Original article

Over the top or endobutton for ACL reconstruction?

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Abstract. There are an estimated 80-100,000 ACL repairs in the US each year: most ACL tears occurs from noncontact injuries. The 3.9% of the knee ligament injuries undergoes surgery: in the 80% of these patients, this means ACL reconstruction. The purpose of this study is to compare two surgical techniques normally used for acl recustruction; the first one is the intra- extra articular technique with single bundle fixed with staples and the second one is the intra-articular technique with double bundle and endobutton post-fixation. We evaluate the clinical outcome of our patients at the time of 4 years follow up. From January 2006 to April 2009 40 patients underwent to ACL reconstruction, all operated by using hamstring tendons: 20 patients with an average age of 28,75 years (12 men and 8 women) underwent surgery using the intra-extra articular technique, whereas the remaining 20 patients with an average age of 34,5 years (11 men and 9 women) benefited the intra-articular technique with double bundle ligament and endobutton post-fixation. Our study shows no substancial difference between these two technique, but clinical outcome measures (I.K.D.C., Lysholm and Tegner) estimated better results for the double bundle technique with Endobutton post-fixation. (www.actabiomedica.it)

Key words: ACL, rupture, reconstruction, knee arthroscopy, over the top, endobutton

Introduction

There are an estimated 80-100,000 ACL repairs in the US each year: most ACL tears occurs from noncontact injuries. The 3.9% of the knee ligament injuries undergoes surgery: in the 80% of these patients, this means ACL reconstruction (1). The choice of the operative technique depends not only on the age of the patient but also on the general conditions, expectations and functional requirements. It is essential to ensure a return close to pre-injury lifestyle, so that the patient can, after an appropriate period of rehabilitation, resume work, recreational activities and sports without restrictions. The main purpose of the ACL reconstruction is to provide an intrinsically stable knee with a full range of motion, even if recent studies have shown no correlation between ACL reconstruction and osteoarthritis prevention (2). The basic factors of ACL reconstruction that may affect the clinical out-come, include graft selection and harvest (autografts, allografts, artificial tendons), the graft site (in our study hamstring tendon graft), correct bone tunnel placement, graft fixation (endobutton, interference screw fixation, staples) and postoperative rehabilitation (3, 4). The graft must be at least as strong as the original ACL in order to bear the weight.

The purpose of this study is to compare the two surgical techniques used; the first one is the intra- extra articular technique with single bundle fixed with staples (Figure 1) and the second one is the intra-articular technique with double bundle and endobutton post-fixation. We evaluate the clinical outcome of our patients at the time of 4 years follow up.

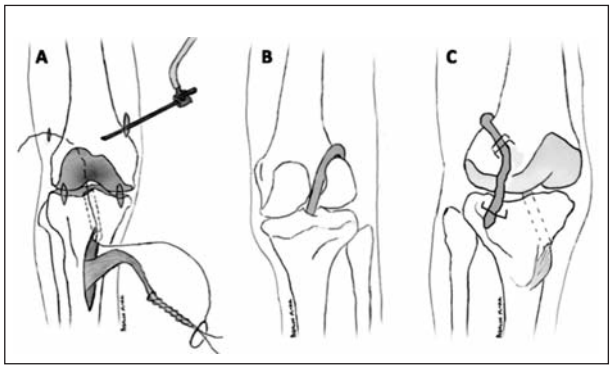

Figure 1. Over the top technique: A graft removal; B over the top passage; C graft fixation

Materials and methods

From January 2006 to April 2009 40 patients underwent to ACL reconstruction, all operated by using hamstring tendons: 20 patients with an average age of 28,75 years (12 men and 8 women) underwent surgery using the intra-extra articular technique, whereas the remaining 20 patients with an average age of 34,5 years (11 men and 9 women) benefited the intra-articular technique with double bundle ligament and endobutton post-fixation.

The case study was restricted to patients with isolated rupture of the ACL, who practice sports at competitive level. The average time of follow up was 45 months (24-63 months).

Surgical Techniques

Intra –extra articular technique with single-bundle (over the top)

The patient is placed supine on the bed with a lateral thrust for valgus stress maneuvers and the ischemic band is placed at the root of the thigh. The arthroscopy portals are prepared (superior medial, anterior medial, anterior lateral) and a clinical evaluation of the articular structures is performed (3). It proceeds with intra condylar notch plasty. Our current trend is to perform a limited notch plasty: however if the notch is very narrow, A-shaped, the plastic must necessarily be more extensive. The plastic can take a lot of time and should always be adapted to the graft dimension.

Anterior cruciate ligament stump should be removed to prevent anterior impingement. With the limb in position 4 we proceed with graft removal through an incision centered on the pes anserinus.

Hamstrings tendons are loaded one by one, released from the tendon sheath and extra tendon connection by leaving the tibial insertion intact (4, 5) (Figure 2). They are harvested singularly with the stripper, released from the residual portion of the muscle, basted and measured with apposite calibers.

The tibial tunnel is then prepared. Through the anteromedial portal the tibial guide with adjustable guide of 55° is inserted and placed between the two spines on the median line: this guide is used to introduce a K –wire. At this point a tibial tunnel as long as the prepared tendon is formed by using cannulated cutter.

The articular emergence of the tibial tunnel is cleared by using a motorized instrument and a wire loop is placed to the tibial emergence of the tibial tunnel retrieved trough the medial portal: this is used for the passage of the autografts tendons (Figure 3, 4).

Figure 2. Graft removal, the tibial insertion is intact and the vascularization in preserved

Figure 3. Wire loop used for the passage of the tendons

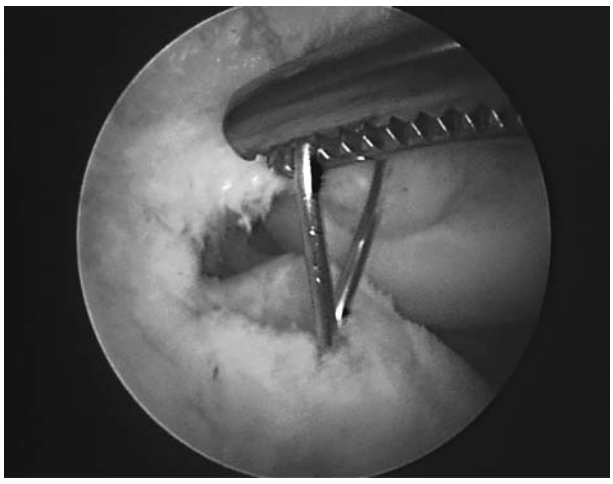

Figure 4. Wire loop used for the passage of the tendons, arthroscopic view

An incision to the inferior part of the ileo-tibial band is then made, with the knee flexed at 90°, in order to reach the lateral femoral condyle.

By palpating the retro- condylar tubercle and using a clamp which passed through the medial portal it recovers the Tycron from the external incision to the medial portal. The wire through the metallic loop is reported at the tibial tunnel. The remaining part of the harvested graft is reported behind the lateral condyle through the tibial tunnel and fixed with two staples at the lateral femoral condyle (4, 5).

Once performed intra articular reconstruction it precedes with the lateral plasty: making a small incision at the Gerdy's tubercle the remaining tendon portion is fixed with a single staple (6) (Figure 5).

Limb position during femoral fixation for intra-articular reconstruction and Gerdy's fixation for external plasty is externally rotated and posterior drawered.

Finally the position in flexion and extension of the neoligament is evaluated arthroscopically (Figure 6).

Intra-articular technique with double bundle and endobutton fixation

The patient position is the same of the previous technique. We perform a knee arthroscopy and we do the same incision at the centre of pes anserinus to harvest the tendons and perforate the tibial tunnel. Once the tendons are identified, we proceed with the incision of the band. The distal part of the tendons is released, ensuring that we have obtained the full length;

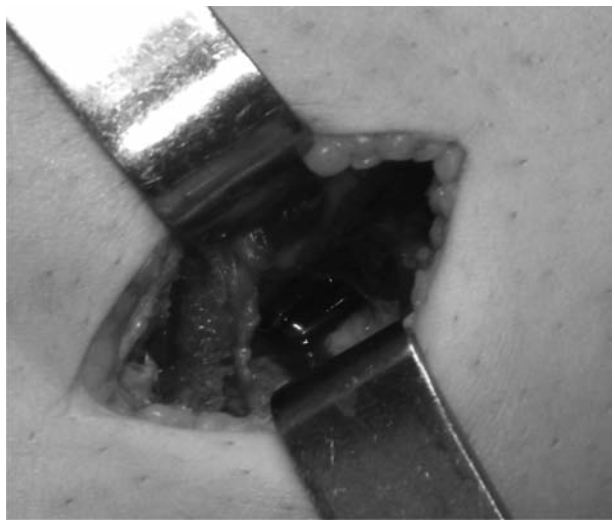

Figure 5. Graft fixation at Gerdy's Tubercle

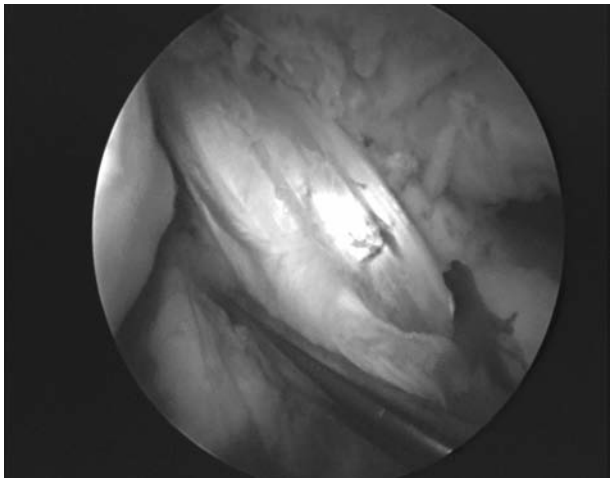

Figure 6. The position of the neoligament is evaluated arthroscopically

we pull them firmly. The stripper is pushed proximally along the course of the tendons, taken one by one: it is essential to maintain the tension of the tendon edges to prevent a short cut. Then the graft is placed on the table, cleaned, basted, doubled and measured by apposite calibres (3).

After the tendons harvest the inter-condylar notch plasty is performed. The most important point is to place the graft where there is no impingement rather to make the notch larger to accommodate a misplaced tunnel (7). The tibial tunnel is prepared such us the previous technique: it is used to drill the femoral tunnel with a calibrated guide. Basing on the graft size and with the knee placed at 70- 90° of flexion, the tunnels are prepared. The width of the femoral tunnel is determined by the size of the graft; the femoral tunnel should be pointed at the 11 for the right knee or at the 1 o'clock for the left knee. The tunnel has to accommodate the graft for a depth ranging from 2,5 at 3,5 cm and the tunnel drilling has to be 0,8-1 cm superior than the length of the tendons to integrate (8).

The graft is loaded on the endobutton (Figure 7) and passed through the two tunnels and finally is fixed in suspension on the femoral side (8). At this point the knee is flexed at 20° (3) and tibial fixation is performed with a screw and reinforced by a staple if necessary (Figure 8). The knee undergo to a complete range of motion to observe if there is impingement.

Figure 7. Post-operative X-Ray: tibial fixation with interference screw and staple, femoral fixation with endobutton

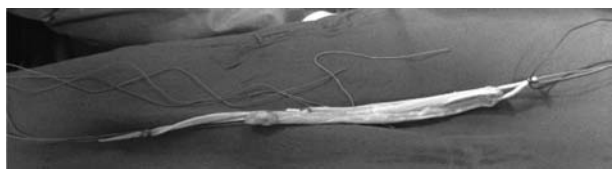

Figure 8. The tendons, prepared and basted, are loaded on endobutton

The graft is attached with the tracer to test the tension of the different bundles.

Postoperative protocol

The postoperative program is the same for the two techniques and consists of passive full extension and active flexion over a range of 0°-60° from the second postoperative day. The partial weight with brace is allowed during the first week: after two weeks the target is to reach full weight bearing, with progressive leaving of brace within three weeks. At the same time isometric and closed chain proprioceptive exercises are

performed as well as active and passive movements in order to reach a full range of motion. After the first month isotonic exercises are started, with an advanced program of isometric-isotonic muscle strengthening and cyclette. Running and quadriceps resistive muscle exercise are started after the second month. Cutting and lateral movement are allowed 4 months after the surgery, with return to sports within 6 months. The purpose is to subject the graft to the normal mechanical stress, which allows that can support the neoligamentization and biological recovery (4).

Results

All patients were evaluated by using clinical tests and three evaluation boards (Table 1):

1. I.K.D.C (International knee Documentation Comittee) (9)
2. Lysholm Knee Scoring System (10, 11)
3. Tegner Activity Level (10).

I.K.D.C.

Between the patients that underwent to intra-extra-articular reconstruction, 8 obtained a result more than 94 with only 2 failures, whereas between the patients who underwent a double bundle technique, 11 obtained very satisfactory score with only one failure (Figure 9).

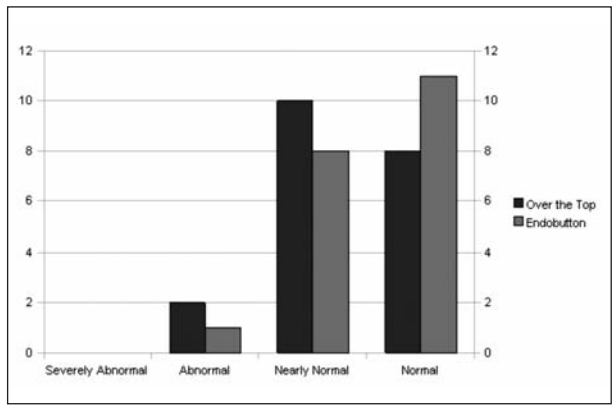

Figure 9. Results evaluated with I.K.D.C. score

Lysholm score

With the first technique 15 patients reached a score more than 82, the rest patients obtained sufficient results. With the second technique 11 patients had very good results, with 2 patients reaching more

Table 1. Patients who benefited intra-extra-articular technique

Patient	Age	Sex	IKDC	Lisholm	Tegner before injury	Tegner after ACL reconstruction	Follow up (months)
VP	28	F	83	88	9	7	62
TM	31	M	92	95	8	7	60
TC	41	F	84	80	7	6	54
PF	26	M	97	96	9	8	61
MS	23	F	92	94	9	7	58
MO	17	M	95	98	10	8	48
CM	19	F	97	95	9	8	57
MA	34	M	86	83	7	6	56
NM	25	M	93	90	8	6	52
LL	21	M	94	96	9	7	39
IA	32	F	87	82	8	6	42
GP	30	M	89	85	8	6	53
GL	42	F	82	81	8	6	39
CT	38	M	88	89	7	6	55
RC	40	F	72	76	7	5	37
BS	32	M	86	84	8	6	60
GB	24	M	83	78	9	6	24
BD	26	M	90	93	9	7	63
BA	27	F	88	86	8	6	61
AM	19	M	68	75	9	6	45

Table 2. Patients who underwent double bundle technique

Patient	Age	Sex	IKDC	Lisholm	Tegner before injury	Tegner after ACL reconstruction	Follow up (months)
VA	31	M	94	96	9	8	35
VR	33	F	89	94	8	7	50
TD	26	F	80	83	9	7	63
TZ	48	M	82	85	6	5	49
SS	40	M	87	86	6	5	36
SL	48	F	65	72	5	5	31
SI	46	M	90	93	7	7	27
RA	35	M	95	94	8	7	52
PR	43	M	86	82	7	6	42
JG	24	F	98	98	9	8	48
IM	18	F	100	99	9	9	54
IA	36	M	92	96	8	7	43
RI	31	M	94	97	8	7	38
GA	26	F	95	95	9	8	47
CS	33	M	86	90	8	7	30
KC	41	F	98	95	7	7	29
CF	31	M	93	88	8	7	35
AC	33	F	83	87	7	6	36
CA	28	F	94	96	9	8	48
BG	39	M	88	91	7	6	27

than 98. None had insufficient results with either technique (Figure 10).

Tegner scale

Preoperatively the patients operated with intra-extra-articoular technique reached upper level than patients which benefited the intra extra articular technique (Figure 11).

The post injury level for the first group was the following: 8 patients reached at least level 7 with only one case obtaining level 5. For the second group: one patient reached even the level 9, but 3 patients did not go beyond level 5 (Figure 12).

Statistical Analisis

The mean follow-up was 45 months (27-63 months). The results were analyzed by using two tests: the Mann-Whitney and the Wilcoxon test. The Mann Whitney test was used for analyses of differ-

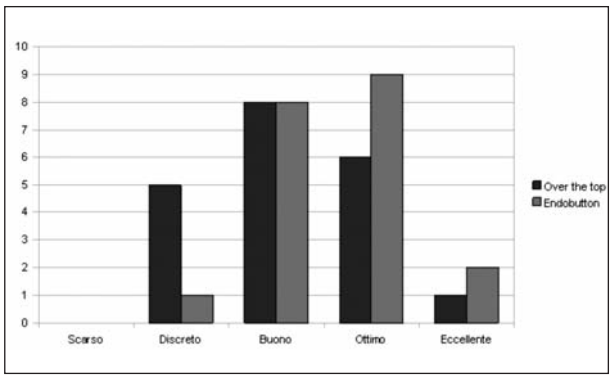

Figure 10. Results evaluated with Lisholm Score

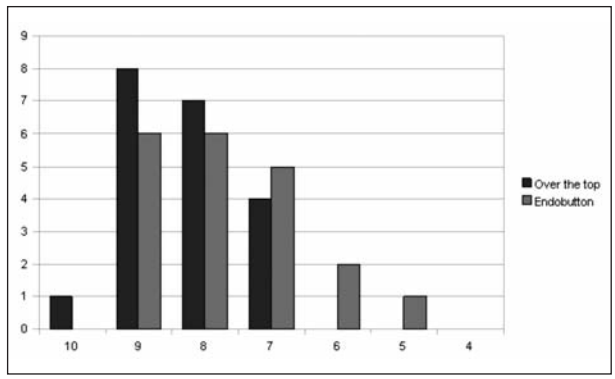

Figure 11. Tegner Score before ACL rupture

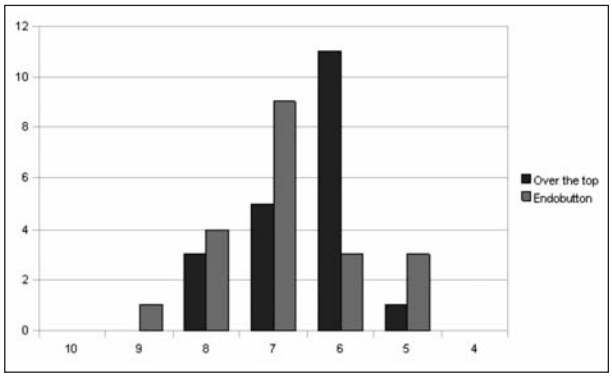

Figure 12. Tegner Score after ACL reconstruction

ences between the two surgical procedures, while the Wilcoxon test evaluates the improving allowed by ACL reconstruction. The differences in I.K.D.C and Lysholm tests were not statistically significant (p=0,30,p=0,09). The level of significance was set at p<0,05. The results with Wilcoxon test were very signicant (p=0,0001 and p=0.005), which means that both groups had good results after reconstruction.

Discussion

The first arthroscopic procedure which combine intra and extra-articular ACL reconstruction using a single bundle fixed with staples was developed in 1992 by Marcacci et al. In 2003 the same authors demonstrated high reliability, low morbidity of the graft site, low functional deficit and optimal rehabilitation of this technique[4]. The overall results of this modified hamstring intra and extra articular ACL reconstruction at a minimum of 5 years follow up were highly satisfactory, how is confirmed in a recent study of the same authors (12). Many parameters such as subjective evaluation, knee laxity, resumption of sport activity and functional evaluation gave high scores, with 92% of normal or nearly normal knees (4). Although the advantages of this technique are numerous, it involves a non-anatomical positioning of the neo-ligament, persistence of objective laxity at KT-1000 and a potential danger for the structures of the popliteal fossa in the over the top passage. For these reasons over the years, numerous reproducible and comparable techniques have been developed including the intra-articular technique with double bundle and post –fixation with endobutton at the femoral cortical. This technique includes tendon disconnection and compromising of blood supply, but due to the construction of a femoral tunnel provide a more anatomical ligament positioning with better findings al KT-1000 and increased strength of the ligament to mechanical stress (4).

The hamstring tendons have been used in different combination (single, double, looped), graft fixation, and surgical approaches (open or arthroscopically assisted).

Noyes- Barber (13) and Lerat (14) have recently found a significant difference in knee stability when an extra- articular procedure is associated with ACL reconstruction. Wilson (15) according to Marcacci6 reported that an extra articular plastic helps to protect the intra articular graft during the critical early phase of remodelling and maturation and does not increase stability but reduces the risk of failure by diminishing potentially damaging torsion forces.

This plastic uses the isometric point for the lateral reconstruction,as suggested by Krackow and Brooks (16) and in this way the risk of overloading of the lateral compartment is decreased. Radiographic findings confirm the low morbidity of this surgical step.

Preservation of hamstring tibial insertion can guarantee an optimal blood supply to the tendons, enhance the maturation process of the graft and ensure a natural fixation of the graft at the tibial side.

Muneta (17) and Howell-Deutsch (18) obtained greater stability with 90% of satisfactory results at KT-1000 evaluation at two years follow up. Marcacci4 obtained similar results at medium term follow up: the dominant leg seems to have significantly better results than the other. Many factors such as tensioning of the graft, fixation method, timing of surgery, associated lesions, rehabilitation protocol and biological factors can influence the clinical outcome, which is difficult to estimate, quantify and verify. Acute reconstruction reduces the time in which the knee presents abnormal kinematics and reduces the risk of laxity. Muneta (19) and Marcacci (4) believe that accelerated rehabilitation does not affect stability. Patients with residual valgus instability had a poorer outcome. These studies also

showed the widening of the tibial tunnel, present in only two cases. These findings are in contrast with other authors (20-22) who have observed tunnel enlargement by using hamstring tendons. Isokinetic scores at 5 years showed a comparable extension value and a mean deficit of 6% for the harvest muscles. The data of Lipscomb (23) and Simonian (24) show similar recovery of muscle strength after hamstring harvesting. In highly motivated athletes with strong muscle preoperatively the preservation of extensor mechanism of the knee allows a faster recovery. Removal of graft fixation continues to be the most common reason of additional surgery using the hamstring tendons as a graft. Howell-Deutsch and Howell-Taylor (25) report required hardware removal in 21% of the patients, Clark (26) in 22% and Siegel (27) and Barber- Westin in 26% reported hardware removal in their series.

In 16% it was necessary to remove staples from the femur due to irritation of ileotibial band probably related to early return to athletic activity. Removal was performed at 3 months postoperatively, with no effects on final clinical outcome (4).

There are not many comparison between different methods of reconstruction with hamstrings in literature: a very recent study of Marcacci et al (28) shows no differences between over the top single-bundle and anatomic double-bundle technique, concerning static knee laxity. In our experience we agree with Marcacci's study: both intra-extra-articular and double-bundle intra-articular reconstruction have good clinical results. We believe that the first technique is more rapid, cheaper, simple and doesn't lead to impingement, the healing process is favored by preservation of blood supply: the anatomic double-bundle reconstruction is technically more difficult to perform and more expensive, there is a risk of malpositioning of bone tunnels with consequent impingement, the bone integration is not favourite because of detachment of tendon insertion and suspension femoral fixation, but the graft anatomic position gives a very good stability.

Both different surgical methods and fixation materials might cause different clinical results.

Concerning the femoral fixation in double-bundle intra-articular reconstruction, Atay (29) found no significant differences in stability outcomes one year after ACL reconstruction using Endobutton post fixation and femoral transfixation, based on the determination of isokinetic muscle strength, neuromuscular coordination, joint position sense and the anterior tibial stability. Deficits in hamstring-quadriceps muscle strength, motor coordination and proprioception were still found in both types of fixation after 12 months (29). Approximately 10% of the patients show deficit in hamstring muscle torque of the operated knee respect the opposite side in his study. Similar results for Bizzini et al (30) 11 months after ACL reconstruction and also Aune (31) and Feller (32) reported a percentage above 15-17%. Many authors have shown that hamstring strength deficit returns to normal 2 to 4 years after surgery. Atay (29) showed the femoral trans-fixation had a 10-15% deficit while the Endobutton post fixation had a 15-20% deficit in quadriceps strength. De long (33) reported similar results. Quadriceps strength deficit was transitory and decreased between 6 and 12 months after surgery. Kobayashi (34) noted that the strength increased 24 months after surgery. Quadriceps weakness occurs mainly not because of donor site morbidity, but damage to the receptor and neuromuscular activation systems. A further important finding of the study of Atay (29) was that both groups showed motor coordination deficits of 15-18% and proprioception deficit of approximately 70%. Denti et al (35) demonstrate a decrease in the number of mechanoreceptors starting 3 months after injury. Many authors find only a few nerve endings after 9 months, which disappear after one year. Studies investigating proprioception function show contradictory results. Some authors have reported decrease joint position sense (36), but others [Grob et al (37)] found no significant differences.

Several studies have measured the graft position. Published recommendations suggest that there is an acceptable range for the graft position.

Lintner et al (38) showed that the femoral tunnel was placed more parallel to the shaft of the femur when the tunnels were drilled with endoscopic technique than when the tunnels were drilled from the outside in.

Khalfayan et al (39) reported that the tunnel position should be no further than 60% posteriorly along the Blumensaat's line.

Yoshiha et al (40) determined the optimum orientation of bone tunnels. They found that the tibial tunnel should be oriented 20° anteriorly in the sagittal plane and 30° medially in the coronal plane. It is generally accepted that the most anatomic placement of the ACL graft is posterior along the femoral notch. Therefore the diameter of the tunnels can vary from 7 mm to 10 mm.

ACL allows some tibial displacement when external forces are increased. Gabriel et al (41) ported a ± 1 mm tibial translation with full extension and a 6.4 ± 2.4 mm tibial translation at 60° flexion. The ACL also allows an anterior translation of 3.7 ± 2.2 mm at 15 flexion and 5.7 ± 2.7 mm at 30° under the combined load of 10 Nm valgus and 5 Nm internal rotations. Further studies showed that ACL reconstructed knees with Endobutton post fixation noted less than 3mm anterior translation when compared to the opposite side. Aune et al (31) showed differences of 2.8 ± 2.6 mm between the operated and the injured side, Feller (32) reported differences 1.9 ± 1.1 mm and Bizzini (30) 2.7 ± 0.7 mm. Dehler et al (42) demonstrate that the double bundle ACL reconstruction has a significant advantage in anterior and rotational stability.

Mae et al (43) studied the migration of endobutton a-year after ACL reconstruction, finding a correlation with interposition of soft tissue visible in postoperative X-ray. Delincè et al (2) reported some complication after ACL reconstruction, that can request further surgery: meniscal lesion (6.9%), range of motion deficit (6.3%), infection (0.6%), graft rupture (9-12% 13 years after surgery). A controlateral LCA rupture occurs in 3-24% in this study.

Nash et al (44) have compared intra articular ACL reconstruction using autogenous hamstrings in men versus women: clinical failure rate is 23% for females and 4% for males. There is also a trend toward increased laxity in female patients and higher intensity of pain a slow return to their pre injury level activity (45).

Conclusions

Our study shows no substancial difference between these two technique, but clinical outcome measures (I.K.D.C., Lysholm and Tegner) estimated better results for the double bundle technique with Endobutton post-fixation. According to our experience the intra – extra articular technique is more rapid than the double bundle technique, cheaper and does not lead to impingement. The hamstring tibial insertion is preserved, as blood supply: this allows for optimal healing of the graft. Extra articular plastic protects the intra articular reconstruction from excessive loads offers better control in rotation laterally and reduces anterior-posterior laxity.

On the other side this technique produces more cosmetic damage, is potentially more dangerous during the over the top passage and inflicts increased non subjective laxity at KT-1000.

In the intra articular reconstruction the execution is more complicated for the surgeon, it is necessary to find the isometric point for an optimal tunnel position. The risk by tunnel mal position is the impingement. Also the post- fixation at the femoral cortical occurs in suspension possible effects ("bungee" and "windshield wiper") that influence the bone integration.

Finally the surgical cost is greater than the intra-extra articular technique but the advantage is that the aesthetic damage is less and better results are objectively recorded using the KT-1000.

Whatever the treatment the patient should be informed that the risk of further knee lesions and osteoarthritis remains high (55), especially if they resume high-risk pivoting sport: the choice of the treatment and the surgical technique must be suitable on the single patient, considering age, clinical situation and personal expectations.

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