INTERESTING MODIFICATION TO SINGLE BUNDLE ACL RECONSTRUCTION TO ACHIEVE DOUBLE BUNDLE MORPHOLOGY

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Introduction:

Single Bundle ACL (SBACL) reconstruction has given good results but follow up showed some anterior laxity on Lachman test, pivot glide and reduced rotational stability(1)(2)(3). Most of this deficiency is attributed to failure of SBACL to restore the anatomy and biomechanics of native ACL.

Double Bundle ACL (DBACL) reconstruction, other alternative to better restore anatomy remains controversial. High quality, prospective, randomised studies have found from “no difference”(4) to “better anterior and rotational stability”(5) “better ROM & Objective functional scores”(6) to “fewer revisions”(7). The currently practised technique of Double bundle ACL reconstruction was described in 2004 by Yasuda et al(8).

Much of the controversy regarding four tunnel DBACL advisability as routine alternative to the conventional single-bundle ACL reconstruction(9)(10)(11) is on account of: this being a technically challenging procedure, its pitfalls like longer surgery, abundant fixation, tunnel coalescence with greater complication rate and difficult revision. There are concerns that drilling 4 tunnels for double-bundle ACL reconstructions may lead to problems with bone stock and consequent tunnel enlargement(12)(13). Markolf et al(14) demonstrated that a DBACL reconstruction significantly over-constrained the anterior tibial translation from 30° to 90° of flexion compared with the ACL-intact knee.

A modification that reduces number of tunnels to just Solitary Tibial and Solitary Principal Femoral Socket with a narrow 4mm Supplementary femoral tunnel is suggested to obtain double bundle morphology with essentially a technique similar to Single bundle ACL reconstruction

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Review of Literature :

Literature describes reconstruction of Double Bundle Morphology of ACL by number of tunnels varying from two, three and four tunnels. Currently practiced technique, pioneered by Yasuda(9) is a four Tunnel Technique with independent Tunnels in Tibia and Sockets in femur respectively for AM & PL bundles and is named as Anatomic Double bundle reconstruction.

Three tunnel technique for achieving a double bundle morphology was first proposed by Rosengraf(15). These three tunnels can either be two in Femur and one in Tibial or one in femur socket and two in Tibia. Cadaveric studies have been conducted by Petersen et al Mae et al(17), Yagi et al(18). Yagi et al reported that anterior tibial translation was significantly less at full extension and 30° of knee flexion; and under combined rotatory loads of internal tibial torque and valgus torque, the coupled anterior tibial translation was also significantly less at both 15° and 30° of flexion angles.

Two tunnel technique was described by Hemanth et al(19). Two bundle morphology was achieved with solitary tibial and solitary femoral tunnel. Authors demonstrated improved control of knee stability in cadaveric study compared to single tunnel single bundle technique. Authors obtained double bundle morphology by “spreading apart”, two strands of Gracilis+SemiT from remaining two strands of Gracilis+SemiT by a special graft positioning tool and fixed in “spread apart” position by strategically inserting femoral Intrafix® screw between two halves of the graft with diameter of screw determining separation of two bundles.

Surgical technique:

Figure 1A shows the schematic representation of the surgical technique. Steps of Technique are shown in Figure 1B (Graft preparation schematic) & Figure 2 (A to J) and are explained hereinbelow.

1.Graft preparation: 5 Strand graft is prepared with 3 Strands of Semi T and two strands of Gracilis. Gracilis strands are suspended through additional Fibretape loop as shown in Figure1B.
2.Principal femoral socket is created through AM portal using over the top offset zig by Inside-out Technique to diameter of 5 strand graft. Outlines of Footprint are carefully delineated (Figure 2A).
3. 4mm tunnel is drilled using Outside-in technique. Drill bit is left in situ for parking a shuttling thread (Figure 2B).
4.Tibial Tunnel is drilled by standard outside-in technique (Figure 2C).
5.Two shuttling threads are parked. Shuttling thread of 4mm tunnel is carefully manoeuvred in posterior position (Figure 2D). While pulling out two threads through solitary tibial tunnel, care is taken to prevent entanglement
6.The bone bridge between the principal socket and supplementary tunnel is decorticated to a shallow trough (Figure 2E).
7.All strands of graft are seated into principal tunnel using main shuttling thread, taking care to pull in increments while also simultaneously checking free sliding of second shuttling thread. While the graft is being seated in principal tunnel a Fibre tape loop/No button adjustable loop is also incrementally pulled into narrow tunnel but is kept loose (Figure 2F). Button is flipped as routine.

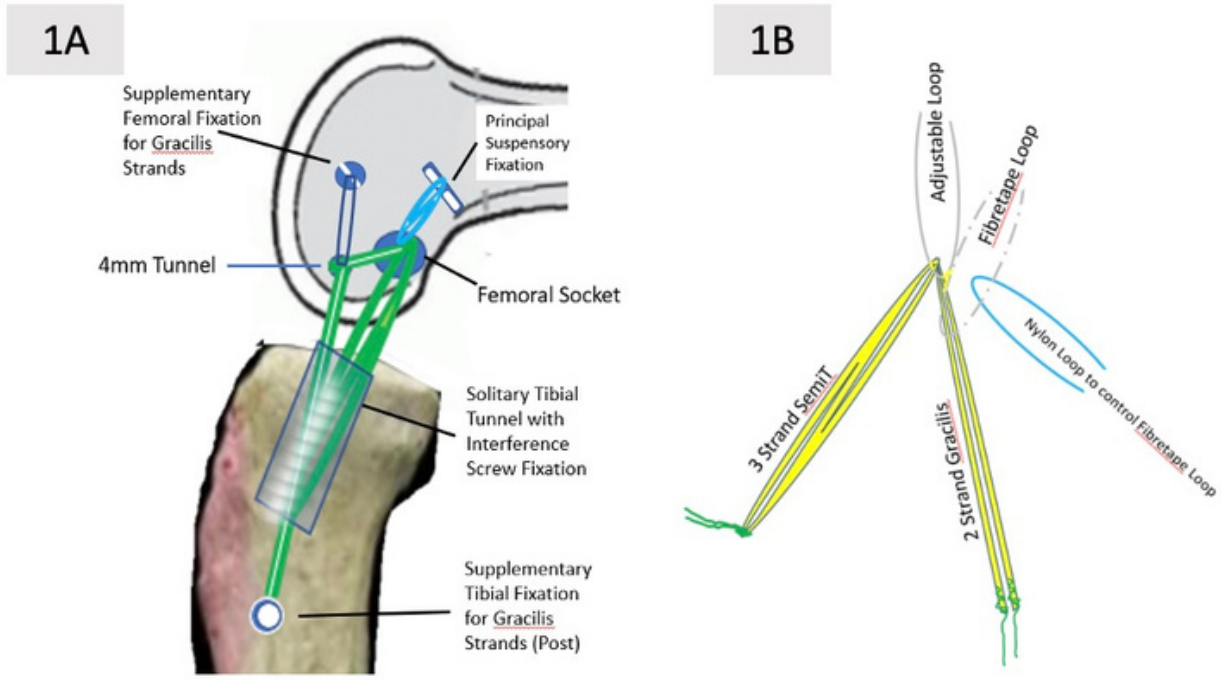

Figure 1: Schematic representation of the surgical technique. A. Schematic Representation of Technique. Note reconstruction of two bundle morphology. B: Graft is suspended from the Adjustable loop. Fibretape Loop is suspending Gracilis Strands.

8.Fibre tape loop is then pulled tight and secured on lateral cortex of femur with ABS button. Two strands of Gracilis get pulled to the mouth of the narrow tunnel creating two bundle morphology (Figure 2G).

9.Two strands of Gracilis are cycled first and fixed on a post ((Figure 2I = swivel lock anchor) in full extension placing gracilis strands in posterolateral position in tibial tunnel.

10.Three strands of Semi T are cycled and an interference screw is inserted in 30 to 45 Degree flexion between two strands of Gracilis already fixed postero-laterally and Semi T strands held tight antero-medially (Figure 2J). Two parts of the graft thus get separated by the diameter of the interference screw.

11.Immediate post op care remains the standard

12.Rehabilitation protocol is steady and deliberate taking care to avoid any acceleration of rehabilitation

Discussion:

Modification described above is primarily an extrapolation of the idea of Hemanth et al(19) of obtaining double bundle morphology by “spreading apart” strands of graft. As Femoral Intrafix is not available in India; a strategy to achieve “spread apart” was devised, by providing an additional anchorage to Gracilis strands. This strategy is an intermediate between solitary femoral socket DB technique and two femoral sockets technique. Like former, all the stands of the hamstring go into the principal socket and double-bundle morphology is obtained by separating some strands from the remaining strands. Like the latter, there is another tunnel in the femoral condyle albeit a narrow 4mm tunnel. The difference is that no strand actually enters in supplementary tunnel and this tunnel just reroutes two strands of Gracilis from principal tunnel to mouth of narrow tunnel (Figure 2H).

Supplementary tunnel acts merely as additional anchorage point for Gracilis strands. Gracilis courses to tibial tunnel from accessory anchorage point while trebled Semi T courses straight from Principal Socket to tibial tunnel.

Advantages of the modification include achieving two bundle morphology: without making the procedure much longer; making it possible with an intermediate technical expertise with lower complication rate; reduced encroachment of bone stock in short individuals; and easier revision. Second tunnel being narrow and drilled outside-in allows choosing starting point safely away from exit point of principal tunnel of ACL or tunnel of LCL in multi-ligament setting reducing tunnels coalescence risk. Cost of implants is reduced because additional fixation is just a Fibretape loop and suture disc. Post fixation on tibia can easily be 4.5mm cortical screw with washer and can be removed after interference fixation in tibial tunnel is done.

All these features, while achieving double-bundle morphology make this surgery, technically speaking, much closer to a Standard SBACL reconstruction than a Three tunnel or Four tunnel DBACL reconstruction and that is exactly how we view our modification. For this reason, this technique may also reduce the chances of over-constrained anterior translation compared to an ACL intact knee which has been described(14) in Anatomic DBACL technique.

Independent tensioning and fixation of the two bundles at different flexed positions of the knee has either been achieved in four tunnel technique(8) or three tunnel technique with two tibial tunnels(16) and only in cadaveric studies in three tunnel technique with two femoral sockets(17)(18). One of notable merits of our technique is that after fixation of all strands in principal tunnel with suspensory fixation and fixation of gracilis strands to accessory anchorage point, Gracilis strands are fixed in full extension on a post and then the knee may be moved to a desirable flexed position to fix all the strands in the tunnel. After interference fixation post becomes superfluous as Differential tension and length differential gets built in different strands once interference fixation is done and post can then be safely removed.

“Insertional Site area” concept has helped us understand the place of SB & DB reconstruction in ACL surgeries(20). Siebold published tables detailing the diameters of drill bit and the angle of drilling that should be used for achieving “complete foot print coverage” with SBACL for a given Tibial insertional size. Details of combination of drills sizes, grafts sizes, and angles of drilling were also detailed for achieving complete foot print coverage by DBACL reconstruction assuming a bone bridge of 2mm. He found that DBACL reconstruction for tibial foot print size of less than 14mm grafts would be 5.0 & 5.5mm which are thin and fraught with high risk of graft failure. A minimum acceptable size of 6mm graft diameter for AM budle was practical with only a Tibial foot print size of 15mm. Considering Femoral footprints tend to be larger by 2mm to tibial foot print, a corresponding minimum acceptable femoral foot print size for DBACL reconstruction would therefore be 17mm. In Indian population, footprints tend to be generally smaller and therefore a small minority of Indian patients may be suitable for Four Tunnel DBACL reconstruction and that is indeed so in our experience. Our modification permits achievement of double bundle morphology of Reconstructed ACL in

much greater proportion of population. There is solitary tibial tunnel, tibial foot print size limiting applicability of our technique due to small tibial foot print becomes non-issue. In effect, short femoral footprint also does not bar any patients from our technique of DBACL because second tunnel doesn't need to be drilled to diameter of PL graft as the graft is not supposed to be insinuated into the supplementary tunnel but held tightly pressed against the mouth of the supplementary tunnel by a fibretape loop. Ordinarily 4mm diameter tunnel is made, but beath pin hole of 2.5mm may be used for supplementary anchorage for two strands of Gracilis. A nitinol wire loop through Meniscus Mender needle can be used for parking second shuttling thread through hole of 2.5mm. Only modification required would be to use Fibrewire instead of fibretape.

A narrow second tunnel doesn't make it mandatory even to leave a minimum of 2mm bony bridge between tunnels. The second tunnel is drilled outside in leaving a safe 4-5mm distance between tunnels at the surface of lateral femoral cortex. On the inside opening the two tunnels may became as much closure as to be right next to each other. Only modification in such situation would be not to create trough in between. Even though the separation between bundles would be small, but as supplementary tunnel is made at the anterior edge of footprint close to cartilage margin, foot print coverage would still be complete. We have achieved two bundle morphology and complete foot print coverage for femoral foot print as small as 9-10mm.

There may be a few pitfalls as well. The obvious would be concern regarding healing of rerouted segment of Gracilis graft on the medial surface of the lateral condyle. Decortication to cancellous surface and gouging out a shallow trough sometimes is an attempt to facilitate such healing. It is our hypothesis that healing to a flat decorticated cancellous surface may not be a problem as the surface available to Gracilis tendon is increased compared to independent tunnel scenario. It is seated in socket as in any ACL reconstruction, pressed against decorticated cancellous surface (much the same way as rotator cuff tendons pressed against cancellous bone of greater tuberosity in double row RC repair) and finally held to the mouth of 4mm tunnel.

Other pitfalls may be entanglement of Shuttling loops inside tibial Tunnel or fibretape loop getting entwined with graft and getting pulled into principal socket and getting stuck. Loops should be pulled inside tibial tunnel one at a time with suture retriever only, taking care to open prongs of instrument only under vision. The graft should be pulled in small deliberate increments while simultaneously checking to and fro sliding of the fibretape loop, using nylon loop, till the graft is seated and button is flipped. If one still gets stuck, one may just pull out the second shuttling thread or fibretape loop, ignore the second narrow tunnel and complete the procedure as a standard SBACL. However, if technique is followed diligently these complications do not happen. Except in first 2-3 cases when we were still sorting out intricacies of the technique, these complications have not happened in a series of 17 cases.

A more common complication is failure to ensure a strict posterolateral position for Gracilis strands and Anteromedial position for SemiT strands which may happen in about 25% cases.

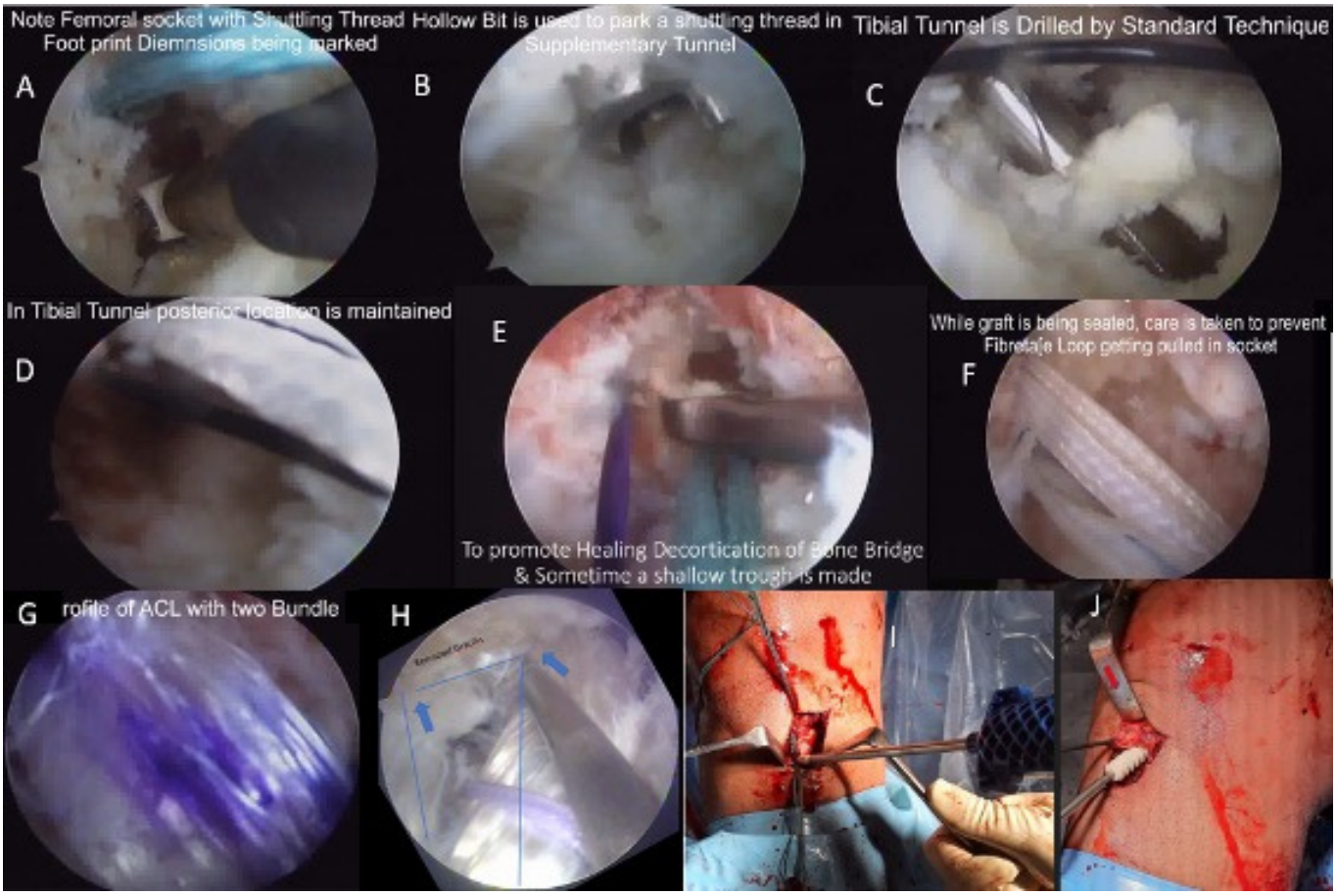

Figure 2(A-J): Steps of Surgical Technique.

The second shuttling thread is carefully maintained in posterolateral position and Gracilis strands are fixed first in posterolateral position to protect against this but accept it if it happens because clinical outcomes of these patients have been as good as in others.

Conclusion:

Described here is a technique which is sort of an intermediate between “Two Tunnel Double bundle” and “Three tunnel Double Bundle technique”. Third Tunnel is a narrow 4mm tunnel which is easily added to a standard SBACL (Two tunnel) technique. Modification can restore ACL morphology much closer to native anatomy than Standard SBACL and has potential to reduce all complications of Conventional Double bundle techniques while restoring double bundle morphology fairly well

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