Outcome of hamstring graft with preserved insertion: Prospective Study with 5 year Follow-up

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Abstract

Background

Autologous hamstring graft remains to be a commonly used graft for Anterior Cruciate Ligament (ACL) in sportspersons. With less graft failure rates, better mechanical stability and proprioception with preserved insertion hamstring graft, we investigated long term outcomes of hamstring graft with preserved insertion. Methods: 441 sportspersons were enrolled in the study. They were divided into two groups by computerized randomization. In Group I, ACL reconstruction was done using hamstring free graft (STGF), and in Group II, ACL reconstruction was done using hamstring graft with preserved tibial insertion (STGPI). Postoperatively, patients were assessed for graft rupture, knee stability, Lysholm score, tegner activity and WOMAC score.

Results

The average age of the patients was 24 ± 2 years in group 1 and 27 ± 8.5 years in group 2. At 5 years, the mean KT-1000 difference was 2.01 in group 1 and 1.96 in group 2 ($P = 0.77$); the mean Lysholm score was 97.80 and 98.60($p = 0.07$), respectively; mean WOMAC score was 3.09 and 3.12($p = 0.89$) respectively; mean difference between the pre-injury and post-surgery Tegner level of sports activity was 1.78 and 0.54($P < 0.05$), respectively and graft failure rate was 4.1% and 7.7%.($p < 0.05$), respectively.

Conclusion

We report STGPI to be a more viable option than hamstring free graft in sportspersons for ACL reconstruction due to less graft failure rates and better tegner activity score postoperatively. Further, STGPI is an option with low graft failure rate like that of Bone Patellar Tendon Bone graft,with added advantage of not having significant donor site morbidity.

Level of Evidence

Level 1, Randomized Controlled Trial

Background

Anterior cruciate ligament (ACL) is one of the most common injuries in pivoting sports for which ACL reconstruction is the gold standard operative treatment[1–3]. Multiple risk factors influence the outcomeof a successful ACL reconstruction such as age, gender, size of graft, correct tunnel positioning, notch width, posterior tibial slope etc[4–6]. However, graft of choice for a successful ACL reconstruction in sportspersons remains an unsolved dilemma[7, 8].

A number of options exist for graft preparation including Bone Patellar Tendon Bone (BPTB graft), hamstring graft, peroneal tendon graft, iliotibial band etc[9]. They can be used either as an allograft or an autograft[9]. With less infection rates and graft failure rates, autografts are the graft of choice[10].

Though several studies report, BPTB graft has a higher return to sports rateand less graft failure incidence compared to the hamstring free graft, there exist some donor site morbidities such as anterior knee pain, heterotrophic calcification and hypertrophic scar which affect the performance of a sportsperson[11–14]. Thus, the choice of graft for ACL reconstruction remains a void in literature, with each graft having its share of merits and demerits.

Autologous hamstring graft remains to be a commonly used graft in sportspersons[15]. With the problems related to the vascularisation of graft, less effective proprioception postoperatively, and weak tibial side fixation, there remains risk of graft pull-out from the tunnel[15–17]. Recent literature reports, preservation of insertion on tibial side led to better mechanical stability and proprioception, though not established conclusively[15, 17–20]. Also, Sacramento *et al*. in a study on double bundle ACL reconstruction with preserved tibial side insertion reported better clinical outcome and stability[20]. In the present study, single bundle ACL reconstruction was done using hamstring graft to assess for side to side translation, functional outcome and graft failure rates in sportspersons between preserved hamstring insertion and detached hamstring insertion on tibial side. We hypothesized that a hamstring graft with preserved insertion is a more viable option with less graft failure rates and better functional outcomes.

Materials

Study Type and Data Collection (FIGURE I): This was a 5 year follow-up of a prospective, single-blind (evaluator was blinded), randomised controlled trial on 442 elite sportspersons with primary ACL tear conducted in our institution from year 2011 to 2019 after getting approval from the ethical committee of our institution. These were divided into 2 groups with 221 patients in each group. After taking written informed consent from each patient, they were randomised into 2 groups after making them pick a sealed envelope containing the name of surgical technique for which they will be operated upon. An automatic randomisation was thus initiated. Inclusion criteria included: sportspersons with primary ACL injury, aged between 18 to 35 years. Exclusion criteria included: ACL avulsion injury, multiligamentous injuries, skeletally immature patients, Beighton score[21] > 6 and any injury to same knee or contralateral knee. Transportal technique was used to make femoral tunnel in all cases in both the groups[22]. Group 1 had patients who got operated with hamstring free graft[23] (Technique 2) and groups 2 patients got operated with hamstring graft with preserved insertion[16] (Technique 1). Preoperatively patients were assessed with anterior drawer test, lachman test, pivot shift test(was performed under anaesthesia) and MRI to confirm the diagnosis. Patients were also assessed for anatomical factors including notch width index[24] and posterior slope[25] on x-rays. Intraoperative findings meniscus tear, chondral damage, femoral tunnel length and size of graft were noted and included in the study. Functional outcome was assessed using Lysholm score[26], Tegner activity score[27], WOMAC score[28] and single leg hop test[29]. Side to side translation was assessed using knee arthrometer (KT1000; MEDmetric, San Diego, CA) by applying 134 N of force[30].The surgical procedure was performed by the single surgeon (R.G.) in all cases. All patients underwent a standard postoperative rehabilitation protocol for 6 months.

Technique 1

The semitendinosus and gracilis (STG) graft was harvested through a 3–5 cm incision centered 2 cm medial to the tibial tuberosity. The sartorius fascia was visualized and incised parallel to the STG tendons. The STG tendon were identified and hooked from the pesanserinus bursa with a haemostat. The associated bands of accessory insertions of these tendons, if any, were severed and the main insertion to the proximal tibia was preserved. The tendons of gracilis and semitendinosus, individually, were harvested using an open ended tendon stripper and the muscle tissue was removed from the aponeurotic ends of the tendons. The proximal free ends of the tendons were sutured together by using Ethibond No. 5 suture (Ethicon, Inc. Johnson and Johnson, India, Mumbai). The tendons were looped around an Ethibond No. 5 suture placed at their middle, thus creating a quadrupled graft. The graft was sized with the graft seizers of 0.5 mm increments. The graft was wrapped with a saline moist gauze piece.

The routine arthroscopy of the knee, the debridement of the ACL stump, the drilling of the femoral and tibial tunnels by transportal technique and the placement of the ethibond no 5 loop in the femoral and tibial tunnels was done. While drilling the tibial tunnel, care was taken not to impale the harvested graft covered with the saline moist gauze piece with the tibial guide pin/ reamer. The length of the tibial tunnel and the intraarticular part (length Y) of the proposed graft was measured with a depth gauge (Figure II) which was added to the already measured length of the femoral tunnel (length X) to know the exact length of the both the tunnels plus the intrarticular path of the graft (length X + Y). The distance between the insertions of the STG and the opening of the tibial tunnel on the tibial cortex was measured and the tendons of STG were transfixed with an ethibond number 5 at the same distance from the insertions so that when the graft was pulled into the femoral tunnel the suture mark (Figure III) lies at the opening of the tibial tunnel on the tibial cortex. Tibial end of the an endobutton (Smith & Nephew, Mumbai, India) was used to pull the quadrupled graft into the joint and the length of the loop of the endobutton was decided so that at least 15 mm of the graft remains inside the femoral tunnel (Figure IV). The free end of the graft is pulled to maximal stretch and the joint was moved through full range of motion at least 20 times to remove any kinks in the graft. The tightness of the ACL graft was checked arthroscopically with a probe. With maximal stretch on the free end of the graft, it was sutured to the preserved end of the graft with a number 5 ethibond.

Technique 2

Standard arthroscopic portals were made, and routine arthroscopic exploration of the knee joint was performed. Free hamstring tendon graft was harvested using a closed-ended tendon stripper. Tunnel placement was similar to that in technique 1. Femoral fixation of the graft was achieved with an EndoButton. The length of the EndoButton loop was chosen such that a minimum of 15 mm of the graft could be incorporated into the femoral tunnel. For tibial fixation, a bioabsorbable interference screw (Smith & Nephew) measuring 1 size larger than the diameter of the tunnel was used.

Rehabilitation protocol

Closed-chain exercises were started from postoperative day 1, and open-chain exercises were introduced at 3 months of follow-up. During the first 6 weeks, patients were allowed unlimited range of motion and full weight bearing in a brace, and they performed straight-leg raises and static quadriceps exercises. At 6 weeks, cycling was introduced in addition to the existing physiotherapy. At 3 months, light jogging was allowed. At 6 months, patients were allowed to practice sports and undergo endurance exercises for the next 1 to 2 months. Finally, after satisfactory performance by players in a practice game, patients were allowed to return to competitive sports. Because the study was a single-blind study, the surgical technique was not disclosed to the patient and the observer.

Statistical Analysis

Quantitative data was presented as mean ± SD or median and interquartile range, as appropriate. Normality of data was checked by Kolmogorov Smirnov tests of normality. For skewed data or scores, Mann-Whitney test for two groups was applied. For normally distributed data, two groups were compared using independent t-test. Proportions were compared using Chi-square or Fisher's exact test, depending on their applicability. All the statistical tests were two-sided and performed at a significance level of α = 0.05. The analysis was conducted using IBM SPSS STATISTICS (version 22.0).

Results

A total of 1512 patients had ACL reconstruction at our institution from year 2011 to 2014. Out of these, 442 patients (29.2%) fulfilled our inclusion criteria. The average age of the patients was 24.62 ± 2 (years) in group 1 and 25.14 ± 8.5 (years) in group 2. The mean follow-up of patients in group 1 was 64.9 ± 7.0 months, whereas the mean follow-up of group 2 patients was 68.2 ± 7.3 months. The mean duration between injury and index surgery was 15.75 ± 20.16 (months) in group 1 and 18.11 ± 19.9 (months) in group 2. In group 1, 106 patients sustained an injury to the right knee, whereas in group 2, 117 patients sustained an injury to the right knee. In group 1, 12 of 221 patients were women, and in group 2, 15 of 221 patients were women. In both the groups' non-contact mode of injury was more with 156 (70.58%) patients in group 1 and 147(66.51%) patients in group 2. Both the groups were comparable for demographic factors including age, gender distribution, body mass index; anatomical factors including posterior tibial slope, notch width index; intraoperative findings including femoral tunnel length (graft length in tunnel was kept ≥ 15 mm in all cases in both the groups), size of graft, chondral damage and meniscal tear; with p value would to be non-significant(> 0.05)[Table-I]. Functional assessment: Lysholm score was found to be non-significant at 6 months, 1 year, 2 years and 5 years follow-up[Table-II]. Similarly WOMAC score was found to be non-significant at 6 months, 1 year, 2 years and 5 years follow-up[Table-II]. Arthrometric KT-1000 difference was found to be non-significant at 6months, 1 year, 2 years and 5 years follow-up[Table-II]. Mean time to return to sports was similar in both the groups, though we observed higher postoperative tegner activity score at 5 year follow-up in group 2 with more patients returning to their pre-injury level [Table-I and III].Limb symmetry index (LSI) using single-leg hop test was 90.2% in group 1, and 88.7% in group 2. The difference between uninjured and injured limb using single-leg hop test was not significant (n.s.). At a mean follow-up of 15.26 ± 6.30 (months) in group 1 and 18.76 ± 8.80 (months), the graft rupture rate was found to be significant, with 9(4.1%) patients in group 1 and 17(7.7%) patients in group 2 with p value of 0.005. Drop Out analysis [Table-IV]: Since out of a total number of 416(26 patients with graft rupture were not included for final follow-up) operated sportspersons in our series, we were able to get 342 patients for final follow up at 5 years, we performed a drop out analysis of the 74 patients who could not be available for the final follow up. The drop analysis is given in Table IV.

Discussion

The most important finding of the present study was that, patients in whom ACL reconstruction was done using hamstring graft with preserved insertion, had significant number of players returning to same level of sports postoperatively. Also, there was a statistical significant correlation of hamstring free graft with graft rupture. However, the two groups were comparable in terms of mean follow up, arthrometricKT-1000 difference, Lysholm score, WOMAC score, limb symmetry index and return to sports.

Neuromuscular control is understood to play an imperative role in injury risk and has been recognised as the most amendable risk factor[31]. Neuromuscular training expedites alterations which improve pre and mid stance neuromuscular activation configurations, which decrease joint motion and prevents ACL injury from high pivoting loads sustained during sports[32]. A study by Hewitt et al states that even after ACL reconstruction the proprioception remains poor and is a major risk factor for re-injury of ACL[2]. Better proprioception leads to better neuromuscular control and thus helps in regaining pre-injury Tegner activity level post ACL reconstruction[33]. A prospective study by Gupta et al found better proprioception and hence neuromuscular control in patients treated with hamstring graft with preserved insertion than free hamstring grafts[16].

Lack of vascularity associated with free hamstring graft prone for graft failure during the initial phase of revascularisation which is absent in case of hamstring grafts with preserved insertion, as they remain vascular due to an uninterrupted supply from the tibial side with the help of inferior genicular artery[34, 35]. A randomised controlled study by Ruffilli et al observed that preservation of blood supply at tibial end restores the blood supply of graft post ACL reconstruction and helps in early ligamentisation of graft within the tunnel[36]. Further, they reported improved morphology of the graft within the tunnel compared to hamstring free graft, which confirms our finding of decreased graft failure in cases of hamstring graft with preserved insertion[36].

Tibial side fixation has been observed to be a weak link post ACL reconstruction as the vector of forces acts in the line of tibial tunnel[37, 38]. Further, tendon to bone healing at insertion site is superior to tendon fixation inside tunnel with screw as observed by various studies inpast[15, 16, 18–20]. As, the biological insertion at tibial side maintains the inherent strength, that is resistant to cyclical forces[15], we propose, hamstring graft with preserved insertion provides less chances of graft pull-out from tunnel. There was no graft pull-out from the tunnel in this study, adding to the debate of secureness of graft on the tibial side with preserved insertion grafts.

Though there has been tremendous improvement in understanding of techniques of graft harvest, fixation devices and biology of graft incorporation, there is very little literature mentioning the superiority within the hamstring graft types[34, 39, 40]. This study adds to the discussion on graft healing, maturation, the necessity for surgeons to objectively assess healing after ACL reconstruction and the benefits of an individualized surgery, including graft choice.

In the present study, both the groups were matched in terms of age, gender distribution, anatomical factors, intraoperative factors including femoral tunnel length, meniscal tear and chondral damage, side involved, hormonal factors, level of sports and mode of injury. Further, this study compared both the grafts in terms of graft failure, functional outcome, objective mechanical stability, and return to sports. To our knowledge, this is the first study of its kind, with such a long follow-up and optimum sample size, reducing the confounding bias to minimum, hence, reducing the dilemma existing with graft type to be used for ACL reconstruction.

There exists concerns of windshield wiper effect and Bungee-cord effect of graft with preserved insertion as fixation on the tibia side is away from aperture, though we didn't observed this till the final follow-up of 5 years. Further, we have not calculated tunnel widening difference between 2 techniques which could have shed more light on graft incorporation within the tunnel.

Conclusion

We report hamstring graft with preserved insertionto be amore viable option than hamstring free graft in sportspersons for ACL reconstruction due to lessgraft failure rates, less donor site morbidity, preserved blood supply at its insertion site, better proprioception, equally significant rates of return to sports and better tegner activity score postoperatively. Further, hamstring graft with preserved insertion is an option in the clinical setting with low graft failure rate like that of BPTB graft and the added advantage of not having significant donor site morbidity.

Abbrevations

ACL: Anterior Cruciate Ligament

BPTB: Bone Patellar Tendon Bone

STGPI: Semitendinosus Gracilis with Preserved Insertion

STGF: Semitendinosus Gracilis Free

Declarations

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Institutional ethical committee approval was taken before the start of research.

Informed consent:

Informed written consent was received from all the patients.

Availability of Data and Materials:

Mentioned as in materials and methods section.

Competing interests:

The authors had no competing interests related to research and authorship is granted to only those individual who have contributed substantially to the manuscript.

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Author’s Contribution

RG was the primary surgeon in this case and conceptualized the study. AS assisted in most of the cases, did review of literature and wrote the manuscript. RM did the proof reading and assisted in some of the cases. GD contributed in review of literature and editing of the manuscript.

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Tables

(n = 221 in each group)	Group 1	Group 2	P value
BMI (kg/m^2)	22.27 ± 4.10	21.80 ± 4.75	0.26
Concomitant meniscus damage	105	96	0.70
Meniscal repair	15	17	0.90
Concomitant chondral damage	69	50	0.70
Grade 4	14	16	0.73
Grade 3	33	25	0.85
Grade 2	72	69	0.81
Size of graft(mm)	7.40 ± 1.13	7.54 ± 1.10	0.18
Femoral Tunnel Length(mm)	36.67 ± 3.81	36.21 ± 3.20	0.17
Notch width Index	0.28 ± 0.04	0.29 ± 0.51	0.77
Posterior Tibial Slope(degrees)	8.01 ± 4.68	8.63 ± 2.65	0.08
Mean time to return to sports(months)	8.10 ± 2.92	7.96 ± 2.65	0.59

Table I: Comparison of different variables between Group 1 and Group 2

Mean KT-1000	Group 1 (n)	Group 2 (n)	P value
At 6 months	2.72 ± 0.80 (n = 221)	2.63 ± 0.80 (n = 221)	0.23
At 12 months	2.52 ± 1.54 (n = 220)	2.40 ± 1.50 (N = 219)	0.40
At 2 year	2.31 ± 1.13 (n = 210)	2.20 ± 1.20 (n = 212)	0.33
At 5 year	2.01 ± 1.43 (n = 176)	1.96 ± 1.86 (n = 166)	0.77
WOMAC Score			
At 6 months	6.45 ± 5.16 (n = 221)	5.96 ± 6.16 (n = 221)	0.36
At 12 months	3.50 ± 2.30 (n = 220)	3.20 ± 3.01 (n = 219)	0.24
At 2 year	3.30 ± 2.23 (n = 210)	3.28 ± 2.12 (n = 212)	0.92
At 5 year	3.09 ± 1.98 (n = 176)	3.12 ± 2.10 (n = 166)	0.89
Lysholm Score			
At 6 months	91.20 ± 5.39(n = 221)	91.5 ± 4.86(n = 221)	0.48
At 12 months	93.50 ± 5.23 (n = 220)	94.10 ± 3.91 (n = 219)	0.21
At 2 year	96.10 ± 5.81 (n = 210)	96.39 ± 4.60 (n = 212)	0.56
At 5 year	97.80 ± 4.04 (n = 176)	98.60 ± 4.13 (n = 166)	0.07

Table II: Results of KT-1000 difference, WOMAC score, Lysholm score at 6 months, 12 months, 2 years and 5 years follow-up

	Group 1(n)	Group 2(n)	P value
Pre-injury Level	8.32 ± 2.12 (n = 221)	8.10 ± 1.98 (n = 221)	0.26
At 5 years follow-up	6.54 ± 1.86 (n = 176)	7.56 ± 2.01 (n = 166)	0.0001(< 0.05)
Difference between pre-injury level and at 5 years follow-up	1.78 ± 1.90	0.54 ± 2.0	0.0001(< 0.05)

Table III: Mean Tegner activity score before injury and post ACL reconstruction at 5 years follow-up

Reasons for Drop Out	N	Percentage(%)
Patients who were unable to come due to long distance from home but telephonically confirmed that they were doing well	20	4.8
Death/tragedy at home/family reasons	5	1.2
Patients who resumed their game, were in healthy condition, had busy sport schedule, hence, couldn't come	24	5.7
Patients who could not be contacted (had their contact numbers/addresses changed)	15	3.6
Patients who consulted local doctors/team doctors out of convenience	1	0.02
Patients who had stopped playing sports (due to reasons not related to surgery), were in healthy condition and refused to come	9	2.1

Table IV: Drop Out Analysis

Figures

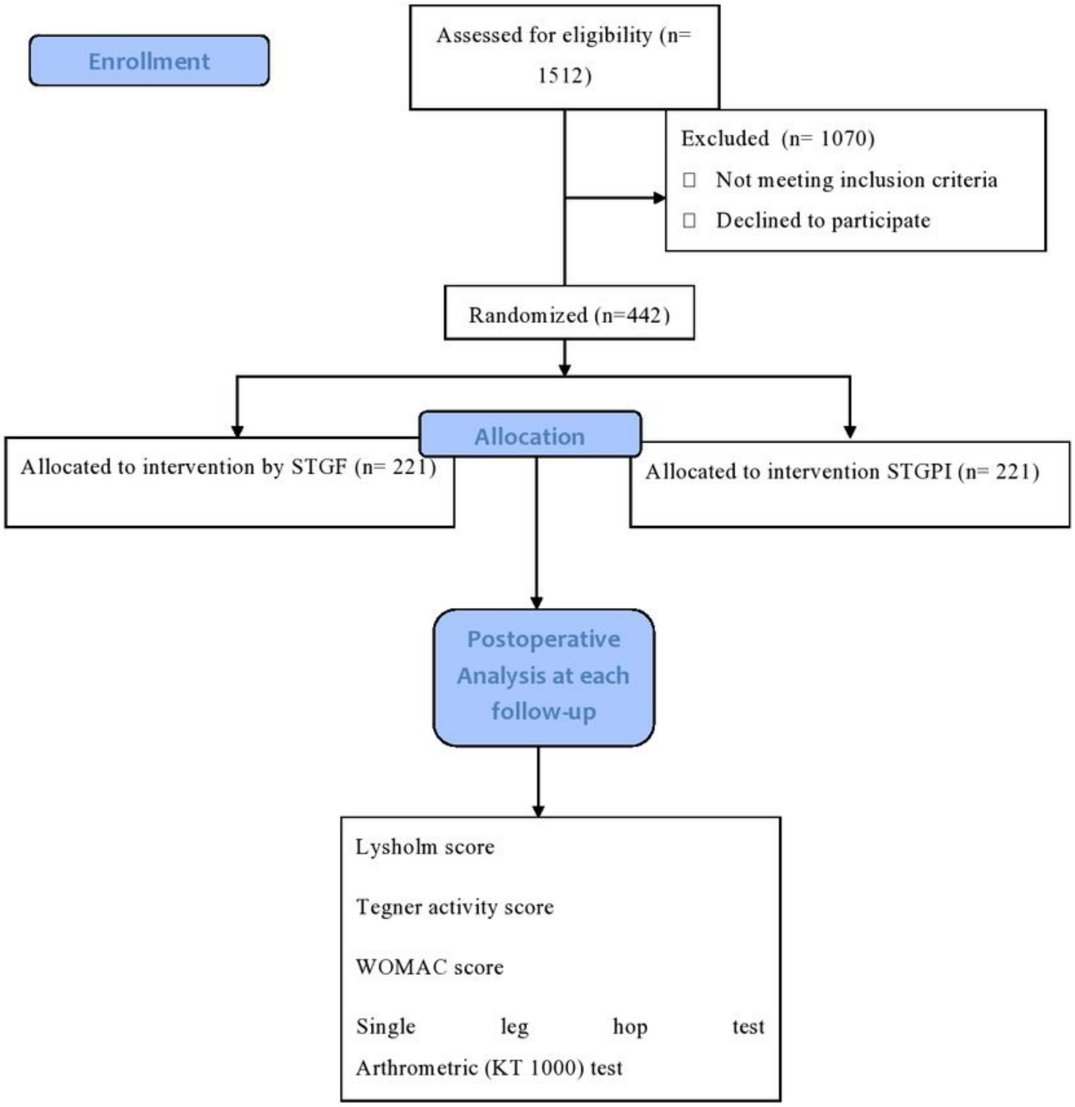

Figure 1

Flowdiagram depicting the distribution of patients into group 1 and group 2

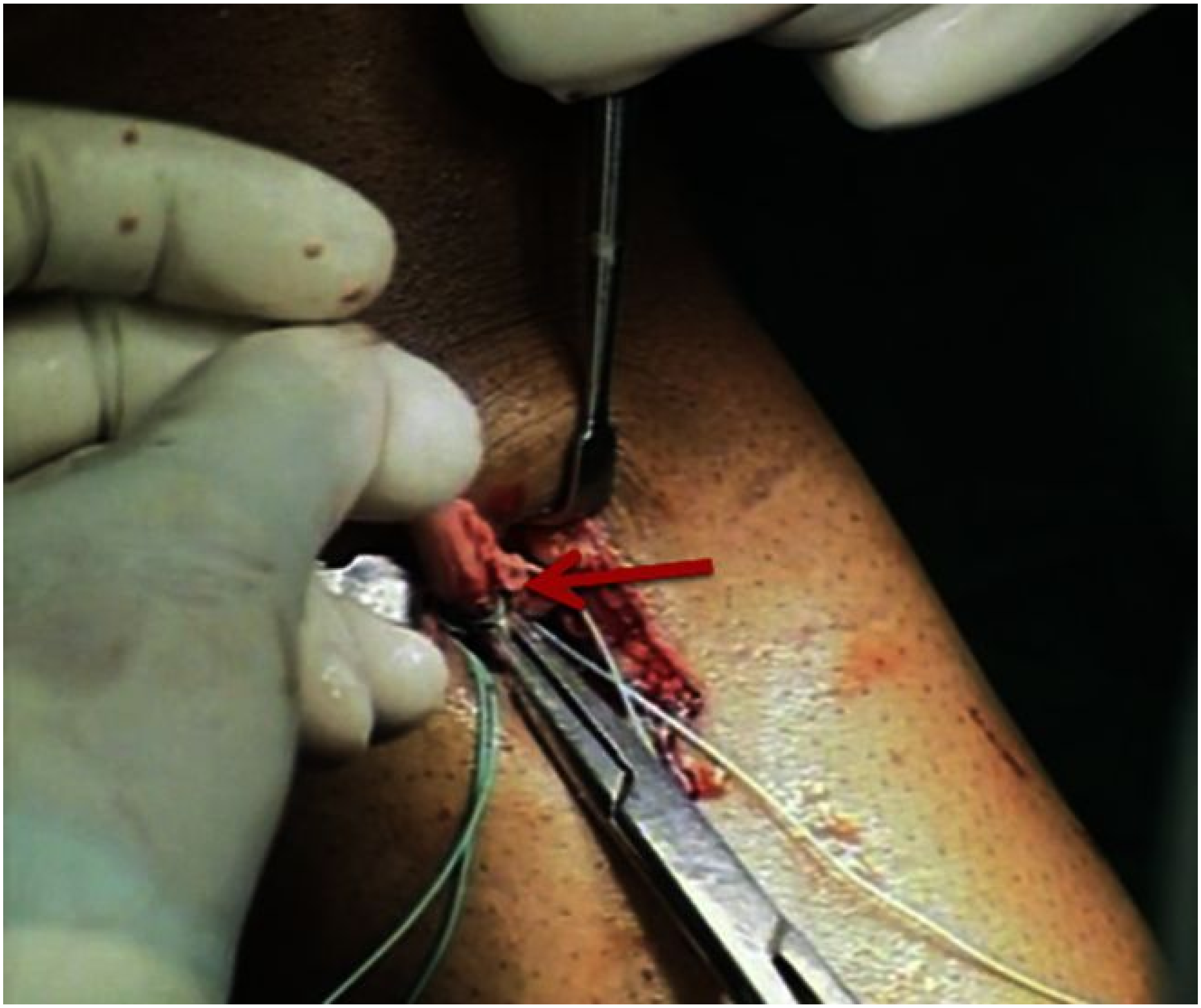

Figure 2

The length of the quadrupled graft and EndoButton loop is adjusted so that it exactly corresponds with length X plus length Y

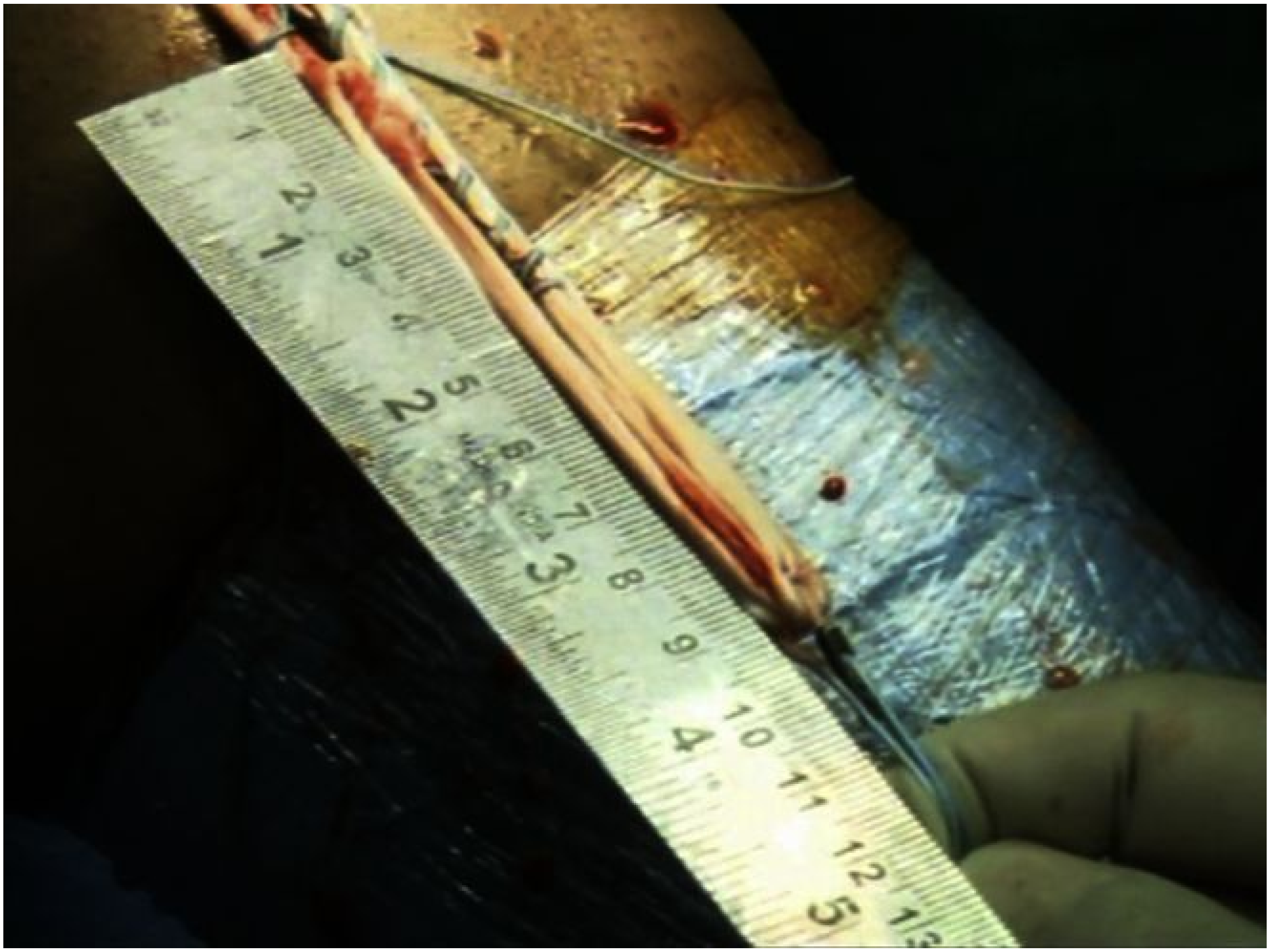

Figure 3

A mark (arrow) is made on the hamstring tendons just opposite the entry of the tibial tunnel so that when the graft is pulled inside the joint, the mark stays at the entry of the tunnel

Figure 4

The sutures of the RetroButton are pulled through the tibial and femoral tunnels by loading them onto the Ethibond loop placed in the tunnels

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- supplement12.docx
- supplement13.docx