Combined Reconstruction of the Anterolateral Ligament in Patients With ACL Injury and Ligamentous Hyperlaxity Leads to Better Clinical Stability and a Lower Failure Rate Than Isolated ACL Reconstruction

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Purpose: To compare functional outcomes, residual instability, and rupture rates in patients with ligamentous hyperlaxity undergoing isolated anterior cruciate ligament (ACL) reconstruction or combined ACL and anterolateral ligament (ALL) reconstruction. Methods: Two groups of patients were evaluated and compared retrospectively. Both groups consisted of patients with ACL injuries and associated ligamentous hyperlaxity, defined based on the modified Beighton scale with a minimum score of 5. Group 1 patients underwent anatomical ACL reconstruction, and group 2 patients underwent anatomical ACL reconstruction combined with ALL reconstruction. The presence of associated meniscal injury, subjective International Knee Documentation Committee and Lysholm functional scores, KT-1000 measurements, the presence of a residual pivot-shift, and the graft rupture rate were evaluated. The study was performed at University of São Paulo in Brazil. Results: Ninety patients undergoing ACL reconstruction with ligamentous hyperlaxity were evaluated. The mean follow up was 29.6 ± 6.2 months for group 1 and 28.1 ± 4.2 months for group 2 (P = .51). No significant differences were found between the groups regarding Beighton scale, gender, the duration of injury before reconstruction, follow-up time, preoperative instability, or associated meniscal injuries. The mean age was 29.9 ± 8.1 years in group 1 and 27.0 ± 9.1 years in group 2 (P = .017). In the final evaluation, group 2 patients showed better anteroposterior clinical stability as evaluated by KT-1000 arthrometry (P = .02), better rotational stability as evaluated by the pivot-shift test (P = .03) and a lower reconstruction failure rate (21.7% [group 1] vs 3.3% [group 2]; P = .03). Clinical evaluations of postoperative functional scales showed no differences between the 2 groups (P = .27 for International Knee Documentation Committee; P = .41 for Lysholm). Conclusions: Combined ACL and ALL reconstruction in patients with ligamentous hyperlaxity resulted in a lower failure rate and improved knee stability parameters compared to isolated ACL reconstruction. No differences were found in the functional scales. Level of evidence: Level III, case control study.

The knee anterolateral ligament (ALL) has been well established as a structure in the anterolateral capsular region. Despite some initial controversy regarding the parameters of this structure, two published consensuses confirm its presence and anatomical parameters. The ALL has an origin posterior and proximal to the lateral epicondyly, a meniscal insertion between its body and anterior horn and a tibial insertion between the Gerdy tubercle and the fibular head.

After several anatomic, imaging, and biomechanical studies of the ALL, surgical techniques were developed and case series in which reconstruction of this structure
was combined with the anterior cruciate ligament (ACL) reconstruction were initiated. Although the biomechanical studies are controversial, in vivo results tend to favor this type of combined reconstruction; however, only a few studies have been conducted. One series found that combined reconstructions resulted in a lower rerupture rate than isolated ACL reconstructions with patellar tendon or hamstring grafts in at-risk populations. Another randomized study showed improvements in the KT-1000 arthrometer test in patients who underwent combined ACL and ALL reconstruction, although other parameters did not show significant differences. Sonnery-Cottet et al. showed a lower failure rate of the medial meniscal repair in patients who underwent combined ALL reconstruction, and Helito et al. showed improvements on functional scales and less instability on physical examination in patients with chronic ACL injuries undergoing combined ALL reconstruction.

In most studies on ALL reconstruction or even extra-articular reconstructions, the indications for such procedures are not well established. Currently, the indications include participation in high-demand sports activities associated with frequent rotational movements of the knee, young age, ligamentous hyperlaxity/genu recurvatum, ACL revision cases, or cases of chronic ACL injury. Nevertheless, none of the existing studies on ALL reconstruction have detailed the prevalence of hyperlaxity. Although a significant number of cases reported by Ibrahim et al. and Sonnery-Cottet et al. and Helito et al. exhibit a high-grade pivot-shift, laxity data were not mentioned.

Ligamentous hyperlaxity is an indication for reconstruction because affected patients are known to have worse functional outcomes, greater postoperative residual instability, and a higher failure rate. One study showed that almost one-third of patients with hyperlaxity and ACL reconstruction experienced graft rerupture, contralateral ACL rupture, or excessive laxity. Larson et al. and Kim et al. suggest that, in cases of hyperlaxity, the patellar tendon is a better graft option than the hamstrings tendons. However, Kim et al. question whether eventual ALL reconstruction can be considered an adjunctive treatment for reduced stability and higher ACL rupture rate in patients with generalized laxity. The authors suggest that the effects of combined extra-articular reconstruction must be further evaluated.

The purpose of this study is to compare functional outcomes, residual instability, and rupture rates in patients with ligamentous hyperlaxity undergoing isolated ACL reconstruction or combined ACL and ALL reconstruction. Our hypothesis is that patients undergoing combined ALL reconstruction will achieve better outcomes than patients undergoing isolated ACL reconstruction with hamstrings tendons.

**Methods**

A group of consecutive patients with ACL injuries and ligamentous hyperlaxity underwent combined ACL and ALL reconstruction by the same surgeon (C.P.H.; 11 years of experience) between January 2015 and August 2016. This group was compared with a historical control group of patients not operated in the same period. The inclusion criteria were hyperlaxity patients based on the modified Beighton scale, with evaluation of the contralateral limb to exclude any possible effects of trauma in the injured limb. Because the injured limb was excluded from the Beighton scale evaluation, a minimum value of 5 of 8 was established as the criteria for hyperlaxity for this study. The evaluation included passive dorsiflexion and hyperextension of the fifth metacarpophalangeal joint beyond 90°, passive apposition of the thumb to the flexor aspect of the forearm, passive hyperextension of the elbow beyond 10°, passive hyperextension of the knee beyond 10°, and active forward flexion of the trunk with the knees fully extended so that the palms of the hands rested flat on the floor. Two examiners performed the Beighton evaluation and correlation was calculated. The exclusion criteria were associated collateral ligament injuries, patients who had undergone previous surgery on the affected knee, cases requiring axis correction by osteotomy, and patients with associated meniscal or chondral injuries requiring surgical treatment, except small meniscectomies (less than 50% of the meniscus width). This group of patients was compared with a group of patients with the same characteristics who underwent surgery (isolated ACL reconstruction) between January 2011 and January 2013 and were evaluated in 2015 (the same follow-up period). A historical control was used because our group has routinely performed combined ACL and ALL reconstruction in laxity cases since 2014. The study was approved by the ethics committee of our institution and informed consent was obtained from all patients.

The patients in group 1 (control) were subjected to anatomical ACL reconstruction with the outside-in femoral tunnel technique using hamstring grafts (doubled semitendinosus and doubled gracilis grafts). The patients in group 2 (ACL + ALL) also underwent reconstruction using the outside-in technique with hamstring tendons but with tripled semitendinosus and single gracilis grafts for ACL reconstruction; the remaining portion of the gracilis was used for ALL reconstruction. Reconstruction was performed by fixing the ALL onto the femur and tibia with an interference...
screw. The femoral tunnel used for the ALL was the same one used for the ACL reconstruction. In combined ACL and ALL reconstructions, the femoral tunnel was performed with entry point in the external surface of the lateral condyle slightly posterior and proximal to the lateral epicondyle, to replicate the ALL femoral attachment. In isolated ACL reconstructions, the entry point was not necessarily this anatomical point. The tibial tunnel for the ALL was created between the Gerdy tubercle and the fibular head, approximately 5 to 10 mm below the lateral articular plateau. Tibial fixation was performed with an interference screw in neutral rotation and close to full extension because this position was shown to restore knee kinematics according to Inderhaug et al.17 (Figs 1 and 2).

Both groups followed the same rehabilitation protocol, which is the protocol used for isolated ACL reconstruction at our hospital. No immobilization device of any type was used, and movement was not restricted. Patients were encouraged to walk as tolerated on the operated limb and range of motion was free and stimulated since the first day after surgery.

The demographic data of the 2 groups were compared to evaluate the similarities between them. Additionally, the following parameters were evaluated: the presence of associated meniscal injuries; intra-articular ACL graft size; KT-1000 arthrometry (graded in millimeters as the difference between the contralateral knee); pivot-shift test (graded in 0 to 3); the rerupture rate; and the International Knee Documentation Committee (IKDC) and Lysholm functional scales. The clinical examination (pivot-shift and KT-1000) and the functional scales were performed by surgeons and physiotherapists not directly involved in the surgical procedure and with experience in physical examination of the knee. The more experienced examiner served as the main examiner, and the less experienced examiner enabled evaluation of interrater agreement.

New ruptures were defined based on clinical ACL failure criteria (physical examination showing laxity with no clear end point for Lachman and Anterior drawer tests (at least 2+/3+) or pivot-shift positivity (at least 2+/3+) associated with instability complaints) and when imaging showed a new graft rupture. Residual pivot was defined as any positivity in the pivot-shift assessment. Apart from graft failure, other complications such as infection, range of motion loss and knee pain were evaluated. The study was approved by the ethics committee of our institution and informed consent was obtained from all patients.

**Statistical Analysis**

The statistical analysis was performed using Pearson’s χ²-square test and the Fisher test for categorical variables. For continuous variables, Shapiro-Wilk tests and histogram analysis were used to check the normality of the data, and t test for independent samples or Wilcoxon rank-sum test for continuous variables as appropriate. The interrater agreement between the 2 examiners for the pivot-shift test and Beighton laxity score was evaluated using the Cohen kappa coefficient.
The interrater agreement for KT-1000 measurements between 2 examiners was evaluated using intraclass correlation coefficient. No sample size estimation was performed because all patients in our database who met the inclusion criteria were analyzed. A post hoc calculation achieved a power of 84.2% for KT-1000 evaluation. Statistical significance was considered when the P value was less than .05.

**Results**

One-hundred and eleven patients were initially included in this study, but 21 (14 in group 1 and 7 in group 2) were excluded because of associated pathology (12 meniscal repairs, 2 proximal tibia osteotomies, 5 associated posterolateral corner reconstruction, and 2 associated medial collateral ligament reconstruction). Ninety patients with ligamentous hyperlaxity underwent ACL reconstruction and were finally evaluated in this study. Group 1 (control) consisted of 60 patients and group 2 (ACL + ALL) consisted of 30 patients. The groups did not differ with respect to gender (P = .80), the time from injury to surgery (P = .41), modified Beighton scale (P = .42), intra-articular ACL graft size (P = .44), or preoperative physical examination results (P = .27 for KT-1000 and P = .73 for pivot-shift). A 3-year difference in the mean age was noted between the groups, with mean ages of 29.9 and 27.0 years for groups 1 and 2, respectively, P = .017. Follow-up time was 29.6 ± 6.2 months for group 1 and 28.1 ± 4.2 for group 2 (P = .51) (Table 1).

In the final evaluation, group 2 patients showed better clinical anteroposterior stability as evaluated by KT-1000 arthrometry (P = .02), better rotational stability as evaluated by the pivot-shift test (P = .03), and a lower reconstruction failure rate (P = .03). In group 1, 51.7% presented positive pivot-shift (83.9% grade 1 and 16.1% grade 2) against 26.7% in group 2 (all grade 1). Clinical evaluations of postoperative functional scales showed no differences between the 2 groups (0.27 for IKDC and 0.41 for Lysholm), although the means in absolute numbers favored the combined reconstruction group (Table 2). The correlation coefficient to assess interexaminer agreement regarding the Beighton classification, pivot-shift, and KT-1000 was 0.967, 0.654, and 0.753, respectively, and were considered almost perfect and substantial agreement according to Landis and Koch (< 0 poor agreement, 0 to 0.2 slight agreement, 0.21 to 0.4 fair agreement, 0.41 to 0.6 moderate agreement, 0.61 to 0.8 substantial agreement, and 0.81 to 1.0 almost perfect agreement).18

As an exploratory subgroup analysis, we evaluated postoperative KT-1000, residual pivot-shift, and rerupture rate according to the severity of modified Beighton classification (Table 3). No correlation was

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**Table 1. Characteristics of the Patients Included in the Study**

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (Control)</th>
<th>Group 2 (ACL + ALL)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>60</td>
<td>30</td>
<td>.017</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>29.9 ± 8.1</td>
<td>27.0 ± 9.1</td>
<td></td>
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<tr>
<td>Number of males</td>
<td>28 (46.7%)</td>
<td>13 (43.3%)</td>
<td>.80 (NS)</td>
</tr>
<tr>
<td>Duration of injury before surgery (mo)</td>
<td>12.4 ± 14.2</td>
<td>13.1 ± 12.8</td>
<td>.41 (NS)</td>
</tr>
<tr>
<td>Preoperative KT-1000 (mm)</td>
<td>7.4 ± 1.2</td>
<td>7.7 ± 1.3</td>
<td>.27 (NS)</td>
</tr>
<tr>
<td>Preoperative pivot-shift</td>
<td>11 grade 1 (18.3%), 28 grade 2 (46.7%), and 21 grade 3 (35.0%)</td>
<td>6 grade 1 (20%), 16 grade 2 (53.3%), and 8 grade 3 (26.7%)</td>
<td>.73 (NS)</td>
</tr>
<tr>
<td>Beighton scale</td>
<td>5.8 ± 0.9</td>
<td>6.1 ± 1.1</td>
<td>.42 (NS)</td>
</tr>
<tr>
<td>Presence of meniscal injuries</td>
<td>20 (33.3%)</td>
<td>8 (26.7%)</td>
<td>.52 (NS)</td>
</tr>
<tr>
<td>Follow-up time (mo)</td>
<td>29.6 ± 6.2</td>
<td>28.1 ± 4.2</td>
<td>.51 (NS)</td>
</tr>
<tr>
<td>Graft diameter (mm)</td>
<td>8.1 ± 0.8</td>
<td>8.2 ± 0.6</td>
<td>.44 (NS)</td>
</tr>
</tbody>
</table>

**Table 2. Intra-articular Graft Diameter, Functional Tests, Physical Examinations, and Graft Rupture Rates of Patients in the Study**

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (60 Patients)</th>
<th>Group 2 (30 Patients)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective IKDC</td>
<td>84.3 ± 9.8</td>
<td>86.9 ± 9.3</td>
<td>.27 (NS)</td>
</tr>
<tr>
<td>Lysholm</td>
<td>86.3 ± 7.8</td>
<td>88.3 ± 7.3</td>
<td>.41 (NS)</td>
</tr>
<tr>
<td>Postoperative KT-1000 (mm)</td>
<td>2.3 ± 1.4</td>
<td>1.5 ± 1.1</td>
<td>.02</td>
</tr>
<tr>
<td>Residual pivot-shift</td>
<td>51.7%</td>
<td>26.7%</td>
<td>.03</td>
</tr>
<tr>
<td>Postoperative pivot-shift</td>
<td>29 grade 0, 26 grade 1, 5 grade 2</td>
<td>22 grade 0, 8 grade 1</td>
<td>.04</td>
</tr>
<tr>
<td>Rerupture</td>
<td>13 (21.7%)</td>
<td>1 (3.3%)</td>
<td>.03</td>
</tr>
</tbody>
</table>

NOTE. Data are presented as mean ± standard deviation. NS, nonsignificant.
found between higher grades of hyperlaxity and worse clinical outcomes for this specific population.

Regarding complications, 1 patient in group 1 had a superficial infection of the tibial incision used to harvest the grafts, which was resolved with oral antibiotics. One group 2 patient had a cyclops-type lesion and arthroscopic removal of the arthrofibrosis was required; this patient progressed satisfactorily after this procedure. No other patient had any loss of range of motion of the knee. Seventeen (28.3%) patients in group 1 and 11 (36.7%) patients in group 2 had lateral discomfort in the first 2 months after surgery. Of these patients, 4 (6.7%) patients in group 1 and 3 (10%) in group 2 had continued discomfort for up to 3 months. After 3 months, no more complaints were reported, and none of these patients had impaired rehabilitation.

**Discussion**

The main finding of this study is that, for patients with ligamentous hyperlaxity, combined ACL and ALL reconstruction reduces the likelihood of failure and improves anteroposterior and rotation stability compared with isolated ACL reconstruction; therefore, ALL reconstruction should be considered in the treatment of ACL injuries in this specific group of patients. Even though the pivot-shift rate was significant different between the 2 groups, functional scores as IKDC and Lysholm presented similar results. This finding might suggest that in this hyperlaxity population minor degrees of pivot-shift positivity do not strongly influence the functional outcomes for patients that do not present graft failure.

The generalized prevalence of ligamentous laxity ranges from 5% to 20% depending on the criteria used.\textsuperscript{19,20} Patients with ligamentous hyperlaxity represent a known risk group for primary ACL injury and for reconstruction failure.\textsuperscript{21} Vaishya and Hasija\textsuperscript{22} reported that hypermobility is more common in patients with ACL injury than in control groups. Sundemo et al.\textsuperscript{23} reported that patients with hyperextension exhibit greater anteroposterior instability in both the pre- and postoperative periods, and Magnussen et al.\textsuperscript{24} reported that ligamentous laxity is associated with increased Lachman, pivot-shift, and anterior drawer tests in cases of ACL injury. A study from the Multicenter ACL Revision Study Group also showed that passive extension of more than 5° is a significant independent predictor of graft failure after ACL revision surgery.\textsuperscript{25}

The ACL reconstruction failure rate is also higher in patients with ligamentous laxity, as was confirmed by the numbers shown in this study. A study by Larson et al.\textsuperscript{14} showed that patients with hypermobility had a 24.4% failure rate, with rates of 25% for hamstrings tendons, and 21.1% for the patellar tendon. These figures are higher than the mean ACL failure rate of 5.8% found by Wright et al.\textsuperscript{26} in a systematic review.
Kim et al.\textsuperscript{21} reported abnormal (C) and severely abnormal (D) IKDC scores in 36.4% of patients with hyperlaxity undergoing ACL reconstruction with hamstrings tendons and in 20% of patients undergoing reconstruction with patellar tendons. Another study by the same group\textsuperscript{15} showed that a greater laxity index corresponded to greater residual postoperative instability and lower IKDC and Lysholm functional scale scores. They also reported worse outcomes for reconstructions with hamstrings tendons compared to those for reconstructions with patellar tendons.

For all of these reasons, ligamentous hyperlaxity may be an indication for combined extra-articular reconstruction at the time of ACL reconstruction. In 2 recent studies performed after expert meetings, Sonnery-Cottet et al.\textsuperscript{4,9} and Getgood et al.\textsuperscript{3} included ligamentous hyperlaxity and genu recurvatum as possible indications for combined extra-articular reconstruction via anatomical reconstruction of the ALL with a free graft or the anterolateral complex using iliotibial band tenodesis. In another study showing worse functional outcomes in patients with ligamentous laxity, Kim et al.\textsuperscript{13} suggested that extra-articular reconstruction may protect the ACL graft in this specific patient population and may therefore serve as a complement to ACL reconstruction. These authors cautioned that at the time of publication of their study, no previous studies had conducted such a comparison.

We believe that isolated ACL reconstruction with hamstring tendons should not be the preferred technique in patients with ligamentous hyperlaxity, especially in patients with Beighton scale above 5, because of the high failure rate (21.7%) and residual pivot-shift (51.7%) found in this patient group. These findings are consistent with those of the studies by Kim et al.\textsuperscript{13} who showed a positive pivot-shift test rate of 38.1%, and Vadala et al.\textsuperscript{27} who showed a positive pivot-shift rate of 57.1% in female athletes. Moreover, when combined with ALL reconstruction, our study demonstrated a rerupture rate of only 3.3% and a residual pivot-shift of 26.7% in this high-risk population.

Reconstructions with the patellar tendon or other types of grafts were not evaluated in this study. We believe that if intra-articular ACL reconstruction alone is selected, the patellar tendon or quadriceps can be used. Nevertheless, the combined ACL and ALL reconstruction failure rate of 3.3% observed in this study is lower than the 21.1% failure rate found by Larson et al.\textsuperscript{14} or the rate of 19.4% for IKDC scores C or D found by Kim et al.\textsuperscript{15} both of whom used patellar tendon reconstructions in patients with ligamentous laxity. Moreover, Kim et al.\textsuperscript{13} showed a failure rate of only 2.3% over a 2-year follow up with the use of patellar tendon grafts.

**Limitations**

This study is not without limitations. First, the analysis of the sample was retrospective despite prospective data collection, with different numbers of patients in the groups, which were treated in different periods. Also, a historical control was used because ALL reconstructions in our group started only in 2013 and became the standard for cases of hyperlaxity in 2014. The study results are limited to short-/mid-term results, and long-term results were lacking; therefore, the complication of overstraining the lateral compartment and inducing osteoarthritis could not be detected in this time period. Also, no objective measurements of the rotational laxity were performed.

**Conclusions**

Combined ACL and ALL reconstruction in patients with ligamentous hyperlaxity resulted in a lower failure rate and improved knee stability parameters compared with isolated ACL reconstruction. No differences were found in the functional scales.

**References**

10. Helito CP, Camargo DB, Sobrado MF, et al. Combined reconstruction of the anterolateral ligament in chronic ACL injuries leads to better clinical outcomes than isolated


