DOUBLE BUNDLE ACL RECONSTRUCTION:
TRANSTIBIAL TECHNIQUE

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DOUBLE BUNDLE ACL RECONSTRUCTION: TRANSTIBIAL TECHNIQUE

I have no financial relationships to disclose

Piero Volpi, MD
ACL RECONSTRUCTION

SURGICAL EXPERIENCE (PV, MD)

- 25 years ACL reconstructions
  (20 years of arthroscopy)
- 200 primary ACL reconstructions
- Arthroscopic technique
- Graft selection
  BPTB 20% - Hamstring 80%
- Patient Population
  Sex  male 70%  female 30%
  Age  < 16 years 10%
        17-40 years 70%
        > 40 years 20%
- Sport competitive 40%
  (professional - amateur)
  Recreational 55%
  Non sport 5%
SPORT MEDICAL PROFILE (PV, MD)

- Professional football player 1972-1985
  (450 officials games)
- Teacher in Coverciano FIGC School
  1988-1994
- Physician Women Italian Team final European Cup, Germany 2001
- Consultant Physician of Italian Footballer’s Association (AIC)
- Member Antidoping Committee FIGC (Federation of Italian Football)
ACL RECONSTRUCTION

Tibial Fixation in Anterior Cruciate Ligament Reconstruction With Bone–Patellar Tendon–Bone and Semitendinosus-Gracilis Autografts

A Comparison Between Bioabsorbable Screws and Bioabsorbable Cross-Pin Fixation

Piero Volpi,* MD, Luca Marinoni, MD, Corrado Bait, MD, Marco Galli, MD, and Laura de Girolamo, PhD
From the Sports Traumatology and Arthroscopic Unit, IRCCS Galeazzi Orthopaedic Institute, Milan, Italy

Volpi P. et al., 2009
ACL RECONSTRUCTION

Materials - Fixation

Bioscrew - Biopins
PLLA - Composite
Technical Note

Surgical Treatment of Anterior Cruciate Ligament Injuries in Adolescents Using Double-Looped Semitendinosus and Gracilis Tendons: Supraepiphysary Femoral and Tibial Fixation

Piero Volpi, M.D., Marco Galli, M.D., Corrado Bait, M.D., and Roberto Pozzoni, M.D.

Abstract: Surgical treatment of anterior cruciate ligament injuries in adolescents continues to be controversial even though the advocates of surgical treatment are growing relative to those who prefer conservative treatment. Those using surgical techniques must respect the epiphyseal cartilages and try to reproduce the same results that are achieved in adults. We report on a technique analogous to that applied to adults, using doubled hamstring tendons that are fixed with 2 transverse femoral and tibial bioabsorbable cross pins without interfering with the growth cartilage. Key Words: Adolescent ACL injuries—ACL reconstruction—Hamstring tendons.
ACL RECONSTRUCTION

SURGICAL TECHNIQUE
HAMSTRING - DSTG

ADOLESCENTS (<16 y.)

• Drilling 7 mm
• Transversal fixation
  (respecting the femoral and tibial epiphysary cartilage)
ACL RECONSTRUCTION
ALL IN SIDE TECHNIQUE
International Forum
Update on Double Bundle ACL Reconstruction
Milano 29/30 maggio 2009
Technical Note

Double-Bundle Reconstruction of the Anterior Cruciate Ligament Using the Transtibial Technique

Piero Volpi, M.D., and Matteo Denti, M.D.

Abstract: We present an arthroscopic surgical procedure for double-bundle transtibial anterior cruciate ligament reconstruction with 2 tibial and femoral tunnels using autologous semitendinosus and gracilis tendons. The first aim is to attempt to create the femoral tunnels correctly through the tibial tunnels. To achieve this, a new tibial guide was used that permitted the simultaneous preparation of the anteromedial and posterolateral tibial tunnels. The intra-articular landmark is the tibial spine region, whereas the extra-articular landmarks are the anterior profile of the medial collateral ligament and the anterior tibial apophysis. We also describe transverse femoral fixation with biopsins (1 for each femoral tunnel) after the preparation of the 2 tibial and femoral tunnels. Key Words: Anterior cruciate ligament reconstruction—Double bundle—Transtibial—Transverse femoral fixation—Technique—Knee.
DB ACL RECONSTRUCTION

BACKGROUND

1. Single bundle ACL reconstruction represents a standardized arthroscopic treatment that is reproducible and reliable over time.
2. But long-term studies demonstrate that instability persists in the 10-30% of patients.

AM and PL bundle have different length and diameter

courtesy F. Fu
BIOMECHANICS

1. The single bundle does not seem to restore normal knee rotational control.
   Woo, 2002 - Gergoulis, 2003 - Ristanis, 2006

2. Other biomechanical studies demonstrate that double bundle improves the anterior tibial translation and the rotation.
Tibial rotation is not restored after single bundle acl reconstruction

- Ristanis S. et al. Arthroscopy, 2005
DB ACL RECONSTRUCTION

DB ACL reconstruction more closely restores the normal tibiofemoral contact area and pressure than SB techniques.

DB ACL reconstruction may reduce the incidence of osteoarthritis by closely restoring tibiofemoral contact area and pressure.

Tibiofemoral Joint Contact Area and Pressure After Single- and Double-Bundle Anterior Cruciate Ligament Reconstruction
Yusuke Morimoto, M.D., Mario Ferretti, M.D., Max Ekdahl, M.D., Patrick Smolinski, Ph.D., and Freddie H. Fu, M.D.
Arthroscopy, 2009
BIOMECHANICS

• PL bundle plays a significant role in the stabilization of the knee against a combined rotator load (Robotic)
  Gabriel MT et al., 2004 (J. Orthop Res)

• PL bundle is more of a restraint to tibial rotation than the AM bundle (In vivo - RSA - tantalium markers)
  Tashman S, 2004 (AJSM)
DB ACL RECONSTRUCTION

BIOMECHANICS
The results of this study suggest that increased posterior tibial slope appears to contribute to non-contact ACL injuries in females, but not in males.

An increased posterior tibial slope may be one of the reasons why female athletes exhibit the recognized higher incidence of non-contact ACL injuries compared with male athletes.

ACL RISK FACTORS

ANATOMICAL ACL

Tibial slope

• angle between the medial tibial plateau and the tibial shaft
Domzalski et al. found that notch width is a risk factor for ACL injury.

Domzalski M et al. (2010); Int Orthop 34:703–707

Vrooijink et al. found notch width is only a risk factor in the male population.

Their study also found condyle size to be a risk factor for ACL injury: condyle size, and M:L ratio may influence the knee kinematics. One possible explanation for this is that if the difference of the medial to lateral condyle width is bigger, this influences the amount of rotation in the knee joint, which could lead to more rotation and therefore a greater risk of ACL tear (Fig. 1).

ACL RISK FACTORS

ANATOMICAL ACL

Narrow notch
INJURY MECHANISMS

The injury mechanism of the ACL is complex: rotation - flexion - hyperextension - varus - valgus and is reflected by the different rupture patterns of the AM and the PL bundle.
INJURY MECHANISMS

INTRODUCTION. A rupture of the fibres of the ACL leads to an increased anterior tibial translation as well as to an increased mobility of the lateral tibial plateau leading to an increased coupled internal tibial rotation (anterolateral rotatory instability [ALRI], Hughston, et al. 1976). Anterolateral rotatory instability may be further increased by associated injuries to peripheral structures such as the lateral collateral ligament, the iliotibial tract, and the postero-lateral capsule that act as primary restraints to tibial rotation laxity (Markolf, et al. 1976). Due to the mechanism of injury, these structures can easily be injured during rupture of the ACL (Amis, et al. 2005).

The path of passive flexion-extension of the intact knee joint was determined by the robotic/UPS testing system by maintaining a target force and moment of zero in all remaining degrees of freedom. The system found the positions of the knee that minimized all external forces and moments applied to the joint throughout the range of flexion from 0° to 90° in increments of 1°. The positions determined through this procedure served as the starting point for application of external loads.

A 134-N anterior tibial load at full extension, 30°, 60°, and 90° of knee flexion and a valgus torque of 10 Nm combined with an internal rotation of 4 Nm was then applied to the tibia. The external loading conditions

SB or DB ACL reconstruction may fail if the LCL is injured
Double bundle or single bundle plus extraarticular tenodesis in ACL reconstruction?

A CAOS study

E. Monaco · L. Labianca · F. Conteddua · A. De Carli · A. Ferretti

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Abstract Anatomic reconstructions of anterior cruciate ligament (ACL) with double bundle gracilis and semitendinosus tendons graft, reproducing AM and PL bundles, have been introduced to offer a better biomechanical outcome, especially during rotatory loads. On the other hand, many methods of tenodesing the lateral aspect of the tibia to the femur to reduce internal rotation (IR) of the tibia and minimize anterior translation of the tibia relative to the femur as a backup for intra-articular reconstruction, have been also suggested. The goal of this study is to evaluate the effect, on the IR of the tibia, of a lateral reconstruction in addition to a standard single bundle ACL reconstruction as compared with an anatomic double bundle ACL reconstruction. Computer assisted ACL reconstruction has been used because it could be very effective in evaluating the global kinematic performance of the reconstructed knee. We selected 20 consecutive ACL reconstruction procedures to be performed in males in our hospital. Patients were alternately assigned to one of the two groups—group A: standard single bundle ACL reconstruction with doubled gracilis and semitendinosus tendons graft with an arthroscopically assisted two incisions technique and a lateral extraarticular reconstruction; group B: double bundle ACL reconstruction with doubled gracilis and semitendinosus tendons graft with an arthroscopically assisted two incisions technique. In all ACL reconstruction procedures navigation process was performed. Both surgical techniques reduced significantly AP displacement, IR and external rotation (ER) of the tibia respect to pre-operative
DB ACL RECONSTRUCTION

CASE 1  S. E. - 36 a.
Ski - antero-medial lesion
DB ACL RECONSTRUCTION

CASE 2  S. G. - 20 a.
Volley - antero-medial lesion
DB ACL RECONSTRUCTION

PATIENT SELECTION

- Injury
- Male/female
- Adolescent/old
- Sport (type and level)

All patients require DB ACL reconstruction?
ACL RECONSTRUCTION

SB BPTB
• Pro athletes (sport related - male)

SB Hamstrings (STGD- STD/T)
• No pro athletes (sport related)
• “Over 35/40”
• Patellar problems
• Adolescents (All in side)

DB Hamstrings
• Pro athletes (sport related - female)
• Rotational problems
ACL RECONSTRUCTION

HAMSTRINGS STRATEGY

1. SB STGD

2. SB STD/T
   (Save the gracilis)

3. SB STD
   (augmentation - partial lesion - AM / PL)

4. DB STG
DB ACL RECONSTRUCTION

GRAFT CHOICE

The hamstrings seem to be universally accepted

BPTB

HAMSTRINGS

QUADRICEPS

ALLOGRAFT
Technical Note

Double-Bundle Reconstruction of the Anterior Cruciate Ligament Using the Transtibial Technique

Piero Volpi, M.D., and Matteo Denti, M.D.

Abstract: We present an arthroscopic surgical procedure for double-bundle transtibial anterior cruciate ligament reconstruction with 2 tibial and femoral tunnels using autologous semitendinosus and gracilis tendons. The first aim is to attempt to create the femoral tunnels correctly through the tibial tunnels. To achieve this, a new tibial guide was used that permitted the simultaneous preparation of the anteromedial and posterolateral tibial tunnels. The intra-articular landmark is the tibial spine region, whereas the extra-articular landmarks are the anterior profile of the medial collateral ligament and the anterior tibial apophysis. We also describe transverse femoral fixation with biopins (1 for each femoral tunnel) after the preparation of the 2 tibial and femoral tunnels. Key Words: Anterior cruciate ligament reconstruction—Double bundle—Transtibial—Transverse femoral fixation—Technique—Knee.
Anatomic Reconstruction of the Anteromedial and Posterolateral Bundles of the Anterior Cruciate Ligament Using Hamstring Tendon Grafts

Yasuda et al. Arthroscopy 2004

Combined anatomic and clinical study including 57 consecutive patients, 24 months follow-up
TECHNICAL ASPECTS

- Two independent tibial tunnels
- Two independent femoral tunnels
- Four anatomical attachments (AM-PL)

Yasuda “the greatest criticism to anatomic DB R has been summarized in this question: Are the clinical results of anatomic DB R better than the results of SB R?”
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE (Cadaver Study)

• Tibial guide (for the tibial tunnels construction)
• Transtibial femoral approach
• Femoral fixation (New instrumentation Rigid-Fix)
Calibrated tibial guide with vertical swing arm and first bullet for the PL (Postero-lateral) tunnel.

The Second Bullet is positioned on the calibrated guide rail for the AM Tunnel.

**EXIT POINT** for the PL tunnel: at the guide tip.

**EXIT POINT** for the AM tunnel: the drill pin has to exit 3 mm inferior to the guide tip side.
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE

Tibial tunnels

Guide

PL more medial
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE

Transtibial femoral approach

K wire handly

Flex 80/90°
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE

Transtibial femoral approach

PL tunnel
DB ACL RECONSTRUCTION

PL tunnel

Transtibial versus anteromedial portal drilling for anterior cruciate ligament reconstruction: a cadaveric study of femoral tunnel length and Obliquity

DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Femoral fixation
(New instrumentation Rigid-Fix)

Rod  5 - 6 mm diam  Spacer  5mm diam
DB ACL RECONSTRUCTION

SURGEON EXPERIENCE

• Knowledge in the field
• CAD LAB/ educational
• > 80 ACL R/year
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Surgical Procedure
1. Arthroscopy evaluation
DB ACL RECONSTRUCTION

Fig. 1

Fig. 2

Wolters F, Fu Freddy H et al

Our experience
There is a significant but low correlation between the notch size and the ACL insertion site size. There are significant differences in notch widths and ACL insertion sites size between men and women and a high variation in insertion site sizes.

Women had a smaller notch and a smaller insertion site than men. This knowledge could influence pre-operative decision-making with regard to graft choice, single or double-bundle surgery, and graft size.

2. Grafts harvest and preparation
DB ACL RECONSTRUCTION

Grafts evaluation
Size (length - diameter)
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Surgical Procedure

3. Tibial Tunnels
   Drilling (According to graft diameters 5/6/7 mm.)
4. Femoral Tunnels
   - PL (half tunnel depth 30 mm.)
   - AM (half tunnel depth 35 mm.)
DB ACL RECONSTRUCTION

Femoral footprint

Heming et al, 2007
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Surgical Procedure

5. Femoral Fixation (Rigid Fix - one pin)
   a. AM Tunnel (35 mm.)
      Usual orientation of the guide.
      Positioning of the cannula in the superior hole of the guide plates
   b. PL Tunnel (30 mm.)
      Usual orientation of the cannula in the superior hole of the guide plates
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Surgical Procedure

5. Femoral Fixation (Rigid Fix - one pin)
   Bone scope
   (Check the positioning of the transversal hole)
DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Surgical Procedure

5. Femoral Fixation (Rigid Fix - one pin)
   Pass the graft
   Press-fit relevance
   Fix the grafts with one pin
Surgical Procedure

5. Femoral Fixation (Rigid Fix - one pin) Biomechanical Test
TRANSTIBIAL TECHNIQUE
Surgical Procedure

6. Tibial Fixation
   (Staples - Bio screw - Tibial Rigid Fix)
   • PL  extension (0-10°)
   • AM  flexion (40-50°)
DB ACL RECONSTRUCTION

Tibial Fixation – Tensioning protocol

(PL 15°/AM 45° - PL e AM 20°)


DB ACL RECONSTRUCTION

TRANSTIBIAL TECHNIQUE
Surgical Procedure

7. Final check
DB ACL RECONSTRUCTION
TRANSTIBIAL TECHNIQUE

Advantages

• Easy and reproducible technique
• 80°/90° of knee flexion during tunnel drilling
• Femoral PL tunnel less horizontal than AM technique
• Easy to put handly K wire on femoral footprint from tibial tunnel

Disadvantages

• Wrong position of tibial tunnel compromises the right execution of the femoral tunnel
• Tendency to have tibial tunnel too posterior and femoral tunnel too vertical
DB ACL RECONSTRUCTION

CONCLUSIONS

TRANSTIBIAL TECHNIQUE

• Tibial articular convergence tunnels and femoral divergence tunnels (the essence)
• Little tunnels (5-6-7 mm) similar native ACL bundle (PL and AM) dimension
• Wider osteointegration area (two tunnels)
• Appropriate tibial tunnels are easy to create femoral tunnels
• Easy and reproducible technique (knee position fix at 80/90 degree of flexion)
DB ACL RECONSTRUCTION

TAKE HOME MESSAGE

• Improve methods for the clinical evaluations (pivot shift and rotational stability)

• There must not be competition between DB “users” but only a common philosophy

• Using DB technique you improve your scientific knowledge and surgical skills also for the SB procedure
DB ACL RECONSTRUCTION

CLINICAL EVALUATION (Studies)

1. The results of several studies suggest that DB ACL reconstruction technique seems to better control a functional pivot shift.

2. 3D motion analysis and computer assisted ACL navigation can be used as evaluation methods.

3. In vivo no clear quantifiable method currently exist to measure the pivot shift and rotational stability has not been critically evaluated.
DB ACL RECONSTRUCTION

CLINICAL STUDIES (Level I or II)

Yasuda et al, 2006 72 Pz Arthroscopy
Aglietti et al, 2007 76 Pz Clin Orthop Relat Res
Muneta et al, 2007 68 Pz Arthroscopy
Yagi et al, 2007 60 Pz Clin Orthop Relat Res
Jarvela et al, 2007 65 Pz Knee Surg Sport Traum Arth
Siebold et al, 2007 70 Pz Arthroscopy

Streich et al, 2008 50 Pz Knee Surg Sport Traum Arth
Tsuda et al, 2008 113 Pz Knee Surg Sport Traum Arth
KT-1000 arthrometer side to side difference was closer to normal in patient treated with double-bundle reconstruction.

Meredick R.B et Al.

The postoperative anterior and rotational stability after the anatomic double-bundle ACL reconstruction was significantly better than that after the single-bundle reconstruction, although there were no significant differences between the 2 procedures concerning the complications and the clinical evaluations.

Kondo et al.  
Double-bundle ACL reconstruction using quadriceps tendon-bone autografts provide less laxity (1.79 mm) than single-bundle ACL reconstruction bone patellar tendon bone autograft (2.64 mm) as measured by the KT-2000 (61 patients).

Kim S.J. Et Al
Arthroscopy 2009 Jan; 25(1):70-7
DB ACL RECONSTRUCTION

Double bundle ST/G ACL reconstruction technique allow to obtain slight better outcomes than the traditional technique with single bundle BPTB

(DB ACL reconstruction showed better results in IKDC evaluation)

ACL reconstruction in sports active people: Transtibial DB technique with ST/G vs. transtibial SB technique with BPTB: Preliminary results

Piero Volpi a,*, Matteo Cervellin a, Matteo Dentì a, Corrado Bait a, Gianluca Melegati b, Alessandro Quaglia a, Laura de Girolamo c

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DB ACL RECONSTRUCTION

CLINICAL EVALUATION POST-OP

SB BPTB  SB Hamstrings  DB Hamstrings
DB ACL RECONSTRUCTION
DYNAMIC FUNCTIONAL EVALUATION
GAIT ANALYSIS ELITE – PILOT STUDY

- Group A: 10 subjs
  Healthy

- Group B: 10 pts
  STG-SB

- Group C: 10 pts
  STG-DB
DB ACL RECONSTRUCTION
DYNAMIC FUNCTIONAL EVALUATION
GAIT ANALYSIS ELITE – PILOT STUDY

KNEE ROTATIONAL STUDY (GAIT ANALYSIS)
ACL RECONSTRUCTION

REHAB ALGORITHM

1° month  recovery of ROM - strength
2° month  proprioception - stationary bike - pool - running activities
3° month  technical skills (sports - specific)
4° month  clinical healing - diversified training
5° month  team training - competition
“The two groups showed a different pattern of functional adaptation to the end of the rehabilitation period after surgery, suggesting that the two different techniques require special attention in drafting the post-surgical rehabilitation programs “

Bisciotti G N et Al. Med Sport 2011;64:185-200
The deficit of muscle strength following the ACL reconstruction are intimately associated with the choice grafts.

It seems that these deficits are NOT resolved within a period of two years after reconstruction.


The influence of graft choice on isokinetic muscle strength 4–24 months after anterior cruciate ligament reconstruction

Sofia A. Xergia · Jodie A. McClelland · Joanna Kvist · Haris S. Vassiliadis · Anastasios D. Georgoulis

RETURN TO SPORT
AFTER ACL RECONSTRUCTION

RECOVERY - SPORT

Clinical healing (medical evaluation)
- Diversified training
  (Athletic - technic - psychologic)
- Team training
  (Tactics - competitive attitude)

≥30 DAYS

Game
- Re-injury prevention
RISK FACTORS

- Previous surgery
  (Associated lesions)
- Sex female < male
- Age > 40/45 years – adolescent
- No pro athletes (amateur)
- Weight
- Allograft
ACL RECONSTRUCTION

How to treat ACL injury in high level athletes

CONCLUSIONS

Graft selection: BPTB - Hamstring
Technique: anatomic SB - DB - All in side
Reduce the donor site morbidity
Different rehab and return to sport
DB ACL RECONSTRUCTION

ARTHROSCOPIC EVALUATION
New injury (football)
10 months after DB ACL reconstruction
Revision with SB BPTB
the technique is important but …
the most thing is the anatomical position of your graft
DB ACL RECONSTRUCTION

A matched pairs comparison of single- versus double-bundle anterior cruciate ligament reconstructions, clinical results and manual laxity testing

R. Siebold · T. P. Branch · H. I. Freedberg · C. A. Jacobs

DB ACL reconstruction appeared to more consistently result in significantly higher subjective outcome scores and manual tests of joint stability than SB ACL reconstruction.

“The image-matching technique is able to quantify dynamic rotational and antero-posterior instabilities with static parameters in ACL-deficient knees.”

“All Inside” ACL RECONSTRUCTION

Uso di fresa ad andamento retrogrado per il posizionamento di trapianto rotuleo libero pro-LCA: note preliminari di tecnica
F. Ghisellini, A Fortina
“All Inside” ACL RECONSTRUCTION

G. Cerulli et al.
Tecnica all inside di ricostruzione del legamento crociato anteriore
Chirurgia artroscopica dell’arto inferiore, Mattioli Ed 2005 vol 2, F16

G. Puddu
Retrodrill system (Arthrex Inc., Naples, USA)

P.A. Smith, J. Lubowitz et al.
No tunnel 2 socket technique: all inside anterior cruciate ligament double bundle reconstruction
Arthroscopy, 2008, 24, 10, 1184-1189
“All Inside” ACL RECONSTRUCTION

Surgical technique
Save the gracilis
“All Inside” ACL DB RECONSTRUCTION