. No Lesion | 1.843 | [0.178 ; 11.21] | . |
| MM LM vs. No Lesion | 0.318 | [0.002 ; 3.277] | . |

Table 7 Univariate Analysis of Predictive Factors of contralateral ACL rupture

| Variable | Unadjusted HR | Unadjusted HR 95% Conf. Limits | p-value |
| --- | --- | --- | --- |
| Age |  |  |  |
| >=20y vs. < 20y | 0.424 | [0.105 ; 1.603 ] | 0.201 |
| Sex |  |  |  |
| Female vs. Male | 2.342 | [0.646 , 8.51 ] | 0.182 |  |
| Type of sport |  |  |  |
| Contact vs. Non-contact | 1.348 | [0.301 ; 12.721 ] | 0.750 |
| Laxity pre-op | . |  | 0.745 |  |
| (6mm-10mm) vs. (3mm- 5mm) | 0.624 | [0.079 ; 80.46 ] | . |  |
| >10mm vs. 3mm-5mm | 0.205 | [0.001 ; 39.226 ] | . |  |
| Meniscal lesion | . |  | 0.848 |
| LM vs. No Lesion | 1.083 | [0.149 ; 5.589 ] | . |
| MM vs. No Lesion | 2.109 | [0.29 ; 10.936 ] | . |
| MM LM vs. No Lesion | 1.073 | [0.145 ; 5.655 ] | . |

Of the 70 athletes, four sustained a graft rupture, and ten sustained a contralateral ACL injury after the index surgery. The details are reported in Table 7.

Table 7 The incidence of graft rupture and contralateral ACL rupture occurring after the Index procedure, stratified by sport

|  |  |  |  |
| --- | --- | --- | --- |
|  | n (%) | n contralateral ACL (%) | n graft Rupture (%) |
| Total | 70 | 10 (14.3) | 4 (5.7) |
| Soccer | 32 (45.7) | 4 (40) | 3 (12.5) |
| Rugby | 11 (15.7) | 2 (20) |  |
| Basketball | 10 (14.3) | 3 (30) |  |
| Ski | 9 (12.9) | 1 (10) |  |
| Handball | 4 (5.7) | 0 |  |
| Hockey | 2 (2.9) | 0 | 1 (50) |
| Motocross | 2 (2.9) | 0 |  |

**Return to Sport and Retirement**

At one-year follow-up, 60 athletes (85.7%) returned to a professional level with a mean delay of 7.9 months (range 5-12). At final follow-up, 16 athletes had retired from professional sports, with one citing knee problems (Table 8 and 9).

Table 8 Return to sport metrics

|  |  |
| --- | --- |
|   | All athletesn = 70 |
| Mean delay | 7.9 (5 – 12) |
| Return to professional level (%) | 60 (85.7) |

Table 9 Reasons for retirement from professional career

|  |  |
| --- | --- |
|   | No. (%) |
| Retirement from professional sports | 16 (22.5) |
| Age | 5 (31.25) |
| Without a Club | 4 (25) |
| Studies | 5 (31.25) |
| Knee | 1 (6.25) |
| Other injuries | 1 (6.25) |

**Discussion**

The main findings of this study are that combined ACL and ALL reconstruction are associated with good clinical results in the professional athlete. 85.7% of patients were able to return to the same level of competitive sports that they had participated in prior to the injury. The time taken to return to this level varied between 5-12 months from the date of surgery. The overall graft rupture rate was 5.7% at a mean follow up of 3.9 years. These figures are broadly comparable to the findings of Lai et al, who in a recent systematic review reported that a mean of 83% of elite athletes were able to return to the preinjury level of sport, they took a mean time of 6-13 months to do so, and the pooled graft rupture rate was 5.2% 9. However, it is important to note that both the return to sport rate (42 21-100% 22,23) and the graft rupture rates (0 22,24,25-19.3% 26) reported in the studies included by Lai et al varied broadly 6. This highlights the fact that the risk of graft rupture is higher in certain sports or even certain positions within the same sport. For example, in NFL, receivers and backs have a significantly greater injury risk than players in other positions 27. To the authors knowledge, the highest rates of graft rupture in professional athletes are reported in female patients participating in handball (19.3%) 27 and alpine ski (27% revision rate) 28. In the current study, there were no graft ruptures in the skiers or handball athletes but the overall numbers of patients in these categories was too small to gain a reliable estimate of the graft rupture rate. However, in keeping with previous reports 29-31, female patients had a significantly higher risk of graft rupture (13.6%) than male patients (2.1%) and this six-fold increased risk was statistically significant (p=0.048). Similarly, the contralateral ACL injury rate was also higher in female patients (22.7% vs 10.4%) but this trend was not statistically significant.

The largest category in the current study was professional soccer players. In this group, three patients sustained a graft rupture at 13, 22 and 25 months after the index procedure. In contrast, Walden et al, reported a 7% early (within one year or 3 months of the first match played after ACLR) graft failure rate in a series of professional soccer players 9. Although, insufficient demographic data was available to evaluate for differences between the study populations it was considered reasonable to compare the graft rupture rates because professional soccer athletes are likely to be a fairly homogeneous group. This analysis demonstrated that there was a significantly reduced graft rupture rate in patients undergoing combined ACL and ALL reconstruction in the current study when compared to the patients reported on by Walden et al, who underwent ACLR only 9. Although this analysis has several limitations, including the lack of information about concomitant chondral/meniscal injuries and other risk factors for graft rupture, it does demonstrate a statistically significant advantage of a combined ACL+ALLR graft over isolated ACLR grafts.

Graft choice in professional athletes undergoing ACLR has been evaluated by Erickson et al in a survey of team orthopaedic surgeons responsible for NHL, MLS and US Olympic Ski/Snowboard teams. It was identified that 70% of surgeons would use BTB for their athletes 32. Although the authors of this study agree that this has been considered the gold standard 33-35 it should be highlighted that in a large comparative series of young patients involved in pivoting sports, the rate of ACL graft rupture was 3-fold less in patients who underwent combined ACL+ALL reconstruction when compared to a BTB graft choice 14. Similar advantages of BTB have not been demonstrated in the meta-analyses or systematic reviews comparing the outcomes of BTB and hamstring tendon autografts 36,37. The significant advantage of a combined ACL+ALL graft has been attributed to load sharing of the ALL 38 with the reconstructed ACL. Furthermore, it has also been demonstrated that injury to the anterolateral structures occurs in up to 90% of apparently isolated ACL injured knees 39and in that scenario an isolated ACL reconstruction fails to restore normal knee stability 40. However, when a combined ACL+ALL reconstruction is performed, normal knee kinematics can be restored 40.

Although 85.7% of patients in this series returned to the pre-injury level of competition after combined ACL and ALL reconstruction, by the mean final follow up of 3.9 years, 22.5% of the original population had retired, leaving 77.5% still involved in professional sports. This compares favourably to data from Mai et al. who reported that overall, 3 seasons after ACLR, only 67% of professional athletes remain on the active roster 41. However, when the specific sports included are evaluated individually, it can be seen that there are significant differences between them with NFL players being least likely to still be on the active roster (60%) and NHL players being most likely (98%). The authors concluded that ACLR leads to excellent outcomes for professional athletes but that the intricacies of each sport place significantly different physical demands on the reconstructed ligament and lead to differences in outcomes 42. In the current series, only one patient stated that they retired due to ongoing knee related issues. This type of data has not been reported in other series so no comparison can be drawn.

**Limitations**

The main limitation of this study was the small population of professional athletes in each sports category. This limited the ability to provide a reliable estimate of graft rupture in many of the categories and also prevented comparison with other published data. Despite that, it should be highlighted that to the authors knowledge, this is the largest reported series of professional athletes undergoing ACLR combined with an extra-articular procedure.

Further limitations include the lack of a sample size analysis when conducting comparison with previously reported rates of graft rupture in professional soccer players and a minimum follow up of only two years.

**Conclusions**

Combined ACL and ALL reconstruction is associated with excellent outcomes in professional athletes with respect to graft rupture rates, return to sport, knee stability, and re-operation rates after injury. Subgroup analysis in professional soccer players demonstrates that combined ACL and ALL reconstruction is associated with significantly reduced graft rupture rates when compared to isolated ACL reconstruction.

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