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INTRODUCTION

G. CERULLI[1,2,3] and G.POTALIVO[1]

Nicola's Foundation Onlus, Arezzo; [1]Let People Move Research Institute, Perugia-Arezzo; [2]International Orthopedics and Traumatology Institute, Arezzo; [3]Residency Program in Orthopedics and Traumatology, University of Perugia, Perugia, Italy

ACL injury is about 36.9 per 100.000 person-year, and there are something like 80.000-100.000 ACL repairs each year in the United States alone (1-3). It generally occurs in the twenties – thirties age group, in young athletes and most often with associated lesions. Women have an increased risk of ACL tears 2-3 times higher compared to males (4-5). So it is easy to understand how a lot of economical and social interests revolve around this type of injury (6). This has led, over the past twenty years, to an impressive increase in surgical techniques compared to the past, quickly evolving from a complicated surgery to a safe and highly recommended surgery (7), from a non anatomical and extra-articular reconstruction to an anatomical and isometric reconstruction that better restores knee function (8). Despite this, most of the techniques for ligament reconstruction have unresolved issues: type of graft, how to make the tunnels, the difficulty of performing the technique, donor site morbidity, infection of the surgical wounds and chronic sequels such as anterior knee pain and instability of the system (9-10).

To solve these problems, biomechanical studies and personal experience induced Cerulli and his équipe in to identifying the best technique that would be an easy to perform procedure combined with low cost, and excellent results at both short and long term follow-up. Therefore we decided to write this volume to illustrate all the ideas and experimental studies that led to the development and clinical application of the "All-Inside" technique, from the nineties to today. The aim of this volume is to retrace the steps to the origin of the original "All-Inside" Surgical Technique.

REFERENCES

1. Cimino F, Volk BS, Setter D. Anterior cruciate ligament injury: diagnosis, management, and prevention. Am Fam Physician 2010; 82(8):917-22.
2. Gianotti,SM, Marshall SW, Hume PA, Bunt L. Incidence of anterior cruciate ligament injury and other knee ligament injuries: a national population-based study. J Sci Med Sport 2009; 12(6):622–7.
3. Griffin LY, Agel J, Albohm MJ, Arendt EA, Dick RW, Garrett WE, Garrick JG, Hewett TE, Huston L, Ireland ML, Johnson RJ, Kibler WB, Lephart S, Lewis JL, Lindenfeld TN, Mandelbaum BR, Marchak P, Teitz CC, Wojtys EM. Noncontact anterior cruciate ligament injuries: risk factors and prevention strategies. J Am Acad Orthop Surg 2000; 8(3):141–50.
4. Waldén M, Hägglund M, Werner J. The epidemiology of anterior cruciate ligament injury in football (soccer): a review of the literature from a gender-related perspective. Knee Surg Sports Traumatol Arthrosc 2011; 19(1):3-10.
5. Giron F, Losco M, Lup D, Buzzi R, Aglietti P. Anterior cruciate ligament reconstruction in females: a prospective randomized comparison between hamstring and patellar tendon grafts Journal of Orthopedics 2009; 1(2):111-21.
6. Colombet P, Allard M, Bousquet V, De Lavigne C,

Mailing address: Prof. G. Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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Flurin PH. The History of ACL Surgery, Bordeaux-Mérignac Centre of Orthopaedic and Sports Surgery. Free Internet Sorce
7. McCulloch PC, Lattermann C, Boland AL, Bach BR Jr. An illustrated history of anterior cruciate ligament. J Knee Surg 2007; 20(2):95-104.
8. McCulloch PC, Lattermann C, Boland AL, Bach BR Jr. An illustrated history of anterior cruciate ligament surgery. J Knee Surg 2007; 20(2):95-104.
9. Naranja RJ Jr, Corsetti J, Kuhlman JR, Torg JS. The search for the Holy Grail: a century of anterior cruciate ligament reconstruction. Am J Orthop 1997; 26(11):743-52.
10. Dandy DJ. Historical overview of operations for anterior cruciate ligament rupture. Knee Surg Sports Tramatol Arthrosc 1996; 3(4):256-61

CHAPTER I

HISTORY OF THE "ALL INSIDE" TECHNIQUE AND ITS CLINICAL APPLICATION

G. POTALIVO[1], G. PLACELLA[1,2] and E. SEBASTIANI[1,2]

Nicola's Foundation Onlus, Arezzo; [1]Let People Move Research Institute, Perugia-Arezzo; [2]Residency Program in Orthopedics and Traumatology, University of Perugia, Perugia, Italy

As far back as 1845, Bonnet, a French surgeon from the Lyon school described acute Anterior Cruciate Ligament (ACL) rupture based only on his clinical experience (1-2). The first to describe the role of the ACL and how its integrity should be tested was Noulis in 1875 (3). In 1895 Robson successfully performed the first cruciate ligament repair in a 41-yr old miner. In fact the patient did not miss a single day of work because of his knee and over six years later he described it as very stable (4).

In 1903, Lange of Munich performed the first ACL replacement using braided silk attached to the semitendinosus as a ligament substitute (5). As an alternative in 1917, Groves performed the first ACL reconstruction using an iliotibial band graft through an anterior curve incision involving tibial osteotomy for good joint exposure. The graft was detached from the tibia and passed through the femoral and tibial tunnel then sutured to the tibial periosteum and the tibialis anterior muscolaris fascia. The tibial tubercle was then anchored with ivory nails (6).

In 1935 Campbell reported the first use of a tibia-based graft of the medial third of the patellar tendon. The technique involved drilling two tunnels, one in the tibia and one in the femur. The graft was stitched to the periosteum at the femoral tunnel exit. The operation was followed by posterior-splint fixation for a period of 3 weeks. He described 17 cases of ACL reconstruction, most of whom were athletes. Nine patients had an excellent outcome, and were able to return to playing football from 6 to 10 months after the operation (7). Jones in the sixties modified this technique, which took his name when it became popular in the nineties (8).

In 1939 Harry B. Macey, of Rochester, Minnesota, described the first technique using the semitendinosus tendon. The tendon was left attached to the tibia, then passed through a tibial and a femoral tunnel, and sutured to the periosteum. The joint was approached via an anterior oblique parapatellar incision. Only the tendinous portion of the semitendinosus was harvested, stopping short of the musculotendinous junction. The tunnels were 4.7 mm in diameter, and the graft was attached with the knee in full extension. A cast was applied for 4 weeks; full activity was permitted at the end of 8 weeks (9). A similar procedure, using the semitendinosus tendon alone was proposed in 1975 by K. O. Cho (10).

Although the techniques were changed and improved, ligament reconstruction surgery was very invasive and destabilizing for the patient. The greatest innovation occurred in the eighties with the introduction of arthroscopy (Fig. 1).

During those years the failure of synthetic ligaments was still too raw: there had been an unacceptably high rate of rupture, synovitis and subsequent reintervention. The autograft as a substitute became the only viable alternative for the reconstruction of the ACL.

The international community was divided between the French school of Out-In reconstruction (11) and Rosenberg's American school with the In-Out reconstruction (12).

Key words: ACL reconstruction, half tunnel, hamstring, in-out

Mailing address: Prof. Giuliano Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956 Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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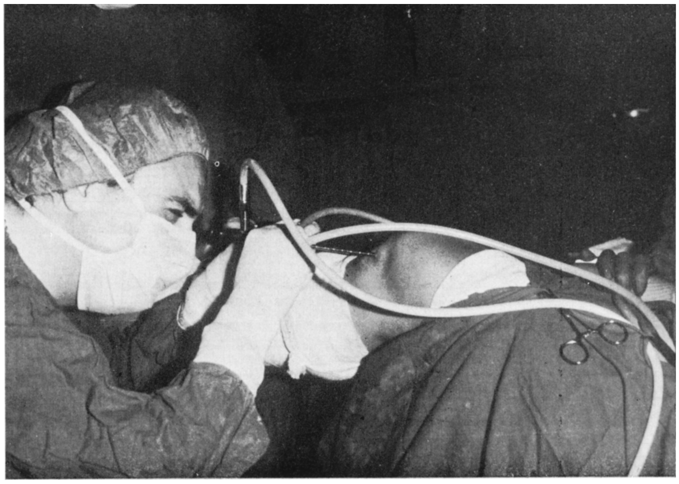
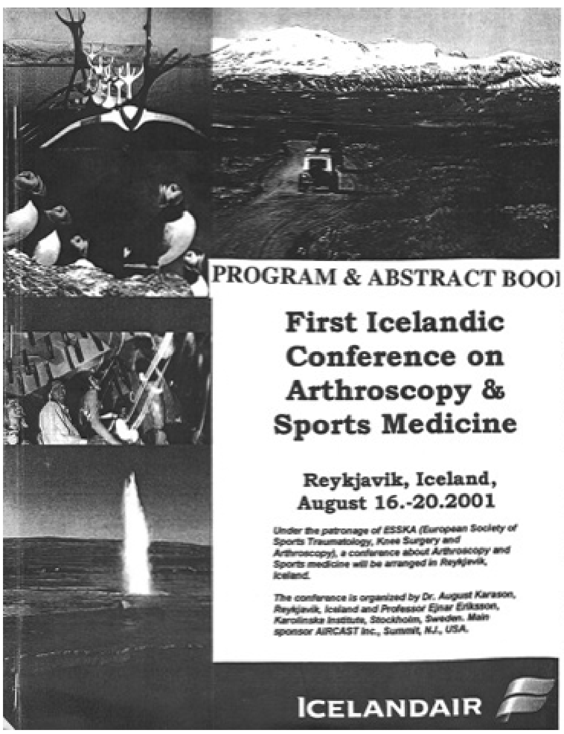


Fig. 1. *Introduction of athroscopy in the eighties*



ACL RECONSTRUCTION ONLY INSIDE TECHNIQUE

G.Cerulli, A.Caraffa, G.Favilli, P.Antinolfi

University of Perugia – Hospital "R.Silvestrini" Traumatology – Orthopaedic Dept. Perugia (Dir. Prof. G. Cerulli)

The authors propose a new ACL reconstruction only inside technique with double half tunnel that unifies itself the advantages of the technique bi-tunnel out-in and of the femoral half tunnel technique, eliminating the disadvantages of both. Using percutaneous k-wires introduced free handed, under arthroscopic control the direction of the tunnels are chosen, following precise angular parameters already consolidated. The half tunnels are prepared with a specific device in-out direction. The new ligament (semitendinosus or gracilis, triplicated) is tensed using synthetic traction wires. It is introduced in the joint by the antero-medial arthroscopic portal and then towards the both half tunnels. Finally, the graft is fixated with specific cannulated interference screws with an out-in technique.
The advantages of such technique are:

- unbounded tunnels choice
- possibility to regulate the length of the half tunnel according the length of the tendon
- limited esthetic damage
- lower infection risk
- less blooding
- with this technique you can control the introduction of the cannulated screw
- eliminating the risk of loosing the fixation device in the joint
- eliminating "windscreen wiper" effect
- we can use this technique even if you choose other kind of graft (BPTB or synthetic materials).

Fig. 2. *Reykjavik 2001: first presentation of the All-Inside Technique*

The Jones procedure became the gold standard, although much modified from the original, because of its simplicity and excellent results.

Kurosaka et al in 1987 demonstrated that the mechanically weak point of the reconstructed graft was its fixation, suture of the graft to the soft tissues; it did not have the required strength, it lengthened recovery time and was the cause of most failures. He performed a study in young human cadavers and proved clearly that 9-mm diameter screws were much better than other fixation systems (13). Over the years many clinical studies have shown how metal interference screws brought excellent sealing results of the graft; solving one of the most important

A B

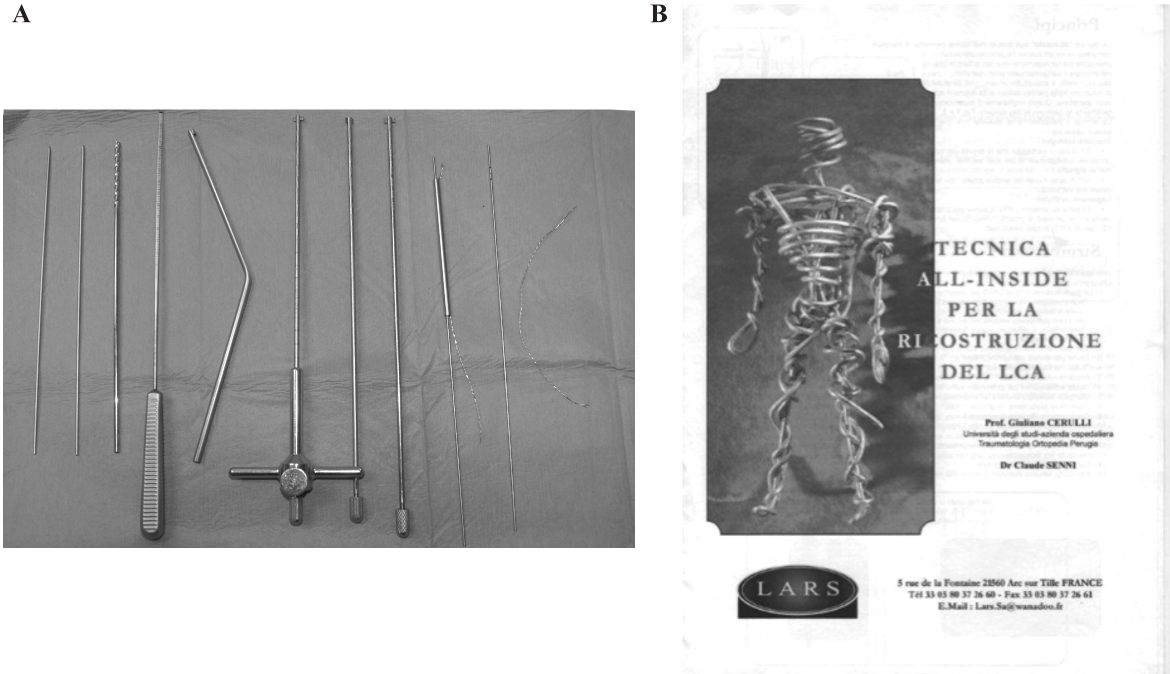


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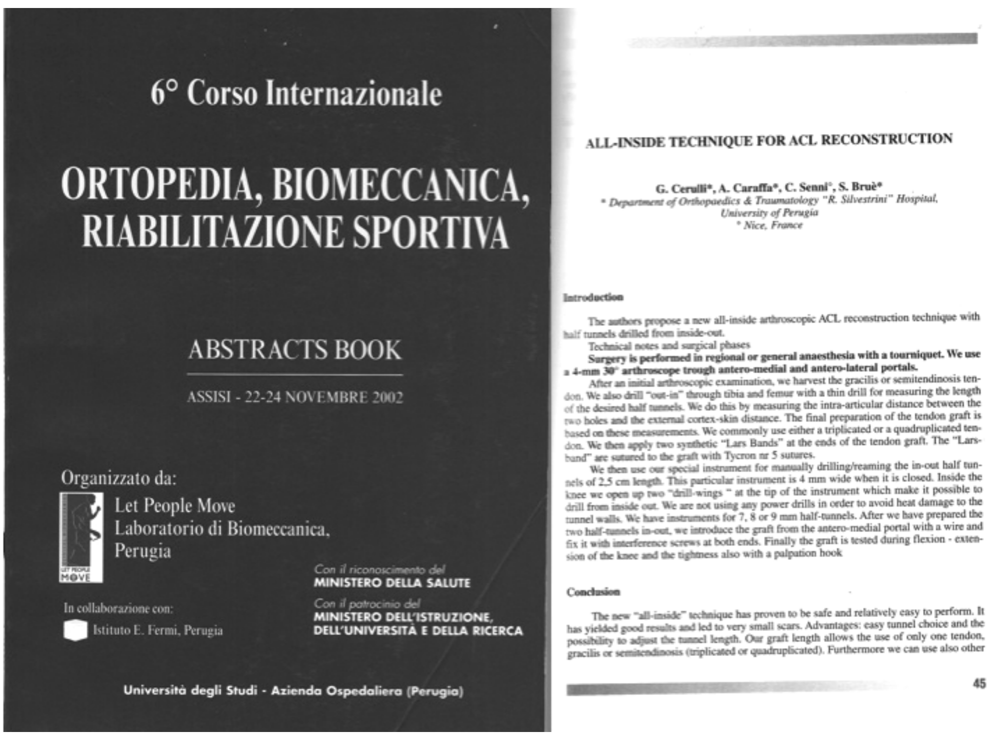
Fig. 3. A) and B) *First surgical instruments made for All-Inside Technique in 2001 (L.A.R.S.)*



ALL-INSIDE TECHNIQUE FOR ACL RECONSTRUCTION

G. Cerulli*, A. Caraffa*, C. Senni°, S. Bruè*
** Department of Orthopaedics & Traumatology "R. Silvestrini" Hospital, University of Perugia*
° Nice, France

Introduction

The authors propose a new all-inside arthroscopic ACL reconstruction technique with half tunnels drilled from inside-out.

Technical notes and surgical phases

Surgery is performed in regional or general anaesthesia with a tourniquet. We use a 4-mm 30° arthroscope trough antero-medial and antero-lateral portals.

After an initial arthroscopic examination, we harvest the gracilis or semitendinosis tendon. We also drill "out-in" through tibia and femur with a thin drill for measuring the length of the desired half tunnels. We do this by measuring the intra-articular distance between the two holes and the external cortex-skin distance. The final preparation of the tendon graft is based on these measurements. We commonly use either a triplicated or a quadruplicated tendon. We then apply two synthetic "Lars Bands" at the ends of the tendon graft. The "Lars-band" are sutured to the graft with Tycron nr 5 sutures.

We then use our special instrument for manually drilling/reaming the in-out half tunnels of 2,5 cm length. This particular instrument is 4 mm wide when it is closed. Inside the knee we open up two "drill-wings " at the tip of the instrument which make it possible to drill from inside out. We are not using any power drills in order to avoid heat damage to the tunnel walls. We have instruments for 7, 8 or 9 mm half-tunnels. After we have prepared the two half-tunnels in-out, we introduce the graft from the antero-medial portal with a wire and fix it with interference screws at both ends. Finally the graft is tested during flexion - extension of the knee and the tightness also with a palpation hook

Conclusion

The new "all-inside" technique has proven to be safe and relatively easy to perform. It has yielded good results and led to very small scars. Advantages: easy tunnel choice and the possibility to adjust the tunnel length. Our graft length allows the use of only one tendon, gracilis or semitendinosis (triplicated or quadruplicated). Furthermore we can use also other

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Fig. 4. *Assisi 2002: codification of the All-Inside Technique*

weak points until then. A few years later these screws were to be made of resorbable materials.

Jones' procedure had its disadvantages. It could lead to some stiffness and, above all, extensor mechanism problems (patellar and patellar tendon) (14). In 1982 Lipscomb started using semitendinosus

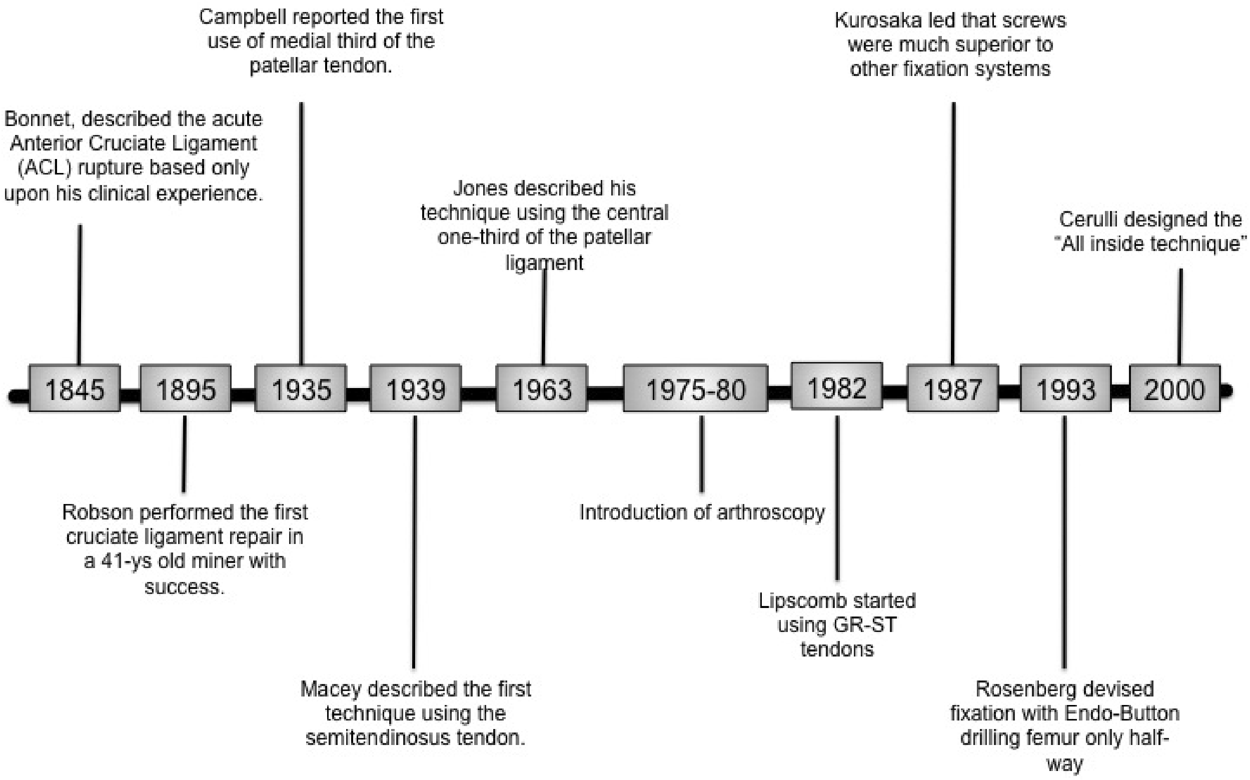

Fig. 5. *Timeline of ACL Reconstruction*

and gracilis tendons for ACL reconstruction (14).

Tom Rosenberg, drilling the femur only half-way, devised fixation with the so-called Endo-Button that locked itself against the lateral side of the femoral condyle (12) (Fig. 5).

Studies conducted in Italy (Perugia) and in U.S.A (Pittsburgh) have led to the design and improvement of a technique for the reconstruction of the ACL: the "All-Inside" Technique.

These experimental studies began in the late nineties and led to small changes being made to traditional techniques which resulted in quicker and more effective ACL reconstructions, with less scarring, and greater sparing of the anatomical structures. These advantages added to the satisfaction of patients and the excellent results obtained in terms of recovery even of top-level athletes. The traditional set of instruments lacked the essential element that would guarantee the least possible sacrifice of bone: the manual drill first invented by Cerulli.

An example of a motor drilling instrument was developed by Puddu et al in 2004 (16): however, this technique was difficult to perform due to the risk of the drill breaking as it was assembled inside the joint space.

The "All-Inside" Technique was designed to be used with all types of grafts, biological and synthetic, so as to be as versatile and adaptable as possible to every kind of patient and orthopedic surgeon.

The collaboration with several international experts, biomechanical studies carried out in Pittsburgh and Ottawa, cadaveric studies combined with advances in the field of rehabilitation led to the improvement of the technique and its final consolidation.

It was presented for the first time to the world in August 2001, at Reykjavik, during the First Icelandic Conference on Arthroscopy & Sport Medicine (17) (Fig. 2).

Since then the technique has been explained at numerous conferences and meetings so that everyone would know the revolutionary technique (see the chapter on "Proceedings Around the World") (18-20).

In April 2002, in collaboration with LARS, the first surgical instrumentation was made based on Cerulli's method (Fig. 3).

During a very important conference in Assisi (Italy) in 2002, it was finally codified, described and qualified with the presentation of the absolutely encouraging, first short term follow-up (21) (Fig. 4).

Longer follow-ups have been described in articles published in national and international journals (22-25).

REFERENCES

1. Bonnet A. Traité des maladies des articulations, vol I & 2 avec atlas. Baillière, Paris 1845.
2. Dandy DJ. Historical overview of operations for anterior cruciate ligament rupture. Knee Surg Sports Traumatol Arthrosc 1996; 3(4); 256-61.
3. Noulis G. Entorse du genou. Thèse N° 142. Fac Med Paris 1875; 1-53
4. Mayo Robson AW. Ruptured cruciate ligaments and their repair by operation. Ann Surg 1903; 37:716-8.
5. Lange F. Uber die Sehnenplastik. Verh Dtsch Orthop Ges 1903; 2:10-2.
6. Hey Grose EW. Operation for the repair of cruciate ligament. Lancet 1917; 2:674-5.
7. Campbell WC. Repair of the ligaments of the knee: Report of a new operation for the repair of the anterior cruciate ligament. Surg Gynecol Obstet 1936: 62;964-8.
8. Jones KG. Reconstruction of the anterior cruciate ligament. A technique using the central one-third of the patellar ligament. J Bone Join Surg 1963; 45A: 925-32.
9. Macey HB. A new operative procedure for repair of ruptured cruciate ligament of the knee joint. Surg Gynecol Obstet 1939; 69:108-9.
10. Cho KO. Reconstruction of the anterior cruciate ligament by semitendinosus tenodesis. Bone Joint Surg 1975; 57A:608-12.
11. Dejour H, Deshamps G, Walch G. Résultat du traitement des laxites antérieures chroniques par opération de Kenneth Jones-Lemaire. Journées Lyonnaises de chirurgie du genou 1984; 5:129-40.
12. Rosemberg TD. Technique for endoscopic method of ACL reconstruction. Technical Bulletin Mansfield MA. Acufex Microsurgical 1993.
13. Kurosaka M, Yoshima S, Andrish JT. A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction Am J Sports Med 1987; 15:225-9.
14. Lipscomb AB, Johnston RK, Synder RB, Warburton MJ, Gilbert PP. Evaluation of hamstring strength following use of semitendinosus and gracilis tendons to reconstruct the anterior cruciate ligament. Am J Sports Med 1982; 10:340-2.
15. Colombet P, Allard M, Bousquet V, De Lavigne C, Flurin PH. The History of ACL Surgery, Bordeaux-Mérignac Centre of Orthopaedic and Sports Surgery.
16. Puddu G, Cerullo G. My Technique in Femoral Tunnel Preparation: The "Retro-Drill" Technique. Tech Orthop 2005: 20;224-7.
17. Cerulli G. ACL reconstruction only inside technique in Proceedings 1st Icelandic Conference on Arthroscopy & Sports Medicine Reykjavik, Iceland, 16-20 August 2001.
18. Cerulli G, Caraffa A, Senni C, Bruè S. All-Inside technique for ACL reconstruction in Proceedings of the First Libanese Sports Medicine Congress, Beirut, Lebanon, 29 May – 1 June 2003.
19. Cerulli G, Caraffa A, Antinolfi P, Senni C, Bruè S. All-Inside technique for ACL reconstruction in Proceedings of the 6th congress of the European Federation of National Associations of Orthopaedics and Traumatology Helsinki, 4-10 June 2003.
20. Cerulli G, Trinchese E, Caraffa A, Alfredson, Lorentzon R. All-inside technique for ACL reconstruction: clinical and histological study in Proceedings of the 29th Annual Meeting of the Japan Knee Society, Hiroshima, Japan, 12-14 February 2004.
21. Cerulli G, Caraffa A, Sennì C, Bruè S. All-inside technique for ACL Reconstruction in Proceedings of 6th Corso Internazionale Ortopedia, Biomeccanica, Riabilitazione Sportiva Assisi, Italy, 22 – 24 November 2002
22. Cerulli G, Vercillo F, Sennì C, Amanti A, Antinolfi P. ACL reconstruction with the All-Inside technique J Orthopaed Traumatol 2008; 9(1):S87.
23. Cerulli G, Zamarra G, Vercillo F, Pelosi F. ACL

reconstruction with “the original all-inside technique” KSSTA 2011; 19(5):829-31.

24. Cerulli G, Caraffa A, Zamarra G, Antinolfi P, Vercillo F. Mid-term follow-up of ACL reconstruction with All-inside technique in Abstract volume of 12th ESSKA 2000 Congress, Innsbruck, Austria May 2006.

25. Cerulli G. My way in ACL reconstruction - from knowledge, EBM to my experience. Proceedings of the II Round Table Conference of Moscow Arthroscopy Club, Moscow, Russia October 2011.

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CHAPTER II

SCIENTIFIC BACKGROUND

G. CERULLI[1,4,5,6], S.L-Y. WOO[2,4,5], M. LAMONTAGNE[3,4,5], S. BRUÉ[6], F. VERCILLO[6], G. ZAMARRA[6] and A. CARAFFA[7]

[1]*Residency Program of Orthopedics and Traumatology, University of Perugia, Perugia, Italy*
[2]*Musculoskeletal Research Center, Department of Bioengineering, University of Pittsburgh, U.S.A.;*
[3]*School of Human Kinetics, University of Ottawa, Ottawa, Canada;* [4]*Nicola's Foundation Onlus, Arezzo;* [5]*Let People Move Research Institute, Perugia-Arezzo;*
[6]*International Orthopedics and Traumatology Institute, Arezzo, Italy*
[7]*Residency Program of Physical Medicine and Rehabilitation, University of Perugia, Perugia, Italy*

Reconstruction using the bone-patellar tendon-bone graft has many disadvantages compared to that using the hamstrings tendon including inferior patellar contracture, quadriceps weakness, extension deficits, anterior knee pain, as well as donor site morbidity such as patellar fractures. The "All-Inside" technique is based on the Rosenberg technique using half tunnels and quadrupled hamstrings. To solve the problem of the slow integration of the graft, animal studies were carried out which showed that integration is much more effective when manual versus motorized drilling is used. The technique was not meant to be limited by the use of special instrumentation or the choice of graft. The use of GR-ST autograft presents new issues. Hamstrings have the role of protecting the ACL in elongation during jumping, stopping and cutting movements. The peculiarity of the half tunnels in the "All-Inside" technique allows the surgeon to use only one hamstring thus restoring strength and function to the ACL.

BIOLOGICAL RATIONALE

The techniques developed for ACL reconstruction have unresolved problems from the biological point of view: type of graft, donor site morbidity, surgical wound infections and chronic sequels.

Until the nineties the bone-patellar tendon-bone (BPTB) had the highest consensus as graft for ACL reconstruction. However as extensively demonstrated in literature it has many disadvantages compared with reconstruction using the hamstrings tendon (GR-ST) in terms of reducing inferior patellar contracture, quadriceps weakness, extension deficits, anterior knee pain besides donor site morbidity such as patellar fractures and deficiency of the extensor mechanism (essential in some sports) (1-7). Even the greatest advantages that it was supposed to have were challenged in many meta-analyses which compared the use of BPTB and GR-ST. It is not true that BPTB offers better long term stability (8-9); it is not true that it has a better rate of return to full activity (10) and it is not true that it has better long term integration.

In fact long term integration depends on the contact surfaces of the tunnel and graft: the quadrupled hamstring positioned press fit has a contact surface greater than 35% compared with BPTB. This makes it well integrated with results comparable to those obtained with bone grafts, especially in the long term, with the formation of Sharpey's fibers and type I collagen which fix the graft to the tunnel (11). This in turn gives rise to the important process called

Key words: hamstrings, manual drilling, biomechanics, strain gauge

Mailing address: Prof. Giulano Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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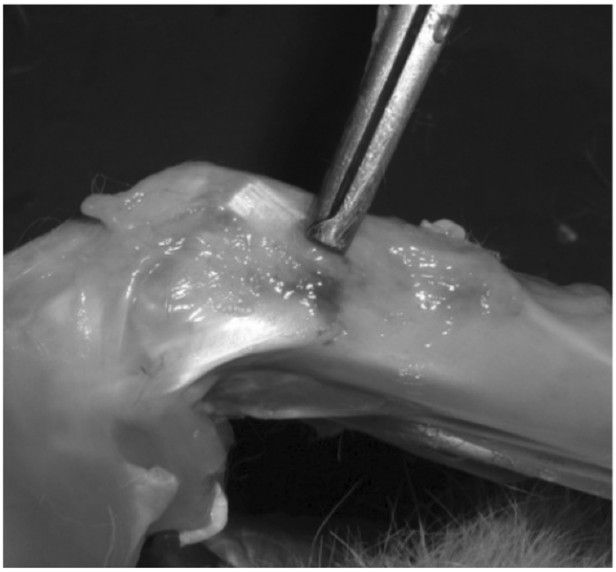

Fig. 1. *Histologic study in the rabbit model.*

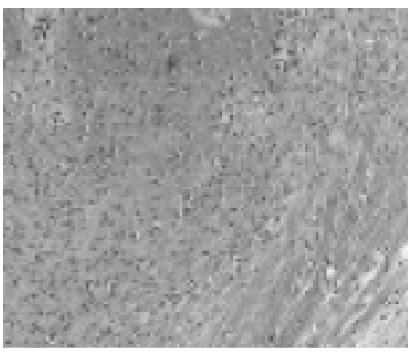

Fig. 2. *Osteoblastic activity at the transplant/tunnel interface.*

"ligamentization" about which little is known as yet despite the numerous on going studies, especially regarding the enthesis (12).

Furthermore the use of the hamstring permits a more cosmetic wound (significant for some patients) and more importantly consents a decrease of wound complications.

Finally, it must be underlined that in case of recurrence, the use of only one hamstring allows alternative surgery to be performed. Furthermore, besides there being no benefits in using BPTB, the cost of surgery with the BPTB graft is higher than that with the hamstrings (13).

For these reasons the "All-Inside" technique was based on Rosenberg's studies on ACL reconstruction which provides half tunnels and quadrupled hamstring (14), which is bone sparing on the tibial and femur side. This is very important for several reasons: it reduces pain and bleeding with a faster recovery and less downtime; it makes it possible to operate on young people without affecting the growth plates; it makes it possible to operate on older people (> 40 yrs) preserving as much as possible of the cortical bone which is an important structure for those who have thin spongy bones.

This does not solve the problem of the prolonged tendon-to-bone healing process that excludes the possibility of early loading using soft tissue grafts, a problem that does not occur using bone-to-bone healing (15). The link between tendon and bone is further delayed by the presence of necrosis and inflammation at the surgical site.

Motorized drilling increases the temperature of the bone in correlation to the speed and force of drilling, and bone quality, leading to thermo-necrosis; thus compromising tissue viability. A histological animal study performed by Cerulli et al. on 20 healthy, skeletally mature Giant Gray rabbits weighing 4.8 ± 0.7 kg under general anesthesia showed important results. A leg was chosen randomly to drill manually and as a control, motorized drilling was performed on the contralateral leg. The manual drilling was performed with the "All-Inside" manual drill, the rabbit was returned to the cage after surgery and no immobilization of the leg was performed. At 6 weeks after surgery the rabbits were sacrificed, soft tissues were removed leaving only the tibia and the transplanted tendon (Fig. 1).

The specimens were fixed in a 10% buffered formalin solution immediately after harvesting from each limb. The specimens were then decalcified and embedded in paraffin blocks, and examined under light microscopy. The control group had an interface between tendon and bone filled with fibrous tissue, there was no continuity nor any cartilaginous component (Fig. 2).

In the manually drilled specimens there was a statistically significant ($p<0.001$) lower percentage of necrosis and fibrosis and a higher osteoblastic activity at the transplant/tunnel interface. These histological studies demonstrated that the use of manual drilling increases vascularization of the bone and graft attachment.

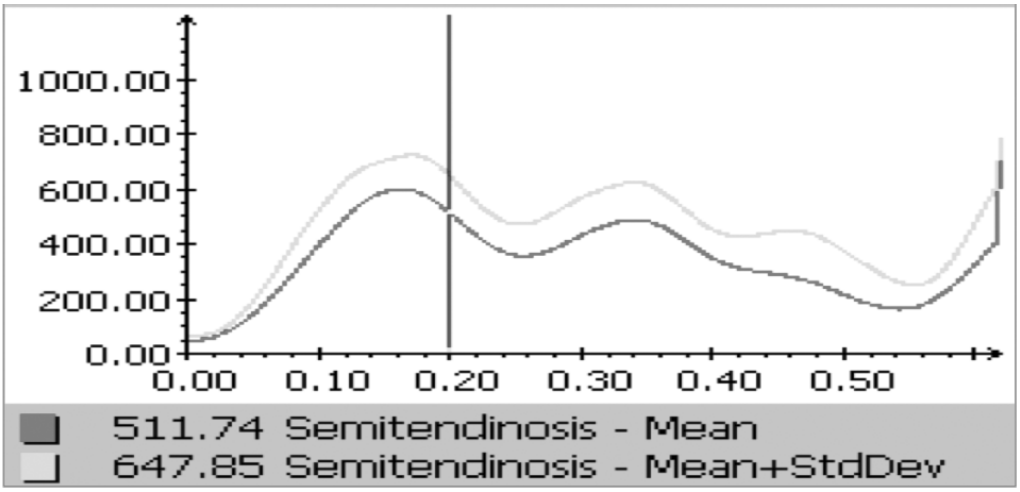

Fig. 3. *Protective mechanism of hamstring muscle to the ACL elongation in jumping and cutting movements.*

BIOMECHANICAL RATIONALE

As several authors have demonstrated the best method for ACL reconstruction depends on many different factors. Factors that could determine the outcome of an ACL reconstruction include graft selection, tunnel placement, initial graft tension, graft fixation, graft tunnel motion, and rate of graft healing (16).

The "All-Inside" technique was designed to combine the best elements of different techniques: no special instrumentation (except for the retrograde tunnel cutter), both the In-Out or the Out-In technique, and above all with no limits to graft choice. It has been practiced successfully with all types of grafts: (BPTB) grafts and ST-GR graft, allograft and artificial ligaments without technical problems and good long-term results.

As mentioned above the use of the GR-ST autograft is the gold standard for biological reconstruction, but it presents some problems including the laxity of active knee flexion at deeper flexion angles, lower internal tibial torque and muscle weakness (17-19). This is damaging to athletic performance especially in those sports where extensive use of the muscles is required (20-21).

Furthermore the semitendinosus tendon is needed to prevent excessive anterior tibial translation when the knee is near the full extension (22). Hamstrings muscles also have the key role of protecting ACL as demonstrated in an *in vivo* study by Cerulli et al in 2003 (23).

The study consisted of the surgical implantation of a calibrated strain gauge device (DVRT) via arthroscopy in the anteromedial band of the intact ACL of three healthy participants (mean age: 23.2 yrs; mean weight: 72 kg) while they were under local anesthesia following informed consent. They had no history of musculoskeletal disease or injury. The participants were transported from the surgery room at the hospital to the biomechanical laboratory for data collection. The zero strain position of the ACL was determined using the slack-taut technique (24). The subjects were asked to perform three types of movement: jumping, stopping and cutting. All movements consisted in jumping from a distance of about 1.5m to the centre of a force plate, landing on the instrumented left leg. The entire collection window was 8 seconds at 1000Hz for electromyography and force plate, and DVRT signals were 50 Hz for the kinematic data. A total of three to five trials were collected and averaged over a jump, stop or cut cycle of less than one second. After the experimental testing, the participant returned to the hospital in order to remove the DVRT. In test conditions with less space for cutting, the subject's neuromuscular strategy does anticipate the impact by contracting the hamstrings and gastrocnemius muscles with high intensity whereas the quadriceps muscles

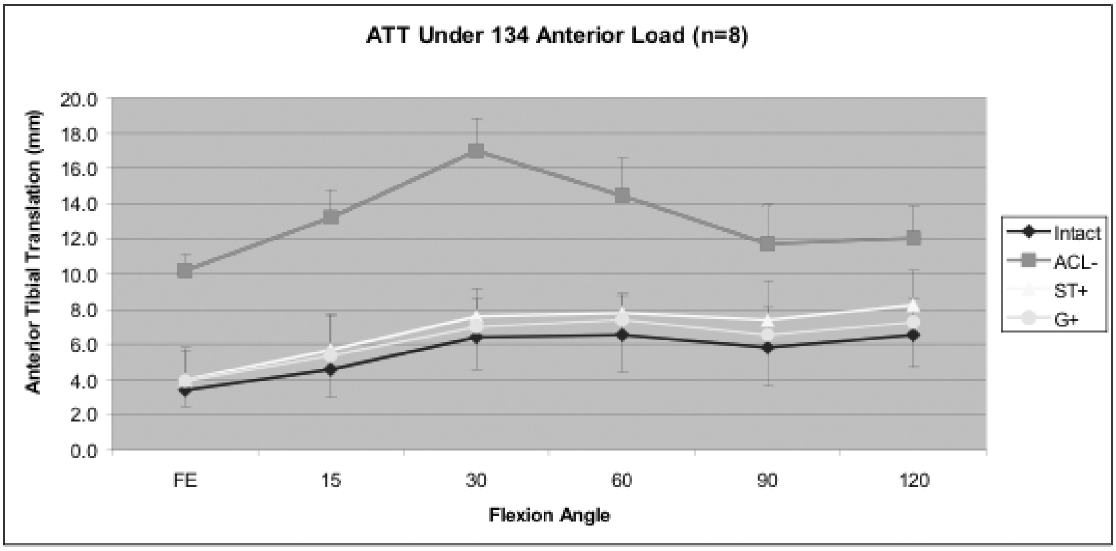

Fig. 4. *Cadaveric Study in human knee with ACL-deficient and ACL reconstruction with the "All-inside" technique using the single semitendinosus tendon graft or single gracilis tendon graft.*

contracted right after impact with the ground. This shows that the hamstrings and gastrocnemius muscles have a protective mechanism on the ACL elongation as occurs in jumping and cutting conditions (24) (Fig. 3).

Therefore it would be desirable to preserve the hamstrings tendon as much as possible for ACL reconstruction, particularly in young and the more athletic patients (25).

The original "All-Inside" technique with manually drilled half tunnels requires a significantly shorter length of graft than the traditional full tunnel methods. This means that only one hamstring tendon (either Semitendinosus or Gracilis) is needed, folded in triple or quadruple strands as an ACL replacement autograft.

The question was is one tendon sufficient for a good ACL reconstruction? Zamarra et al. in 2010 published a human cadaver study using one hamstring tendon for ACL reconstruction (25). In the study ten human cadaver knees were tested in the following conditions: intact, ACL-deficient, and ACL reconstruction with the "All-inside" technique using the single semitendinosus tendon graft, or single gracilis tendon graft. Using a robotic testing system, two, external loads on anterior tibial load of 134-N and combined rotatory loads of 10-Nm valgus and 5-Nm internal tibial torques, were applied. The multiple degrees of freedom of knee kinematics and the *in situ* forces in the ACL and ACL grafts were determined. In response to a 134-N anterior tibial load, the use of either graft could restore anterior tibial translation to within 1.3 mm of the intact knee (Fig. 4). The *in situ* forces in the two grafts were not significantly different from those of the intact ACL. Under the combined rotatory loads, both grafts could restore knee kinematics as well as the *in situ* force in the grafts to the level of the intact ACL. Using either the semitendinosus or gracilis tendon for ACL reconstruction could satisfactorily restore time-zero knee kinematics and the *in situ* forces in either graft to those of the intact ACL.

The "All-Inside" technique has strong biomechanical foundations that make it one of the most versatile and safe techniques for ACL reconstruction.

REFERENCES

1. Maletis GB, Cameron SL, Tengan JJ, Burchette RJ. A prospective randomized study of anterior cruciate ligament reconstruction: a comparison of patellar tendon and quadruple-strand semitendinosus/gracilis tendons fixed with bioabsorbable interference screws. Am J Sports Med 2007; 35(3):384-94.
2. Sajovic M, Vengust V, Komadina R, Tavcar R,

Skaza K. A prospective, randomized comparison of semitendinosus and gracilis tendon versus patellar tendon autografts for anterior cruciate ligament reconstruction: five-year follow-up. Am J Sports Med 2006; 34(12):1933-40.
3. Bonamo JJ, Krinick RM, Sporn AA. Rupture of the patellar ligament after use of its central third for anterior cruciate reconstruction. A report of two cases. J Bone Joint Surg Am 1984; 66(8):1294-7.
4. Christen B, Jakob RP. Fractures associated with patellar ligament grafts in cruciate ligament surgery. J Bone Joint Surg Br 1992; 74(4):617-9.
5. Kartus J, Stener S, Lindahl S, Engström B, Eriksson BI, Karlsson J. Factors affecting donor-site morbidity after anterior cruciate ligament reconstruction using bone-patellar tendon-bone autografts. Knee Surg Sports Traumatol Arthrosc 1997; 5(4):222-8.
6. Risberg MA, Holm I, Tjomsland O, Ljunggren E, Ekeland A. Prospective study of changes in impairments and disabilities after anterior cruciate ligament reconstruction. J Orthop Sports Phys Ther 1999; 29(7):400-12.
7. Sachs RA, Daniel DM, Stone ML, Garfein RF. Patellofemoral problems after anterior cruciate ligament reconstruction. Am J Sports Med 1989; 17(6):760-5.
8. Biau DJ,Tournoux C, Katsahian S, Schranz PJ, Nizard RS. Bone-patellar tendon-bone autografts versus hamstring autograft for reconstruction of anterior cruciate ligament: meta-analysis. BMJ 2006; 332(7548):995-1001.
9. Prodromos CC, Joyce BT, Shi K, Keller BL. A meta-analysis of stability after anterior cruciate ligament reconstruction as a function of hamstring versus patellar tendon graft and fixetion type. Arthroscopy 2005; 21(10):1202.
10. Thompson J, Harris M, Grana WA. Patellofemoral pain and fuctional outcome after anterior cruciate ligament reconstruction: an analysis of the literature. Am J Orthop 2005; 34(8):396-9.
11. Pinczewski LA, Clingeleffer AJ, Otto DD, Bonar SF, Corry IS. Integration of hamstring tendon graft with bone in reconstruction of the anterior cruciate ligament. Arthroscopy 1997; 13(5):641-3.
12. Claes S, Verdonk P, Forsyth R, Bellemans J. The "ligamentization" process in anterior cruciate ligament reconstruction: what happens to the human graft? A systematic review of the literature. Am J Sports Med 2011; 39(11):2476-83.
13. Genuario JW, Faucett SC, Boublik M, Sclengel TF. A Cost- Effectviness Analysis Comparing 3 Anterior Cruciate Ligament Graft Types: Bone-Patellar Tendon-Bone Autograft, Hamstring Autograft, and Allograft. Am J Sports Med 2011 Epub PMID: 22085728.
14. Rosenberg TD, Brown GC, Deffner KT. Anterior cruciate reconstruction with a quadrupled semitendinosus autograft. Sports Med Arthrose Rev 1997; 5:51–8.
15. Insalatea JC, Klatt B, Fu FH, Harner CD. Tunnel expansion following anterior cruciate ligament reconstruction: a comparison of hamstring and patellar tendon autografts. Knee Surg Sports Traumatol Arthrosc 1997; 5:234–8.
16. Woo S.L-Y, Wu C, Dede O, Vercillo F, Noorani S. Biomechanics and anterior cruciate ligament reconstruction J Orthop Surg Res 2006; 1:2.
17. Yasuda K, Tsujino J, Ohkoshi Y, Tanabe Y, Kaneda K. Graft site morbidity with autogenous semitendinosus and gracilis tendons. Am J Sports Med 1995; 23(6): 706-14.
18. Nakamura N, Horibe S, Sasaki S, Kitaguchi T, Tagami M, Mitsuoka T, Toritsuka Y, Hamada M, Shino K. Evaluation of active knee flexion and hamstring strength after anterior cruciate ligament reconstruction using hamstring tendons. Arthroscopy 2002; 18(6):598-602.
19. Ohkoshi Y, Inoue C, Yamane S, Hashimoto T, Ishida R. Changes in muscle strength properties caused by harvesting of autogenous semitendinosus tendon for reconstruction of contralateral anterior cruciate ligament. Arthroscopy 1998; 14(6):580-4.
20. Agel J, Ransone J, Dick R, Oppliger R, Marshall SW. Descriptive epidemiology of collegiate men's wrestling injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train 2007; 42(2):303-10.
21. Arnason A, Andersen TE, Holme I, Engebretsen L, Bahr R. Prevention of hamstring strains in elite soccer: an intervention study. Scand J Med Sci Sports 2008; 18(1):40-8.
22. Shelburne KB, Torry MR, Pandy MG. Effect of

muscle compensation on knee instability during ACL-deficient gait. Med Sci Sports Exerc 2005; 37(4):642-8.

23. Cerulli G, Benoit DL, Lamontagne M, Caraffa A, Liti A. In vivo anterior cruciate ligament strain behaviour during a rapid deceleration movement: case report. Knee Surg Sports Traumatol Arthrosc 2003; 11(5): 307-11.

24. Cerulli G, Lamontagne M, Caraffa A, Liti A, Vercillo F, Beaulieu M. The Role of Hamstrings muscles to protect the ACL. In Proceedings of International Symposium on Ligaments & Tendons Wyndham Washington, DC USA February 19, 2005.

25. Liu W, Maitland ME. The effect of hamstring muscle compensation for anterior laxity in the ACL-deficient knee during gait. J Biomech 2000; 33(7):871-9.

CHAPTER III

SURGICAL TECHNIQUE

G. CERULLI[1,2,3], G. ZAMARRA[2], F. VERCILLO[2], S. BRUÉ[2], C. SENNÍ and P. ANTINOLFI[4]

Nicola's Foundation Onlus, Arezzo; [1]Let People Move Research Institute, Perugia-Arezzo; [2]International Orthopedics and Traumatology Institute, Arezzo; [3]Residency program in Orthopaedics and Traumatology, University of Perugia, Perugia; [4]Orthopedic Division, Santa Maria della Misericordia Hospital, Perugia, Italy

The "All-Inside" technique for ACL reconstruction is a technique based on two half-tunnels, one tibial and one femoral. The tunnels are drilled manually in-out using a special instrument with a two-incision technique. The short length of the tunnels minimizes post-operative blood loss, damage to soft tissues, bone mass loss (54 to 64 % reduction of bone loss), and reduces post-operative pain. These improvements make it a one day surgery, easier for the patient. The technique is particularly versatile and can be used with auto/allografts, Semitendinosus/Gracilis grafts or bone-patellar tendon-bone grafts. It offers the possibility to adapt the half tunnels to the graft length and offers the advantage of harvesting only one hamstring tendon tripled or quadrupled. A specific set of instruments has been designed to make the operation reliable and highly repeatable. The set includes an adjustable tibial guide and femoral guide designed to identify the isometric point and to preserve a linear alignment. The instrument set is not mandatory; the surgeon can choose the preferred tunnel placement and creation techniques. The set can be used: to introduce the guide pin for either the in-out or the out-in approach; to drill the femoral tunnel and tibial tunnel separately; or for the single tibial-femoral or femoral-tibial tunnel technique. The important thing is to be isometric and that the tunnels are in as much of a linear direction as possible at 50° of flexion to avoid a mismatch between the graft and the tunnel.

DESCRIPTION

Surgery is performed in local or general anesthesia with tourniquet. Using a lateral infrapatellar access and a standard anteromedial access, chondral and meniscal lesions are treated if indicated. The notch is debrided and when possible we leave the ACL remnant as suggested by Georgoulis et al (1).

2.4mm guide wires are introduced out-in, to guide the drill for both femoral and tibial tunnels. It can be introduced by free hand or using an aimer as the surgeon prefers. The out-in technique means the neo ACL can be implanted exactly in the isometric point chosen by the surgeon as seen via arthroscopy; moreover the femoral and tibial tunnels can be drilled in 2 different axes giving the graft greater resistance. The introduction point of the tibial pin-guide is 2cm medial to the tibial tubercle with the knee flexed at 80 degrees. The angle of introduction is 20° from the frontal plane and 45° from the tibial plateau. The femoral pin-guide is introduced out-in having the access 2cm proximal and 1cm anterior from the lateral femoral epicondyle. Angulation is 40° lateral to the femoral axis and 45° laterally without using guides (Fig. 1).

Following the pin-guide direction, initial femoral and tibial tunnels, 4mm wide are drilled out-in. The cannulated groove probe is advanced

Key words: All inside technique, ACL reconstruction, surgical indications, half tunnel.

Mailing address: Prof. G. Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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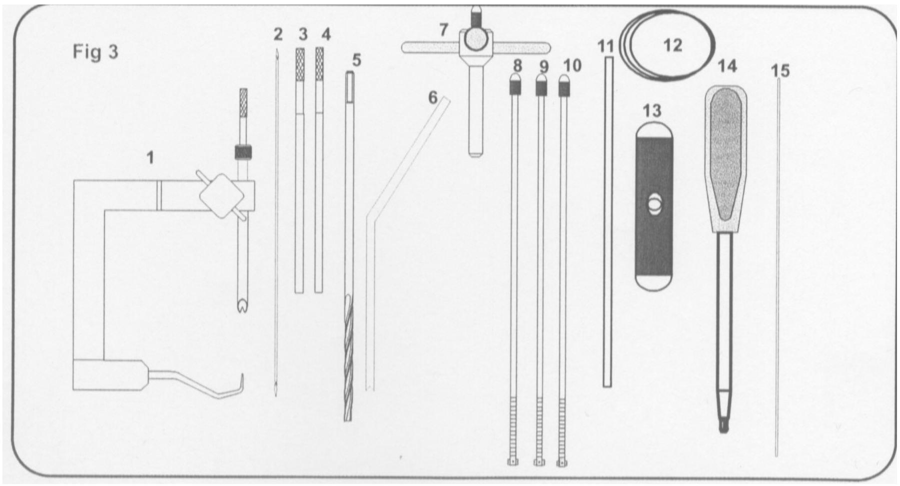


Fig. 1. *Set of first instruments (L.A.R.S. 2002) including: (1) Aimer, (2) 2.4 mm guide wires, (3) guide wires sleeve, (4) cannulated drill sleeve, (5) 4mm cannulated drill, (6) cannulated groove probe, (7) T-handle fore retro drill, (8-10) 3 measure retro drills, (11) passing cannula (12) metal wire, (13) ligament pull handle, (14) screwdriver, (15) passing pin.*

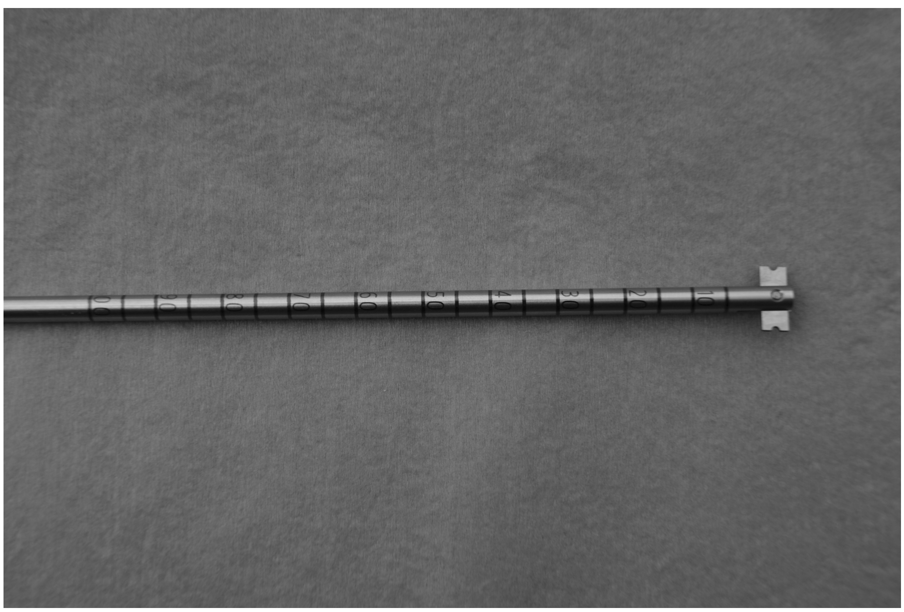


Fig. 2. *Retro drill with length indicators every 0.5 mm and wings open (Smith & Nephew 2010)*

into the femoral tunnel and both pin and drill are removed; it is not necessary for the tibial tunnel as the primary tunnel is easy to find. In order to decide the endobutton loop length and prepare the graft, we take all the measurements: tibial and femoral hole length, intra-articular distance between the two holes and the distance of the external femoral cortex-skin. The graft is then prepared with an endobutton at its femoral end. Two polyester braided sutures (number 5 and number 2) are passed through the outside holes of the endobutton in order to pass the graft and flip the endobutton. A suture is placed on the graft to mark the femoral half tunnel length.

Using a specific device, the tibial and femoral half tunnels are manually drilled in-out. The device consists of a drill guide 4mm wide with length indicators every 0.5cm (Fig. 2) and drill wings that can be turned out inside the joint (Fig. 3). There

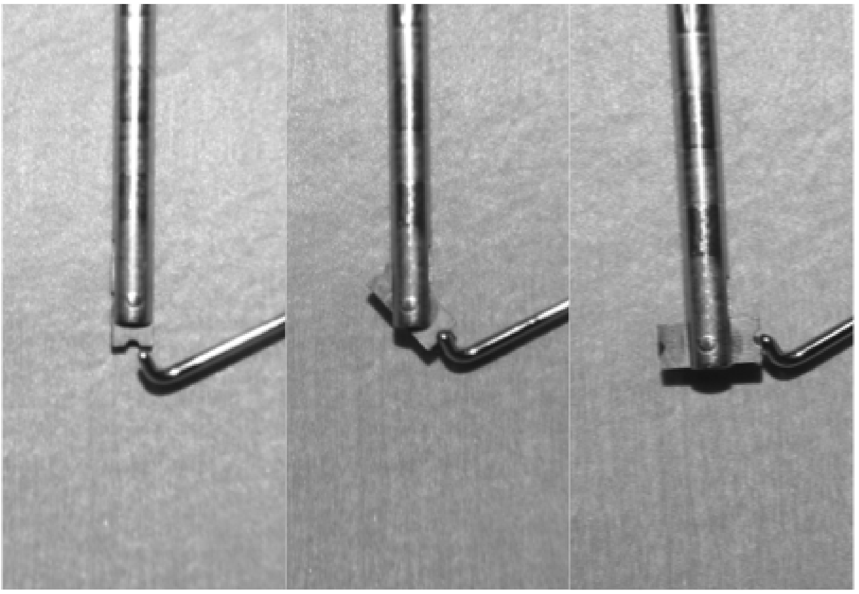


Fig. 3. *The retro drill wing movements are made possible inside the joint by using an arthroscopic probe.*

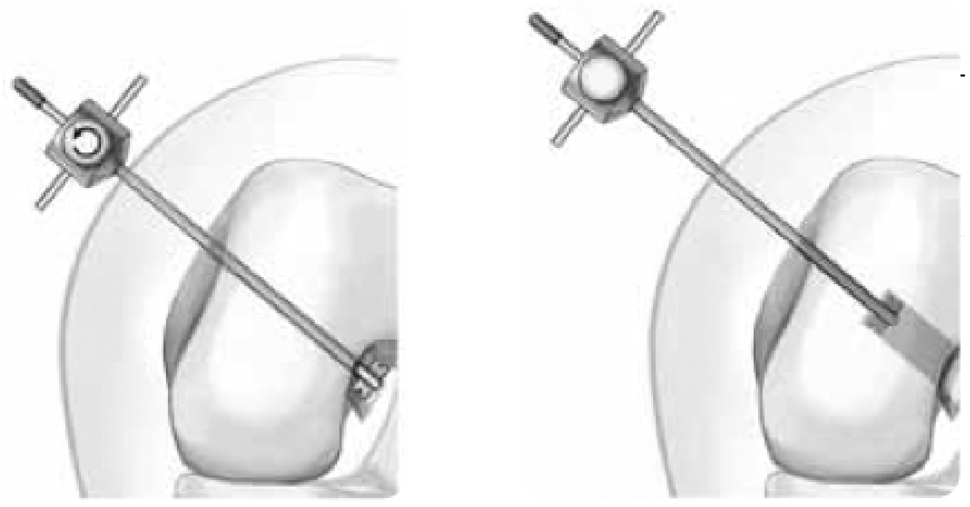


Fig. 4. *Half-tunnel made through the femoral bone (Smith and Nephew, 2010).*

is a choice of 5 different drill guides and drill wings ranging from 6mm to 10mm in diameter. A cannulated groove probe is helpful to maintain the position and the direction on the external femoral cortex. The retro reamer is inserted in the joint through the probe with the blade closed. Once in the joint, the reamer is advanced 10 mm past the end of the tunnel, the reamer's blade is unlocked and using an arthroscopic probe the reamer's blade is move to open, in a perpendicular position. Using a T-handle fixed to the reamer, perform a counterclockwise pull back rotation with the reamer and widen the tunnel until the indicator on the reamer reaches the chosen tunnel length (approximately 25 mm) based on the graft (Fig. 4). The reamer is then moved forward back into the joint space, unlocking, closing and relocking the blade before removing the reamer from the tunnel.

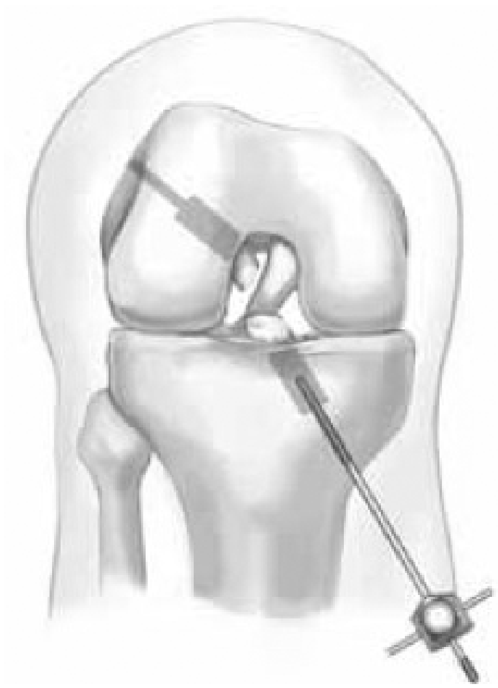


Fig. 5. *Half-tunnel made through the tibial bone (Smith and Nephew, 2010)*

Use the same technique used for the femoral tunnel to widen the tibial tunnel to the selected diameter (Fig. 5). The cannulated groove probe is not necessary here as the primary tunnel is easy to find.

The graft is introduced through the anteromedial portal. Insert by passing the cannula, a pin and a loop of metallic wire through the femoral tunnel, leaving the loop of suture outside the medial portal. Pass the pre-loaded endobutton sutures through the loop and pull them through the femoral tunnel (Fig. 6). The endobutton polyester braided sutures are passed through the loop of the femoral wire and then pulled out from the tunnel. The sutures at the tibial side of the graft are then passed through the loop of the tibial wire to insert the graft into the two half-tunnels. The graft is tensioned and tested with a probe. Tibial fixation is achieved using the Cobra Ligament Fixation Device or a 6 mm base diameter Interference screw out-in following guide-wire (Tab. I).

INDICATIONS

The possibility that this technique gives the surgeon is to be able to vary the length of the half-tunnels so all types of grafts can be used: hamstrings, bone-patellar tendon-bone, quadriceps tendon or synthetic grafts. When hamstrings are used as a graft, only one tendon needs to be harvested for the "All Inside" technique, in fact as the tunnels are so

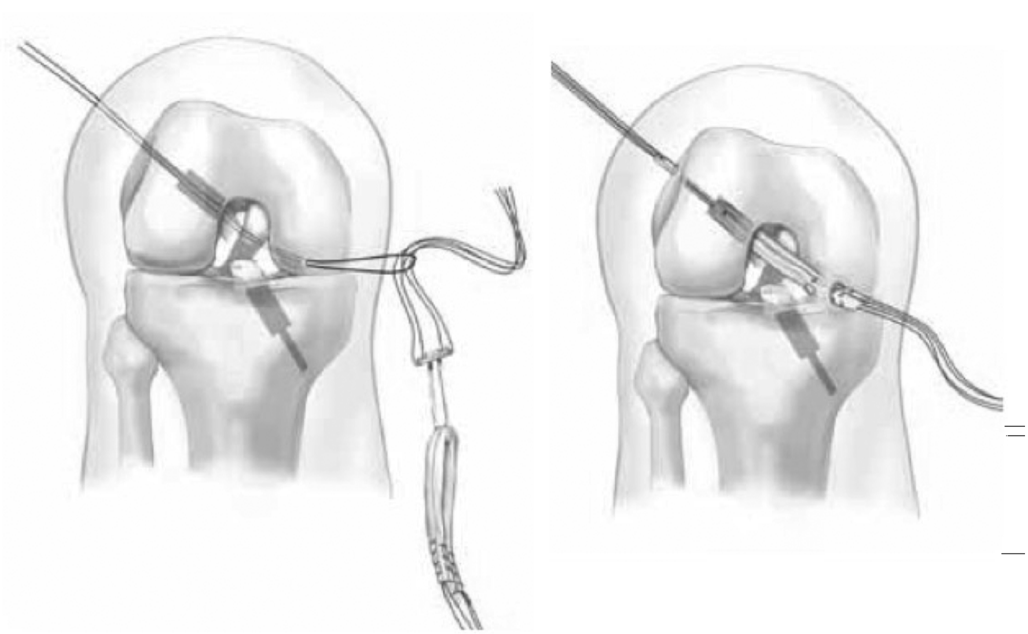


Fig. 6. *Introducing the graft through the anteromedial portal (Smith and Nephew, 2010)*

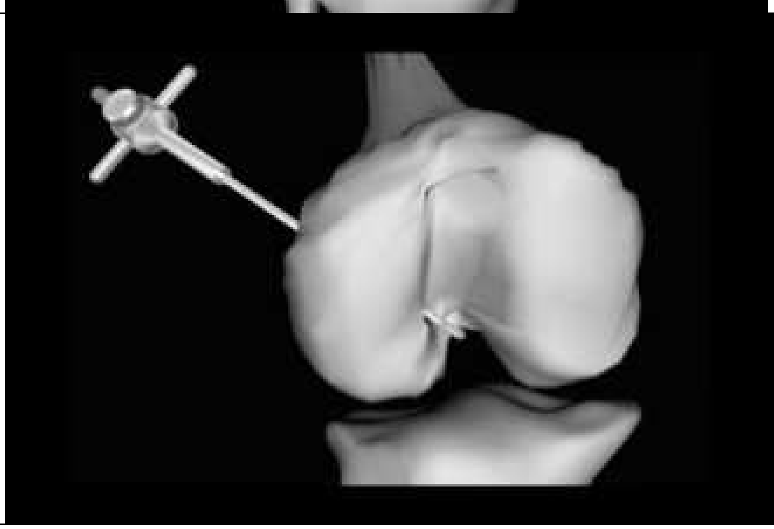
much shorter than those used in other techniques, the final graft length needed is about 7-8cm. Therefore either the triplicated or quadruplicated Gracilis or Semitendinosus can be used alone. After preparation the graft is pretensioned at the workstation and then introduced pressfit into the femoral and tibial tunnels. This technique is particularly suitable for young and active patients as it guarantees a faster return to activity, hamstring sparing, bone sparing and good results. Furthermore bone sparing as a feature should not be underestimated: in skeletally immature patients, the low rate of growth disturbance could be lower with the all inside technique since the half-tunnels do not interfere with the open physis; in elderly patients the technique assures greater stability to the tibial bone because it does not weaken the cortical bone.

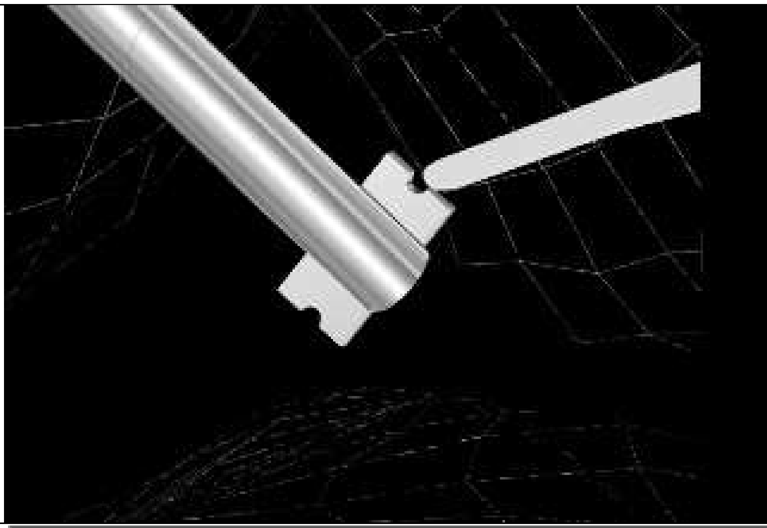
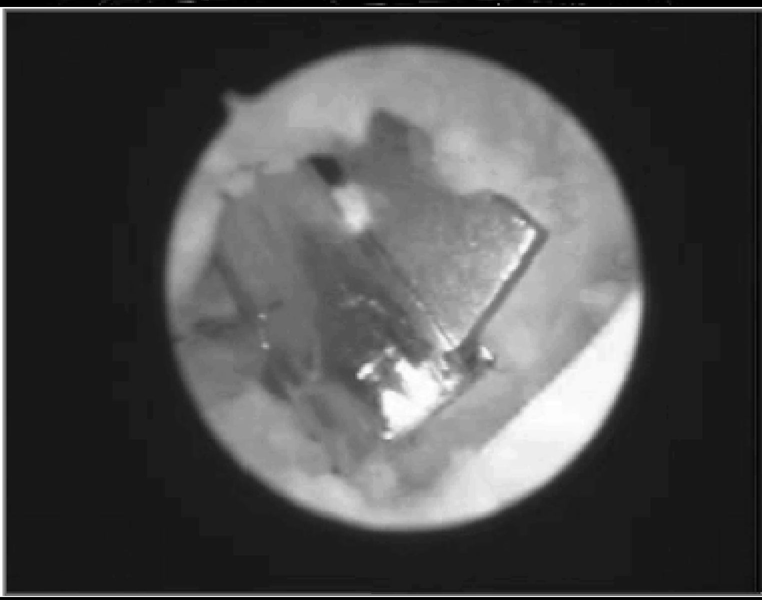
Either a biologic or a synthetic graft can be used, however we suggest that a synthetic graft implanted using the "All-Inside" technique should be done in very few selected cases: mainly in subjects over the age of 45, symptomatic and motivated and who need a fast recovery. We must be sure that the patients understand that a synthetic ligament is only an Intra Articular Brace (Cerulli G, 2001). In selected cases it can be used in professional athletes if they are at an important moment in the sport season, at the end of their career or they risk missing a chance of their (sport) lifetime. From 2001 to 2005 we treated 15 professional soccer players with the "All-Inside" technique using the synthetic graft. We achieved good functional and biomechanical results, high patient satisfaction, rapid return to sport activities, good muscle strength and no synovitis or reaction to graft material. Only one failure occurred due to the fixation (2).

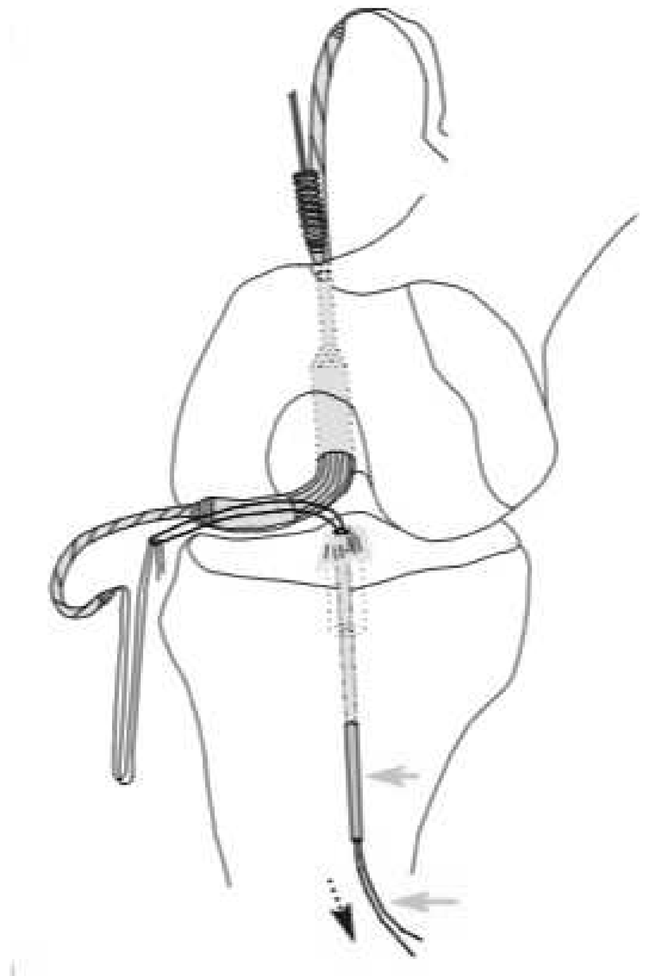
REFERENCES

1. Georgoulis AD, Pappa L, Moebius U, Malamou-Mitsi V, Pappa S, Papageorgiou CO, Agnanti NJ, Soucacos PN.. The presence of proprioceptive mechanoreceptors in the remnants of the ruptured ACL as a possible source of re-innervation of the ACL autograft *K*nee Surg Sports Traumatol Arthrosc. 2001 Nov; 9(6):364-8.
2. Cerulli G, Vercillo F, Senni C, Zamarra G, Migonney V.The biomimetic-Bioactive Ligament Proceedings at 26th International Jerusalem Symposium on Sports Medicine Jerusalem (Israel), 20-21 Jan 2010

Table I

	2.4 mm guide wires are introduced out-in having the access 2 cm proximal and 1 cm anterior from the lateral femoral epicondyle. Angulation is 40 degrees lateral to the femoral axis and 45 degrees laterally.
	Initial tunnel 4 mm wide is drilled out-in.
	e o rea er is inserted in the joint through the initial tunnel with the blade in closed position.

	Blade is opened w h an ar hroscop c p obe and locked in this posi on.
	Using the T-handle fixed to the reamer, perform a counterclockwise rotation pull back on the reamer and widen the tunnel.
	Use the same technique used for the femoral tunnel to widen the tibial tunnel to the selected diameter.

	Insert with the passing cannula a passing pin and a loop of metal wire through the tunnel, bond the graft to the metal wire and pull it through the tunnel.

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CHAPTER IV

REHABILITATION PROGRAM

G. PLACELLA[1, 2], E. SEBASTIANI[1, 2], S. LOTITO[3] and G. POTALIVO [1]

Nicola's Foundation Onlus, Arezzo; [1]Let People Move Research Institute, Perugia-Arezzo; [2]Residency Program in Orthopedics and Traumatology, University of Perugia, Perugia; [3]Orthopedic and. Traumatology Unit, "L. Bonomo" Hospital, Andria, Bari, Italy

The aim of surgery is to achieve better functional recovery. This is why rehabilitation is as important as the surgery itself. Correct rehabilitation starts preoperatively with a program, as much as possible, patient-specific. For patients that undergo the "All-Inside" technique we have introduced a program of personal Adjuvant Rehabilitation that will take patients to surgery in the best possible muscular condition. This ensures quick functional recovery and an early return to exercise and sport-specific activities. The post-op rehabilitation program begins a few hours after surgery. Following the rehabilitation program meticulously allows the patient to return to daily activities in 28 days and sport in 5 months.

ADJUVANT EXERCISES

The "All-Inside" technique enhances faster rehabilitation by reducing pain and entailing smaller surgical wounds. The choice of a single hamstring tendon as a graft is a winning choice for rehabilitation as it allows a faster and easier recovery (1).

ACL rupture leads to muscular structure deficit of the entire kinetic chain of the affected limb. This is particularly evident in the femoral quadriceps and knee flexors (2); but the altered stance also involves alterations in the contralateral limb (3).

The cross-sectional area in the injured limb decreases by 2-3% per week of inactivity (4).

This suggests the need of an Adjuvant Rehabilitation Program to minimize the negative effects of the preoperative period on muscle trophism.

The wide variability among patients who require ACL reconstruction, and the differences in reduction of the volume between the various muscular structures (quadriceps femoris between 8-17%, leg flexor 2-6%, hip adductor 7%) means that the Adjuvant Program must, as far as possible, be tapered to each individual patient (5-6).

This is why when surgery is not performed in the immediate post-trauma period, we perform biomechanical tests including gait analysis, stabilometry, isokinetic and arthrometry evaluations that enable us to decide which exercises the patient needs, how many repetitions and how long the Adjuvant Program should take.

A decrease in quadriceps strength and contraction of the flexors are the main findings in the biomechanical tests. That is why in the overwhelming majority of cases the Adjuvant Exercise scheme includes isometrics for the quadriceps femoris, mono- and bipodalic squats, stretching for flexors muscles and 0-90° flexor reinforcement.

The results of Adjuvant Rehabilitation Program are evident in patients with a faster recovery of the cross-sectional area and greater stability in the pre-op period; less pain and better muscular recovery in the immediate post-op period.

Key words: rehabilitation, biomechanical evaluation, kinetic chains

Mailing address:
Prof. G. Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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POST-OPERATIVE EXERCISES

All therapy should be tailored to the patient, especially a rehabilitation program which must carefully meet the needs of each individual.

Staying in bed for more than three days results in a decrease of more than 10% of the maximum force of the quadriceps femoris and rises above 20% if the days of rest are seven, with an average of 3% per day (7). Among the factors that accelerate muscle weakness even more than immobility are inflammatory processes (8); so immediately after surgery the patient begins with ice packs, compression and elevation.

Post-operative rehabilitation starts a few hours after surgery as soon as the anesthesia allows the leg to move. The patient leaves the operating room with a brace locked at 0° ROM (the straps are not tight, used only for restraint) or negative degrees (-5°, -10°), if the degree of hyperextension of the patient's normal knee is higher to prevent extension deficits. This is highly important especially for top-level athletes, in whom even a small extension deficit is very dangerous and leads to prolonged rehabilitation. When patients suffer an extension defect, their patella takes the load thus increasing the amount of anterior knee pain. Therefore the patient must begin the isometric exercise for quadriceps femoris: the patient is in a semi-sitting position on the bed, at a 20 cm slope, 90° ankle flexion, contralateral knee at 90°, he pushes the knee into hyperextension for 10 seconds, after rising the leg by flexing the hip to 45° and remains in that position for 10 seconds, then goes down slowly stopping midway for another 10 seconds and finally rests for 10 seconds, placing the foot on the slope. The exercise must be repeated for 15 minutes 6 times a day.

The second exercise is the venous pump, it must be repeated 5 minutes every hour to prevent the ankle pitting.

One week after surgery the knee flexion exercises are added to the program; the first exercise is done in the prone position, helping the operated leg in flexion with the contralateral one, this should be repeated for 20 min 6 times a day. In addiction the patient can sit on the edge of the bed and let the operated leg drop to 90°, helping to extend it with the contralateral leg. If necessary: mobilization of the patella.

The partial load then begins using two crutches and then after the 23rd day using one while continuing to do all the exercises described above. In the 28th day the stick is removed, walking with a correct gait pattern is begun and the patient can resume daily activities including driving and work.

At this point muscle strengthening starts: femoral quadriceps isometric exercises with increasing weights, starting from 1kg and active flexion of the knee increasing the weight too.

From the 40th day bipodalic squat exercises begin: series of maximum flexion and a series of 90° knee flexion.

As of the seventh week the patient begins the monopodalic leg squat exercises 0-30° in the neutral position and in external rotation of the foot in order to strengthen the vastus medialis; and begin bipodalic and monopodalic proprioceptive exercises and stretching exercises.

A crucial point in the rehabilitation is reached at the tenth-twelfth week after surgery. It is known that the recovery of isometric strength reaches preoperative levels after three months (9) and clinical evidence shows that in order to achieve a rapid recovery, open kinetic chain exercises (10) must start as soon as possible; so it will be necessary to perform a biomechanical evaluation. The biomechanical criteria for returning to sport are: arthrometric, stabilometric and isokinetic analysis. Arthrometry is useful to evaluate the residual instability of the knee: side to side differences must be less than 2mm for an excellent result, less than 4 for a good result. Stabilometric analysis with force plates is a functional test of the proprioceptive system; in our experience often better results are achieved in the operated knee than in the contralateral healthy knee. Isokinetic analysis evaluates knee flexors and extensors: for a safe return to sport the operated knee should not present a deficit greater than 15% compared to the contralateral knee; both the peak and the resistance are important to prevent re-injury and injury. These evaluations enable the specialist to decide if the functional recovery is sufficient to begin jogging on an even surface and changing direction.

From the fourth month, jogging on an uneven surface, 90°, 180° and 360° turns, 45°changes of direction, acceleration and deceleration and

Table I. *Adjuvant Exercises*

PRE-OPERATIVE ADJUVANT EXERCISES	Isometric exercise for quadriceps femoris Mono- and bipodalic squats Stretching for flexor muscles Reinforcement of flexors 0-90°
POST-OPERATIVE EXERCISES	
After a few hours	Isometric exercise for quadriceps femoris Venous pump
1st week	Flexion in prone position Flexion in sitting position Partial load on operated limb
4th week	Isometric exercise for quadriceps femoris with ankle weights Complete weight-bearing
40th day	Bipodalic squats
7th week	Monopodalic squats Monopodalic and bipodalic proprioceptive exercise
10th-12th week	BIOMECHANICAL EVALUATION
4th month	Jogging on even surface Turns at 90°, 180°, 360° Changes of direction at 45° Acceleration and deceleration of velocity Plyometric training
5th month	BIOMECHANICAL EVALUATION Sport-specific exercises

plyometric training can all begin.

From the fifth month, after a careful clinical evaluation, sports specific exercises are allowed.

Return to competitive sport must be gradual and can be done if the results of the biomechanical evaluation of sport-specific movements demonstrate that a complete functional recovery has been achieved; i.e. when the patient has regained preoperative knee ROM, when the thigh muscle strength is more than 85% of the contralateral leg, if balance and proprioception are good, and when all functional tests can be performed without pain and swelling.

Once competitive training has begun, it is crucial to practice proprioceptive training programs and plyometric exercises to decrease the latency of activation and contraction of the hamstrings and to increase proprioceptive capacity. As seen in several studies proprioceptive training and the protective role of hamstrings are essential to reduce injuries in top-level athletes, this can be achieved by performing unplanned movements during training (11-12).

REFERENCES

1. Feller JA, Webster KE, Gavin B. Early post-operative morbidity following anterior cruciate ligament reconstruction: patellar tendon versus hamstring graft. Knee Surg Sports Traumatol Arthrosc 2001; 9(5):260-6.
2. Kannus P, Latvala KI Jarvinen M: Thigh muscle strength in the anterior cruciate ligament deficient knee: lsokinetic and isometric long-term results. J

Orthop Sports Phys Ther 1987; 9(6):223-7.
3. Wilk KE, Romaniello WT, Soscia SM, Arrigo CA, Andrews JR. The relationship between subjective knee scores, isokinetic testing, and functional testing in the ACL-reconstructed knee. J Orthop Sports Phys Ther 1994; 20:60-73.
4. Narici M, Capodaglio P. Changes in muscle size and architecture in disuse artrophy. Advances in Occupational Medicine and Rehabilitation 1998; 4: 55.
5. Tesch PA, Berg HE. Muscle strength and endurance following lower limb suspension in man. The Physiologist 1991; 34:104.
6. Gogia PP, Schneider V. Bed rest effect on extremity muscle torque in healthy men. Archives of Physical Medicine and Rehabilitation 1988; 69:1030.
7. Fuglsang-Frederiksen A, Scheel U. Transient decrease in number of motor units after immobilisation in man. J Neurol Neurosurg Psychiatry 1978; 41(10): 924-9.
8. Fink H, Helming M, Unterbuchner C, Lenz A, Neff F, Martyn JA, Blobner M. Systemic inflammatory response syndrome increases immobility-induced neuromuscular weakness. Crit Care Med 2008; 36(3):910-6.
9. Yasuda K, Tsujino J, Ohkoshi Y, Tanabe Y. Graft site morbidity with autogenous semitendinosus and gracilis tendons. Am J Sports Med 1995; 23(6):706-14.
10. Mikkelsen C, Werner S, Eriksson E. Closed kinetic chain alone compared to combined open and closed kinetic chain exercises for quadriceps strengthening after anterior cruciate ligament reconstruction with respect to return to sports: a prospective matched follow-up study. Knee Surg Sports Traumatol Arthrosc 2000; 8(6):337-42.
11. Cerulli G, Benoit DL, Caraffa A, Ponteggia F. Proprioceptive training and prevention of anterior cruciate ligament injuries in soccer. J Orthop Sports Phys Ther 2001; 31(11):655-60.
12. Cerulli G, Benoit DL, Lamontagne M, Caraffa A, Liti A. In vivo anterior cruciate ligament strain behaviour duing a rapid deceleration movement: case report. Knee Surg Sports Traumatol Arthrosc 2003; 11(5):307-11.

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CHAPTER V

CLINICAL RESULTS

G. CERULLI[1,2,3], A. CARAFFA[4], A. AMANTI[3] and M. TEI[3]

Nicola's Foundation Onlus, Arezzo;[1]Let People Move Research Institute, Perugia-Arezzo; [2]International Orthopedics and Traumatology Institute, Arezzo; [3]Residency Program in Orthopedics and Traumatology, University of Perugia, Perugia; [4]Residency Program in Physical Medicine and Rehabilitation, University of Perugia, Perugia; Italy

We consecutively evaluated 622 patents that underwent ACL reconstruction with the original "All-Inside" technique using only one triplicated or quadruplicated gracilis or semitendinosus tendon. After the clinical tests, we performed the functional biomechanical evaluation including arthrometry, stabilometry, isokinetic and gait analysis; in order to examine joint stability, postural control and finally to evaluate the recovery of strength in the flexor and extensor muscles of the knee and the recovery of the normal gait pattern. The clinical and functional biomechanical outcome shows that satisfactory results were achieved in more than 96% of the cases. The kinematics of the knee muscle strength was restored, compared to preoperative values. Finally this has a positive effect on the recovery of the sports activities as well as gait pattern.

MATERIALS AND METHODS

Between March 2000 and March 2005 we performed more than 1500 ACL reconstructions. Surgery was performed under local or general anesthesia, with the tourniquet at the base of the thigh. We used the arthroscope at 30°-4 mm through the anteromedial and the antero-lateral portals. Joint distension was obtained by gravity with physiological solution.

After an initial arthroscopic evaluation we harvest the gracilis or semitendinosus and then we prepare small (3-4 mm) out-in tibial and femoral tunnels, then we measure the length of the tunnels, the intra-articular distance between the two holes and the external cortex-skin distance. The final harvesting of the tendon is based on the measurements and the tendon is triplicated or quadruplicated.

We performed the two half-tunnels, in an out-in direction using a special manual drilling device. This allowed us to enlarge the half-tunnel (2-3 cm) from 3 mm to 9 mm depending on the type of graft that we intended to use. We introduced the graft from the anteromedial portal, fixing it with special interference screws. Finally the graft was evaluated during flexion and complete extension, and with the palpation hook.

We consecutively evaluated 622 patients that underwent ACL reconstruction with the original "All-Inside" technique using only one tendon gracilis or semitendinosus, triplicated or quadruplicated. The patients were 395 male and 227 female of an average age of 23 years and 8 months (min 17, max 43). The follow-up was 7 years.

For the clinical evaluation we used the IKDC knee form. After the clinical tests, we performed functional biomechanical tests including arthrometry, stabilometry, isokinetic and gait analysis to evaluate joint stability, postural control and the recovery of the knee's flexor and extensor muscle strength as well as the recovery of the normal gait pattern.

These evaluations were performed in Perugia at the Let People Move Biomechanical Laboratory.

Arthrometric evaluation was performed to analyze the stability of the knee joint compared to the healthy contralateral side. The test was performed by the same operator using the KT-1000 taking into consideration the difference side to side, to the Maximum Manual. Each

Key words: ACL, ACL reconstruction, "All-Inside" technique, semitendinosus tendon, gracilis tendon, knee kinematics

Mailing address:
Prof. G. Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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test was repeated 3 times, then the average of 3 tests was taken. For the purpose of evaluation 3 groups based on the differential values were established: group 1, differences less than or equal to 2mm (excellent result), 2nd group differences of more than 2 mm and less than or equal to 4mm (good result), 3rd group differences greater than 4mm (failure).

The stabilometric examination was performed with Bertec force platforms to measure the ability to control the position. The patient using one foot with the knee flexed to 30° tries to maintain balance for 10 seconds. Using a computerized data acquisition system, graphical (ellipses) and numerical representations of the sway area are obtained. Larger the area of the ellipse, less is the ability to control the position and hence the final outcome is worse. The comparison is between the operated side and the healthy one. The isokinetic evaluation to measure the strength of the flexor and extensor muscles was performed with the Kin Com isokinetic machine. It ran the test on the two sides in concentric and eccentric at 90°/sec and 180°/sec with an excursion of the knee joint between 10° and 90°. The values of the peak force of the knee flexors and extensors muscles on the operated side were compared with each other and the ratio was expressed as a percentage. The data of the operated side were compared with those of the contralateral healthy joint and even then expressed as a percentage. The gait analysis was performed using a system consisting of synchronized force plates, a 3D motion analysis system and a 16 channel surface electromyography system. The force plates measured the ground reaction forces, the 3D Simi Motion analysis system performed the kinematic analysis of the lower limbs with measurements of the average velocity of the gait, the joint range of motion and angular velocity and the surface electromyography measured the electrical activity of the muscles. The values of the operated side were compared with those of the contralateral healthy one.

RESULTS

On the basis of individual needs and expectations, 96% of the treated patients said that they were generally satisfied with the outcome of the surgery.

The IKDC form scores recorded an average of 84.3, moreover the knee was considered normal or nearly normal in 94% of cases.

The KT 1000 arthrometric evaluation showed differences in anterior tibial displacement values at the Maximum Manual, side to side, less than 2mm in 91% of the cases (excellent result), between 2mm and 4mm in 6% of cases (good result) and in only 3% of the cases, differences of more than 4mm (failure).

The stabilometric evaluation showed that the average values of the ellipse was in the operated side, 250.00 mm^2, with non-significant differences compared with the contralateral healthy joint (260.00 mm^2).

The Kin Com isokinetic evaluation measured on the strength peak of the flexor and extensors in concentric at 90°/sec and 180°/sec, as well as in eccentric at 90°/sec showed a less than 10% difference in the two sides therefore within the limits of physiological values. The eccentric evaluation at 180°/sec showed a 14% decrease in the strength of the quadriceps on the operated side compared to the contralateral healthy one.

The gait analysis showed a normal gait pattern compared with the preoperative values.

DISCUSSION

The original “All-Inside” technique was designed to respect anatomy as much as possible and be as less invasive as possible (using only the semitendinosus or gracilis tendon). During the past years the use of the hamstrings as a graft in ACL reconstruction has become the main choice of many surgeons (1-2).

The hamstring graft offers many advantages compared to others and in particular to the patellar tendon, which until a few years ago was considered the gold standard (3-4). The hamstring tendon grafts provide security from the point of view of the resistance and load at failure resistance (5). The biggest advantage compared to the patellar tendon is that it preserves the extensor mechanism minimizing post-operative complications such as, fracture of the patella, patellar tendon injuries, patellar-femoral pain, tendonitis, muscle weakness and flexion contracture (6). However, the use of the tendons of the hamstrings has limitations, mainly related to the harvest of both the semitendinosus and gracilis tendons, with repercussions on knee function and stability (7-8).

Numerous studies have demonstrated the protective role of the hamstring on the reconstructed ACL (9). Our previous *in vivo* study analyzed the tension forces of the ACL using a strain-gauge (DVRT) and motion analysis measurements, associated with the evaluation of the kinetic reaction


Fig. 1. and 2. *X-Ray of one of the first patients treated in 2001 with the "All-Inside" technique for ACL reconstruction.*

ground forces and superficial EMG of the muscle. These results show, that there is a contraction peak of the hamstring just before the peak ground reaction. This suggests that the hamstring anticipate impact with the ground and hence they have a protective role on the ACL or ACL graft. This study shows that the use of both hamstring tendons in ACL reconstruction is not a good solution. Moreover we should preserve, if possible, one of the tendons: This is an important factor in ACL reconstruction as was demonstrated by biomechanical studies of ACL reconstruction in cadavers using either the semitendinosus or gracilis tendon. This procedure is comparable in terms of biomechanical reconstruction with both grafts quadruplicated (10).

The original "All-Inside" technique of reconstruction using the hamstring tendon is reliable and easily reproducible. It offers significant advantages such as adjusting the length of the tunnel to the graft thus reducing bone loss; using a single tripled or quadrupled hamstring (semitendinosus or gracilis) tendon; drilling manually the half-tunnel which may improve the integration of graft at bone in turn reducing the necrosis caused by standard techniques with motorized drills (11).

The clinical and functional biomechanical outcome shows that satisfactory results were achieved in over 96% of the cases. The kinematics of the knee muscle strength was restored compared to preoperative values. Finally this had a positive effect on the return to sports activities as well as gait pattern.

REFERENCES

1. Dandy DJ. Historical overview of operations for anterior cruciate ligament rupture. Knee Surg Sports Traumatol Arthrosc 1996; 3:256–61.
2. McDaniel WJ Jr, Dameron TB Jr. Untreated ruptures of the anterior cruciate ligament: a follow-up study. J Bone Joint Surg Am 1980; 62:696-705.
3. Arnold JA, Coker TP, Heaton LM, Park JP, Harris WD. Natural history of anterior cruciate tears. Am J

Sports Med 1979; 7:305-13.

4. Arnold JA, Coker TP, Heaton LM, Park JP, Harris WD. Natural history of anterior cruciate tears. Am J Sports Med 1979; 7:305-13.
5. Winge S, Dunn P, Engstrom BK: Equal tension in all four strands of a semitendinosus graft with a low profile tibial fixation device (Cobra LFD). Knee Surg Sports Traumatol Arthrosc 2006; 14:287-90.
6. Aglietti P, Buzzi R, D'Andria S. Patellofemoral problems after intraarticular anterior cruciate ligament reconstruction. Clin Orthop Relat Res 1993; 288:195-203.
7. Goradia V, Rochat M, Grana W. Tendon-to-bone healing of a semitendinosus tendon autograft used for ACL reconstruction in a sheep model. Am J Knee Surg 2000; 13:143-51.
8. Pinczewski L, Clingeleffer A, Otto D. Integration of hamstring tendon graft with bone in reconstruction of the anterior cruciate ligament. Arthroscopy 1997; 13:641-3.
9. Georgoulis AD, Pappa L, Moebius U, Malamou-Mitsi V, Pappa S, Papageorgiou CO, Agnantis NJ, Soucacos PN. The presence of proprioceptive mechanoreceptors in the remnants of the ruptured ACL as a possible source of re-innervation of the ACL autograft. Knee Surg Sports Traumatol Arthrosc 2001; 9:364-8.
10. Zamarra G, Fisher MB, Woo SL-Y: Biomechanical evaluation of using one hamstrings tendon for ACL reconstruction: a human cadaveric study. Knee Surgery, Sport Traumatol Arthosc 2010; 8(1):11-9.
11. Bartlett R, Clatworthy M, Nguyen T. Graft selection in reconstruction of the anterior cruciate ligament. J Bone Joint Surg Br 2001; 83:625-34.

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CHAPTER VI

PROCEEDINGS AROUND THE WORLD

G. CERULLI[1,2,3]

Nicola's Foundation Onlus, Arezzo;[1]Let People Move Research Institute, Perugia-Arezzo; International Orthopedics and Traumatology Institute, Arezzo; Residency Program of Orthopedics and Traumatology, University of Perugia, Perugia, Italy

Since its ideation the "All-Inside" technique has been presented to the scientific community via proceedings and papers. The technique has been described, the results have been discussed, movies and pictures have been shown all over the world in the past 10 years.

This section is a resumé of the proceedings and papers presented by Cerulli et al. about the "All-Inside" technique.

"ACL reconstruction only inside technique" G. Cerulli, A. Caraffa, G. Favilli, P. Antinolfi Proceedings 1st Icelandic Conference on Arthroscopy & Sports Medicine Reykjavik, Iceland, August 16-20, 2001, (Fig 2 of Chapter 1)

"ACL reconstruction with an inside only technique" A. Cerulli, A. Caraffa, C. Senni, P. Antinolfi Proceedings of the 10th Congress European Society of Sports Traumatology, Knee Surgery and Arthroscopy. Rome, Italy, 23-27 April 2002, pag. 232 (Fig. 1)

"All-inside technique for ACL reconstruction" A. Cerulli, A. Caraffa, C. Senni, S. Bruè, P. Antinolfi Procedings of the 3rd International Symposium Medicine and Sport, Opatija, Croatia, September 26-27 2002 (Fig. 2)

"All-inside technique for ACL Reconstruction" A. Cerulli, A. Caraffa, C. Sennì, S. Bruè Proceedings of 6° Corso Internazionale Ortopedia, Biomeccanica, Riabilitazione Sportiva, Assisi, Italy, November 22–24 2002 (Fig. 4 of Chapter 1)

"I.A.B." G. Cerulli, C. Sennì, A. Caraffa, S. Bruè Proceedings of the 6° Corso Internazionale Ortopedia, Biomeccanica, Riabilitazione Sportiva, Assisi, Italy November 22 – 24 2002

"All-Inside technique for ACL reconstruction" G. Cerulli, A. Caraffa, C. Senni, S. Bruè Proceedings of the First Libanese Sports Medicine Congress Beirut, Lebanon, May 29–June 1 2003 (Fig. 3)

"All-Inside technique for ACL reconstruction" G. Cerulli, A. Caraffa, P. Antinolfi, C. Senni, S. Bruè Proceedings of the 6th congress of the European Federation of National Associations of Orthopaedics and Traumatology Helsinki, Finland June 4-10 2003 (Fig. 4)

"All-inside technique for ACL reconstruction: clinical and histological study" G. Cerulli, E. Trinchese, A. Caraffa, H. Alfredson, R. Lorentzon Proceedings of the 29th Annual Meeting of the Japan Knee Society Hiroshima, 12-14 February 2004 (Fig. 5)

"All-inside technique for ACL reconstruction" G. Cerulli, A. Caraffa, S. Bruè Proceedings of the 3° Corso di Artroscopia Bormio, Italy Sep 28. – Oct 2. 2004

"Tecnica All-Inside di ricostruzione del legamento crociato anteriore" G. Cerulli, A. Caraffa, C. Sennì, S. Bruè Chapter G 7, pag 1-4, "Chirurgia artroscopica dell'arto inferiore" Mattioli 1885 Editore, 2005

Mailing address:
Prof. G. Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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"Tecnica All-inside per la ricostruzione del LCA: studio istologico, biomeccanico e clinico" G. Cerulli, A. Caraffa, S. Bruè,F. Vercillo, G. De Trana Proceedings of the 90° Congresso SIOT, pag. 60 Florence, Italy 2005

"All-inside technique for ACL reconstruction: clinical and biomechanical study" G. Cerulli, A. Caraffa Abstracts: American Academy of Orthopaedic Surgeons, Annual Meeting, Chicago Illinois, USA March 2006, (Fig. 6)

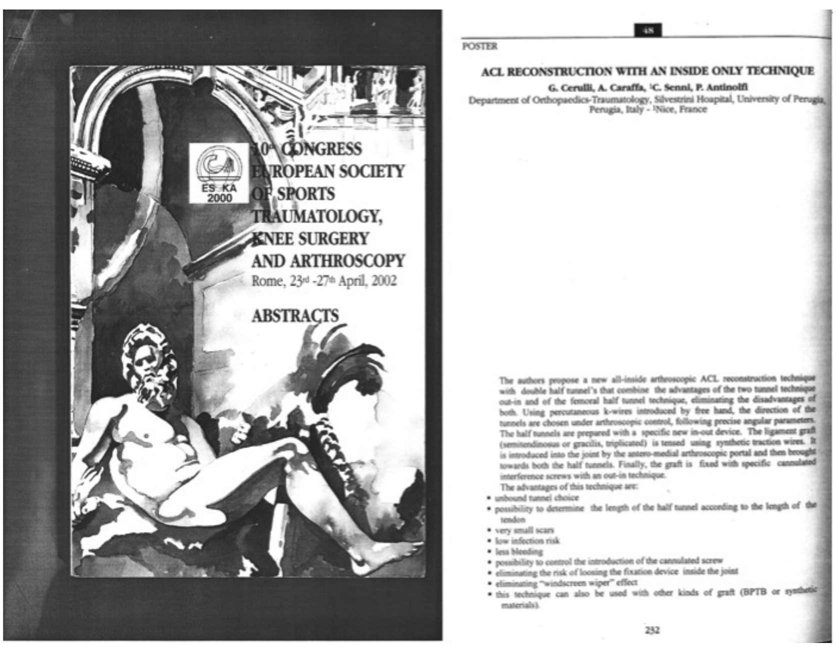
"Mid-term follow-up of ACL reconstruction with All-inside technique" G. Cerulli, A. Caraffa, G. Zamarra, P. Antinolfi, F. Vercillo Abstract:12th ESSKA 2000 Congress. Innsbruck, Austria, May 2006

The "All-Inside Technique" G. Cerulli, A. Caraffa, S. Brué 3rd International Symposium "Sport and Medicine", Book of Abstracts pp. 35-37 Opatija, Croatia, 2007 (Fig. 7)

"ACL reconstruction with the All-Inside technique" G. Cerulli, F. Vercillo, C. Sennì, A. Amanti, P. Antinolfi J Orthopaed Traumatol 2008; 9(1):S87

"Biomechanical evaluation of using one hamstrings tendon for ACL reconstruction: a human cadaveric study" Zamarra G, Fisher MB, Woo SL, Cerulli G. Knee Surg Sports Traumatol Arthrosc. 2010;18(1):11-9.

"ACL reconstruction with "the original all-inside technique" G. Cerulli, G. Zamarra, F. Vercillo, F. Pelosi KSSTA 2011; 19(5): 829-831



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POSTER

ACL RECONSTRUCTION WITH AN INSIDE ONLY TECHNIQUE

G. Cerulli, A. Caraffa, [1]C. Senni, P. Antinolfi

Department of Orthopaedics-Traumatology, Silvestrini Hoapital, University of Perugia, Perugia, Italy - [1]Nice, France

The authors propose a new all-inside arthroscopic ACL reconstruction technique with double half tunnel's that combine the advantages of the two tunnel technique out-in and of the femoral half tunnel technique, eliminating the disadvantages of both. Using percutaneous k-wires introduced by free hand, the direction of the tunnels are chosen under arthroscopic control, following precise angular parameters. The half tunnels are prepared with a specific new in-out device. The ligament graft (semitendinosus or gracilis, triplicated) is tensed using synthetic traction wires. It is introduced into the joint by the antero-medial arthroscopic portal and then brought towards both the half tunnels. Finally, the graft is fixed with specific cannulated interference screws with an out-in technique.

The advantages of this technique are:

- unbound tunnel choice
- possibility to determine the length of the half tunnel according to the length of the tendon
- very small scars
- low infection risk
- less bleeding
- possibility to control the introduction of the cannulated screw
- eliminating the risk of loosing the fixation device inside the joint
- eliminating "windscreen wiper" effect
- this technique can also be used with other kinds of graft (BPTB or synthetic materials).

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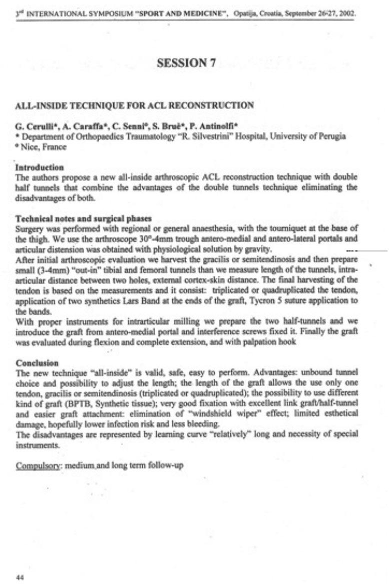
Fig. 1. *Rome 2002.*


3rd INTERNATIONAL SYMPOSIUM "SPORT AND MEDICINE". Opatija, Croatia, September 26-27, 2002.

SESSION 7

ALL-INSIDE TECHNIQUE FOR ACL RECONSTRUCTION

G. Cerulli*, A. Caraffa*, C. Senni°, S. Bruè*, P. Antinolfi*
* Department of Orthopaedics Traumatology "R. Silvestrini" Hospital, University of Perugia
° Nice, France

Introduction
The authors propose a new all-inside arthroscopic ACL reconstruction technique with double half tunnels that combine the advantages of the double tunnels technique eliminating the disadvantages of both.

Technical notes and surgical phases
Surgery was performed with regional or general anaesthesia, with the tourniquet at the base of the thigh. We use the arthroscope 30°-4mm trough antero-medial and antero-lateral portals and articular distension was obtained with physiological solution by gravity.
After initial arthroscopic evaluation we harvest the gracilis or semitendinosis and then prepare small (3-4mm) "out-in" tibial and femoral tunnels than we measure length of the tunnels, intra-articular distance between two holes, external cortex-skin distance. The final harvesting of the tendon is based on the measurements and it consist: triplicated or quadruplicated the tendon, application of two synthetics Lars Band at the ends of the graft, Tycron 5 suture application to the bands.
With proper instruments for intrarticular milling we prepare the two half-tunnels and we introduce the graft from antero-medial portal and interference screws fixed it. Finally the graft was evaluated during flexion and complete extension, and with palpation hook

Conclusion
The new technique "all-inside" is valid, safe, easy to perform. Advantages: unbound tunnel choice and possibility to adjust the length; the length of the graft allows the use only one tendon, gracilis or semitendinosis (triplicated or quadruplicated); the possibility to use different kind of graft (BPTB, Synthetic tissue); very good fixation with excellent link graft/half-tunnel and easier graft attachment: elimination of "windshield wiper" effect; limited esthetical damage, hopefully lower infection risk and less bleeding.
The disadvantages are represented by learning curve "relatively" long and necessity of special instruments.

Compulsory: medium and long term follow-up

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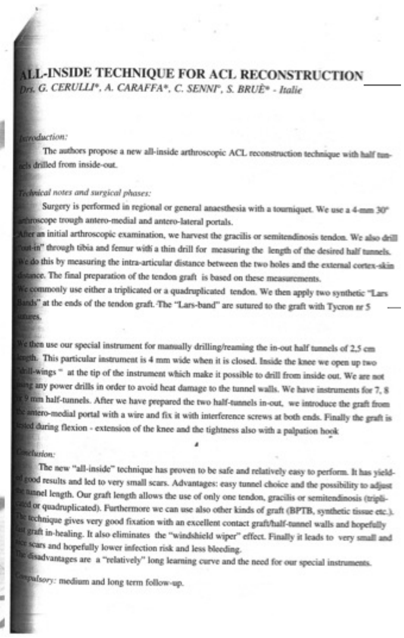
Fig. 2. *Opatija 2002.*


ALL-INSIDE TECHNIQUE FOR ACL RECONSTRUCTION
Drs. G. CERULLI, A. CARAFFA*, C. SENNI°, S. BRUÈ* - Italie*

Introduction:
The authors propose a new all-inside arthroscopic ACL reconstruction technique with half tunnels drilled from inside-out.

Technical notes and surgical phases:
Surgery is performed in regional or general anaesthesia with a tourniquet. We use a 4-mm 30° arthroscope trough antero-medial and antero-lateral portals.
After an initial arthroscopic examination, we harvest the gracilis or semitendinosis tendon. We also drill "out-in" through tibia and femur with a thin drill for measuring the length of the desired half tunnels. We do this by measuring the intra-articular distance between the two holes and the external cortex-skin distance. The final preparation of the tendon graft is based on these measurements.
We commonly use either a triplicated or a quadruplicated tendon. We then apply two synthetic "Lars Bands" at the ends of the tendon graft. The "Lars-band" are sutured to the graft with Tycron nr 5 sutures.

We then use our special instrument for manually drilling/reaming the in-out half tunnels of 2,5 cm length. This particular instrument is 4 mm wide when it is closed. Inside the knee we open up two "drill-wings" at the tip of the instrument which make it possible to drill from inside out. We are not using any power drills in order to avoid heat damage to the tunnel walls. We have instruments for 7, 8 or 9 mm half-tunnels. After we have prepared the two half-tunnels in-out, we introduce the graft from the antero-medial portal with a wire and fix it with interference screws at both ends. Finally the graft is tested during flexion - extension of the knee and the tightness also with a palpation hook

Conclusion:
The new "all-inside" technique has proven to be safe and relatively easy to perform. It has yielded good results and led to very small scars. Advantages: easy tunnel choice and the possibility to adjust the tunnel length. Our graft length allows the use of only one tendon, gracilis or semitendinosis (triplicated or quadruplicated). Furthermore we can use also other kinds of graft (BPTB, synthetic tissue etc.). The technique gives very good fixation with an excellent contact graft/half-tunnel walls and hopefully fast graft in-healing. It also eliminates the "windshield wiper" effect. Finally it leads to very small and nice scars and hopefully lower infection risk and less bleeding.
The disadvantages are a "relatively" long learning curve and the need for our special instruments.

Compulsory: medium and long term follow-up.

Fig. 3. *Beirut 2003.*

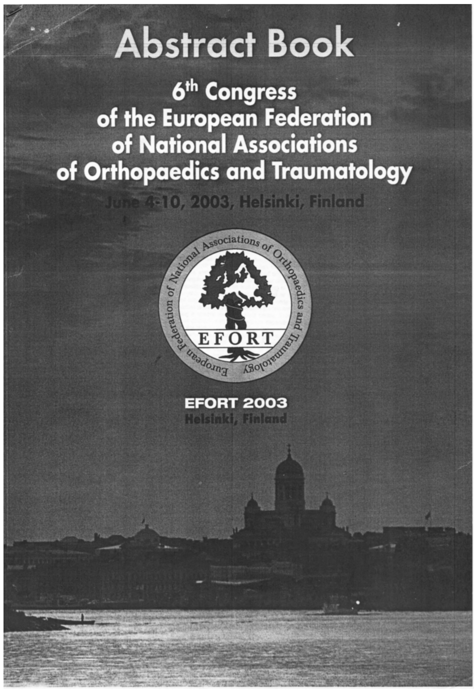
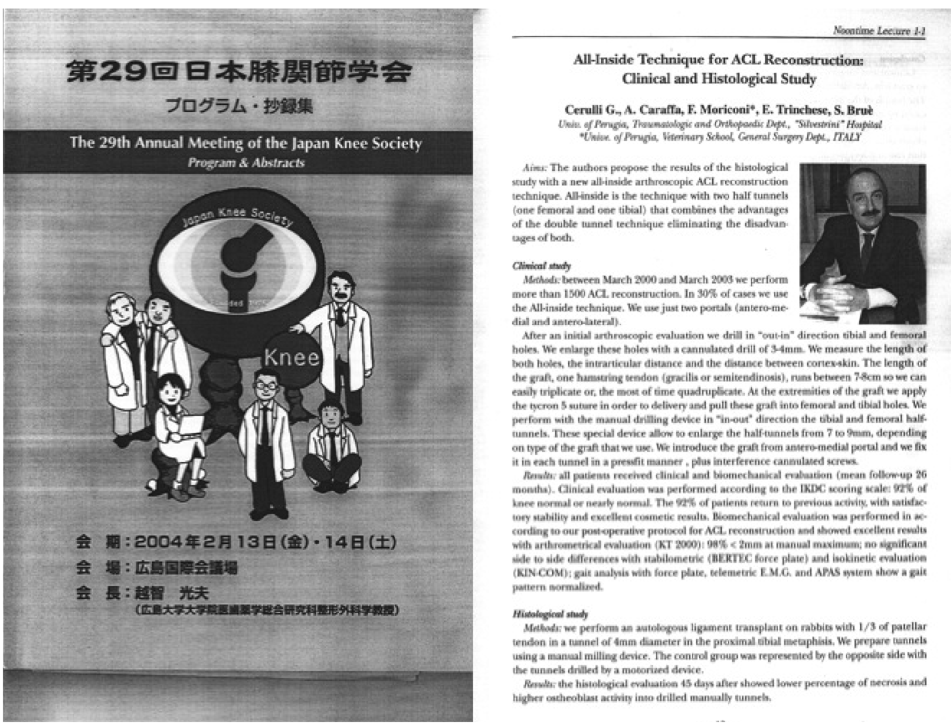


Fig. 4. *Helsinki 2003.*



Noontime Lecture 1-1

All-Inside Technique for ACL Reconstruction: Clinical and Histological Study

Cerulli G., A. Caraffa, F. Moriconi*, E. Trinchese, S. Bruè
Univ. of Perugia, Traumatologic and Orthopaedic Dept., "Silvestrini" Hospital
**Univ. of Perugia, Veterinary School, General Surgery Dept., ITALY*

Aims: The authors propose the results of the histological study with a new all-inside arthroscopic ACL reconstruction technique. All-inside is the technique with two half tunnels (one femoral and one tibial) that combines the advantages of the double tunnel technique eliminating the disadvantages of both.

Clinical study

Methods: between March 2000 and March 2003 we perform more than 1500 ACL reconstruction. In 30% of cases we use the All-inside technique. We use just two portals (antero-medial and antero-lateral).

After an initial arthroscopic evaluation we drill in "out-in" direction tibial and femoral holes. We enlarge these holes with a cannulated drill of 3-4mm. We measure the length of both holes, the intrarticular distance and the distance between cortex-skin. The length of the graft, one hamstring tendon (gracilis or semitendinosis), runs between 7-8cm so we can easily triplicate or, the most of time quadruplicate. At the extremities of the graft we apply the tycron 5 suture in order to delivery and pull these graft into femoral and tibial holes. We perform with the manual drilling device in "in-out" direction the tibial and femoral half-tunnels. These special device allow to enlarge the half-tunnels from 7 to 9mm, depending on type of the graft that we use. We introduce the graft from antero-medial portal and we fix it in each tunnel in a pressfit manner , plus interference cannulated screws.

Results: all patients received clinical and biomechanical evaluation (mean follow-up 26 months). Clinical evaluation was performed according to the IKDC scoring scale: 92% of knee normal or nearly normal. The 92% of patients return to previous activity, with satisfactory stability and excellent cosmetic results. Biomechanical evaluation was performed in according to our post-operative protocol for ACL reconstruction and showed excellent results with arthrometrical evaluation (KT 2000): 98% < 2mm at manual maximum; no significant side to side differences with stabilometric (BERTEC force plate) and isokinetic evaluation (KIN-COM); gait analysis with force plate, telemetric E.M.G. and APAS system show a gait pattern normalized.

Histological study

Methods: we perform an autologous ligament transplant on rabbits with 1/3 of patellar tendon in a tunnel of 4mm diameter in the proximal tibial metaphisis. We prepare tunnels using a manual milling device. The control group was represented by the opposite side with the tunnels drilled by a motorized device.

Results: the histological evaluation 45 days after showed lower percentage of necrosis and higher ostheoblast activity into drilled manually tunnels.

Fig. 5. *Hiroshima 2004.*

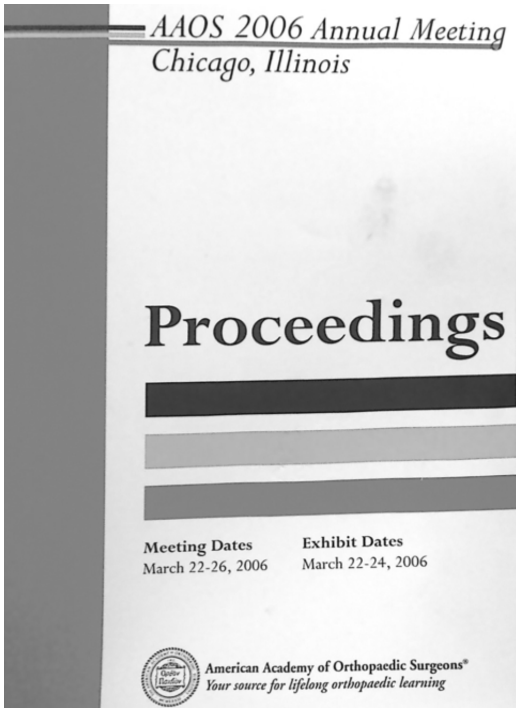
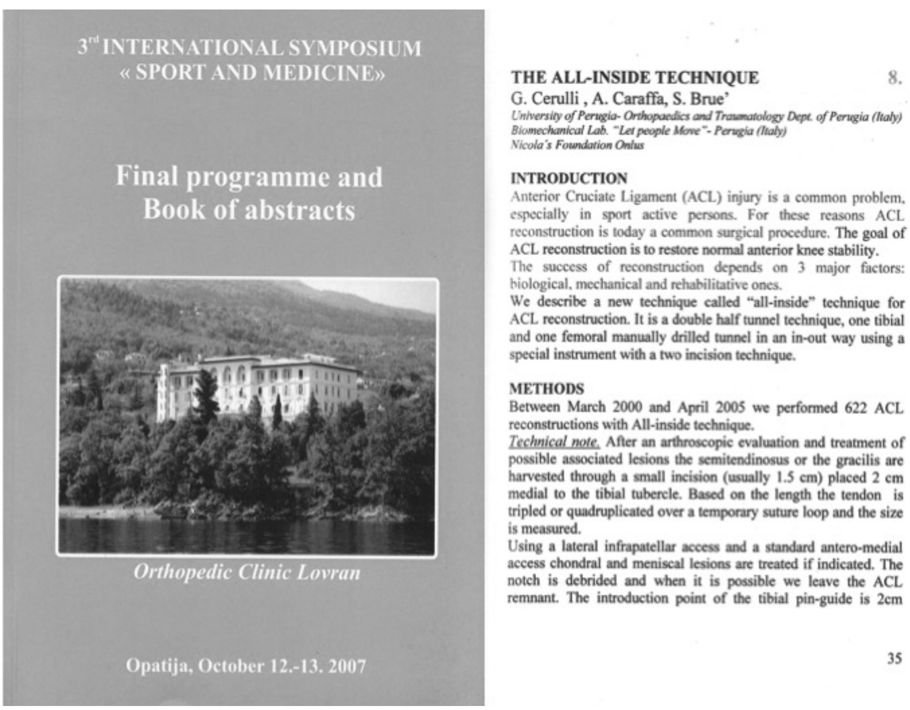


Fig. 6. *Chicago 2006.*



THE ALL-INSIDE TECHNIQUE 8.

G. Cerulli , A. Caraffa, S. Brue'

University of Perugia- Orthopaedics and Traumatology Dept. of Perugia (Italy)
Biomechanical Lab. "Let people Move"- Perugia (Italy)
Nicola's Foundation Onlus

INTRODUCTION

Anterior Cruciate Ligament (ACL) injury is a common problem, especially in sport active persons. For these reasons ACL reconstruction is today a common surgical procedure. The goal of ACL reconstruction is to restore normal anterior knee stability.

The success of reconstruction depends on 3 major factors: biological, mechanical and rehabilitative ones.

We describe a new technique called "all-inside" technique for ACL reconstruction. It is a double half tunnel technique, one tibial and one femoral manually drilled tunnel in an in-out way using a special instrument with a two incision technique.

METHODS

Between March 2000 and April 2005 we performed 622 ACL reconstructions with All-inside technique.

Technical note. After an arthroscopic evaluation and treatment of possible associated lesions the semitendinosus or the gracilis are harvested through a small incision (usually 1.5 cm) placed 2 cm medial to the tibial tubercle. Based on the length the tendon is tripled or quadruplicated over a temporary suture loop and the size is measured.

Using a lateral infrapatellar access and a standard antero-medial access chondral and meniscal lesions are treated if indicated. The notch is debrided and when it is possible we leave the ACL remnant. The introduction point of the tibial pin-guide is 2cm

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Fig. 7. *Opatija 2007.*

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CONCLUSIONS

G. CERULLI[1,2,3] and G. POTALIVO[1]

Nicola's Foundation Onlus, Arezzo; [1]Let People Move Research Institute, Perugia-Arezzo; [2]International Orthopedics and Traumatology Institute, Arezzo; [3]Residency Program of Orthopedics and Traumatology, University of Perugia, Perugia, Italy

After over 10 years of clinical experience and follow-up, biological and biomechanical research we can conclude that the "All-Inside" technique is a reliable, easy to perform and reproducible surgery procedure. To date reconstructing and restoring an injured ACL is still a challenge due to the important role it plays in knee biomechanics, its complex anatomy and biological behavior. For these reasons our original "All-Inside" technique has been developed based on biological and biomechanical rationale that must not be ignored if our aim is to obtain a biomechanically stable and well integrated to bone surface neo-ACL.

In our opinion respecting the anatomy and the biomechanics of the ACL, made possible with this technique first developed by us, enables a reduction in the time required for ligamentization; in the damage from the incision and a better functional outcome. Manual drilling represents a fundamental concept for graft integration, it is the practical application of biological concepts to mechanics. Furthermore, the out-in technique plus drilling femoral and tibial tunnels without constraints, allows the surgeon to identify the ACL's isometric points and reduce complications in eventual revision surgery.

The results achieved by applying biological and biomechanical concepts, our documented experience, ongoing research and the careful analysis of the variables that influence outcome; all suggest the right way the technique should evolve to obtain a neo-ACL as close as possible to the native ACL.

Mailing address:
Prof. G. Cerulli
Via Giovan Battista Pontani, 9
06128 Perugia, Italy
Tel: ++39 075 5003956
Fax: ++39 075 5010921
e-mail: g_cerulli@tin.it

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