A Review Article on Recent Trends in Choosing The Appropriate Hamstring Graft Diameter for ACL Reconstruction

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Abstract

Background: ACL reconstruction is one of the most frequently performed surgery in orthopedic sports medicine. Due to the several advantages offered by hamstring autografts they are preferred in majority of the centres all over the globe. Choosing the appropriate diameter for hamstring graft has always been a dilemma for the surgeons. This study aims to review the recent literature which describe the outcomes associated with different hamstring graft diameters and how to choose the appropriate graft diameter for ACL reconstruction.

Methods: Recent articles were searched on search engines such as PubMed, Google Scholar and additionally by checking references of various articles.

Summary: Hamstring grafts of less than 8mm in diameter are associated with higher chances of failure and revision surgery whereas graft sizes that were larger than their native ligament lead to another set of complications. In the recent studies attempts are made to restore the native anatomy of the ACL which involves choosing the graft diameter that would serve to recapitulate the natural morphology and biomechanics of the ACL but the clinical implications of the same are yet to be studied

Keywords: ACL reconstruction; Hamstring graft; Graft diameter; Anatomical ACL reconstruction; Minimum hamstring graft diameter.

Introduction

Anterior cruciate ligament (ACL) tear is one of the most common injuries in sport and has a devastating effect on level of activity and quality of life [1], also ACL reconstruction is one of the most frequently performed surgery in orthopedic sports medicine [2]. Due to the several advantages offered by hamstring grafts in terms of greater cross sectional area, maintenance of the integrity of the extensor mechanism, adequate tensile strength and with a better rate of return to pre-surgical levels of sporting activity, they are preferred in majority of the centres all over the globe. Also the complication like extension loss, anterior knee pain and infections are lower than those reported for BPTB (Bone patellar tendon bone) graft [20]. Choosing the appropriate diameter for hamstring graft has always been a dilemma for the surgeons hence there have been several studies regarding the appropriate size of graft to be taken, also harvesting an autograft itself is associated with a large variability in graft diameter. Certain studies have shown, smaller graft diameters have been associated with an increased rate of failure and lead to early revision [3, 4, 5], supported by other studies that advocate that larger graft sizes yield better results, while a few studies refute such claims by stating that although large graft may reproduce the entire footprint but may be associated with complications which vary from damage to meniscus to femoral blowout while drilling larger tunnels for larger graft diameters [6,7]. Also, in most cases of ACL reconstruction using auto grafts, the reconstructed ACL size is determined by the harvested graft size, not guided by the native ACL anatomy [8-12]. This mismatch in size could lead to suboptimal outcomes.

Numerous prospective and retrospective studies have been carried out over the past decade to narrow down the appropriate hamstring graft diameter for ACL reconstruction. Aim of this study was to review the recent literature which have describe the surgical outcomes associated with different hamstring graft diameters and how to choose the appropriate graft diameter for ACL reconstruction .

Materials and Methods

Recent articles were searched on search engines such as PubMed, Google Scholar with the use of Key words like 'Hamstring graft diameter ', 'Clinical relevance of graft diameter ' 'anatomical ACL reconstruction'. Additional articles were identified by checking the references. Studies were initially screened based on titles and references and study of relevant topics were selected and a review was done of the same.

Do smaller graft diameters lead to higher revision rates and what is the minimum graft diameter that we can use ?

Smallest hamstring graft diameter that can be used for ACL reconstruction is a debatable topic and many clinical and cadaveric studies have been done so as to quantify the same and also determine

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Author	Year	Sample size	Conclusion
Robert A. Magnussen et al	2011	338	Use of hamstring autografts 8 mm in diameter or less in patients aged under 20 years is associated with higher revision rates
Park et al.	2013	296	Graft diameter of 8.0 mm or more had lower failure rates after ACL-R than patients with a diameter <8.0 mm
Conte et al	2014	Review of 4 clinical studies	ACL reconstruction with a quadrupled-strand hamstring autograft with a diameter equal to or larger than 8 mm decreases failure rates
Robert W. Westermann et al	2016		Increased graft size confers a biomechanical advantage in the ACL reconstructed knee
Lindsey Spragg et al	2016	Case- control study with 124 cases and 367 controls	Within the range of 7.0 to 9.0 mm, there was a 0.82 times lower likelihood of being a revision case with every 0.5-mm incremental increase in graft diamete
Mark Clatworthy et al	2015		The mean size of graft failures was 7.55mm and ACL reconstructions that failed had a significantly smaller hamstring graft diameter. The Hazard Ratio for a smaller diameter graft is 0.51 and concluded that for every 1mm decrease in graft diameter there is a 48.3% higher chance of failure
Ravi Gupta et al	2018	103	Graft size of <8 mm is a risk factor for ACL graft rupture and graft size of >8 mm provides better knee stability and higher return to sports
Rokas Jurkonis et al	2018	214	Graft diameter is not associated with recurrent instability and does not affect laximetry results

if an increasing the diameter of hamstring graft would actually decrease the revision rates and lead to better functional outcomes.

A few studies have proposed that minimum 8 mm of hamstring graft diameter is mandatory to achieve lower revision rates i.e lesser chance of graft failure . Robert A. Magnussen et al who in order to evaluate whether decreased hamstring autograft size and decreased patient age are predictors of early graft revision, conducted a study on 338 consecutive patients undergoing primary ACL reconstruction with hamstring autograft, of which 256 (75.7%) were evaluated. Graft size and patient age, gender, and body mass index at the time of ACL reconstruction were recorded, along with whether subsequent ACL revision was performed and came to conclusion that decreased hamstring autograft size and decreased patient age are predictors of early graft revision. Use of hamstring autografts 8 mm in diameter or less in patients aged under 20 years is associated with higher revision rates [3]. Similar results were obtained by Park et al. where the included 296 patients who underwent SB ACL-R with a quadrupled hamstring autograft and found that patients with a graft diameter of 8.0 mm or more had lower failure rates after ACL-R than patients with a diameter <8.0 mm [5].

On similar lines Conte et al in identified 4 clinical studies that directly compared graft size and failure rate. These studies demonstrated a 6.8 times greater relative risk of failure if the graft diameter was equal to or less than 8 mm (P = .008) and the authors concluded that ACL reconstruction with a quadrupled-strand hamstring autograft with a diameter equal to or larger than 8 mm decreases failure rates [4]. Mark Clatworthy et al had similar findings but the exact lower limit of graft diameter propsed by them was lesser. In their study they observed that the mean size of graft failures was 7.55mm and ACL reconstructions that failed had a significantly smaller hamstring graft diameter. The Hazard Ratio for a smaller diameter graft is 0.51 and concluded that for every 1mm decrease in graft diameter there is a 48.3% higher chance of failure [13].

These findings are supported by a very recent study by Ravi Gupta et al where they had conducted a study to see the effect of quadruple hamstring tendon graft diameter on knee stability, functional outcome, and graft failure where their study had two parts retrospective part and prospective part. 18 athletes who underwent revision ACL reconstruction surgery between were identified along with 103 athletes who underwent primary ACL reconstruction and divided into two groups depending upon their quadruple hamstring tendon graft diameter – group A (graft diameter <8 mm) and group B (>8 mm) and came to the conclusion that Graft size of <8 mm is a risk factor for ACL graft rupture and graft size of >8 mm provides better knee stability and higher return to sports [15]

Does an increase in graft diameter mean better outcomes and lower failure rates ?

A few studies do advocate that there is a improvement in the knee biomechanics and hence improved surgical outcomes with progressively larger diameter grafts. Robert W. Westermann et al used a simulated Lachman manoeuvre to assess knee joint laxity and in situ graft loading for ACL graft sizes between 5 and 9 mm as well as an ACL-deficient knee and observed that the 5 mm graft resulted in 30% greater relative AP translation compared to the 9 mm graft; Stresses which occur in the soft tissues, as well as contact pressure at the articular surfaces, were found to be highly sensitive to ACL graft size. Larger grafts were associated with lower meniscal stress, decreased joint laxity, and less articular cartilage contact stress and hence concluded that an increased graft size confers a bio-mechanical advantage in the ACL reconstructed knee [14], with respect to the effects on revision rates.

Lindsey Spragg et al in 2016 conducted a case-control study where revision was used as a marker for graft failure. Where, A case was defined as a patient who underwent primary ACLR with a hamstring autograft that was revised during the study period (April 2006 to September 2012). In a total of 124 cases and 367 controls the mean (6SD) graft diameter was 7.9 6 +/-.75 mm in the cases and 8.1 +/- 0.73 mm in the controls. The likelihood of a patient needing revision ACLR in the study cohort was 0.82 times lower (95% CI, 0.68-0.98) for every 0.5-mm increase in the graft diameter from 7.0 to 9.0 mm and they concluded that within the range of 7.0 to 9.0 mm, there was a 0.82 times lower likelihood of being a revision case with every 0.5-mm incremental increase in graft diameter [21].

These claims were refuted by Rokas Jurkonis et al in a recently conducted study where they analysed 214 consecutive patients with a completed follow-up of 12 months: 55 (25.7%) women and 159 (74.3%) men. Patients were divided into 3 groups according to the diameter of the middle of the hamstring graft and came to the conclusion that that graft diameter is not associated with recurrent instability and does not affect laximetry results [16].

Can larger graft diameter cause complications ?

The upper limit of graft diameters is also to be defined as a matter of fact use of larger grafts warrant the drilling of larger bone tunnels and these come with their own set of problems, like femoral notch impingement as shown by H Van der Bracht et al in their study on cadaveric knees to analyze anatomical risk factors and surgical technique dependent variables, which determine the risk for femoral notch impingement in anatomically correct placed tibial tunnels for ACL surgery where digital templates mimicking a tibial tunnel aperture at the tibia plateau were designed for different tibial tunnel diameters and different drill-guide angles with the centres of these templates placed over the geometric centre of the native tibial ACL footprint and graft free zone and anatomic risk factors for femoral notch impingement were determined. They found that 8 mm diameter tibial tunnels had a statistically significant larger graft free zone compared to 10-mm-diameter tibial tunnels ($p < 0.00001$). For the 10 mm diameter tibial tunnels with drill-guide angle of 45°, 9 out of 20 knees (45 %) were "at risk" for notching and 4 out of 20 knees (20 %) had "definite" notching. And concluded that with a centrally positioned tibial tunnel, a real risk for femoral notch impingement exists depending on the size of the tibial ACL footprint and surgery-related factors [6]

Drilling of bone tunnels can cause damage to surrounding structures like meniscal roots, Christopher M LaPrade et al studied human cadaveric knees, they found that there was a significant mean decrease in the attachment area for the AL root (%Δ, 38%; 95% CI, 25-51) after ACL tunnel reaming compared with the intact state (P=.003). The mean ultimate failure strength of the native AL root (mean, 610 N; 95% CI, 470-751) was significantly stronger (P=.015) than that of the AL root with a reamed ACL reconstruction tunnel (mean, 506 N; 95% CI, 353-659). Hence, tibial tunnel reaming during anatomic single-bundle ACL reconstruction significantly decreased the AL meniscal root attachment area and ultimate failure strength and creating a larger tunnel may be deleterious to ultimate failure strength of AL root [7]

The concept of anatomical and individualised ACL reconstruction , does it help predict the graft diameter ?

The quest for appropriate graft diameter was led to the concept of anatomic reconstruction which according to van Eck et al is defined as "the functional restoration of the ACL to its native dimensions, collagen orientation and insertion sites" and gave the following principles • Anatomic ACL reconstruction should reproduce as closely as possible the size, shape and location of the native ACL attachment sites • The second principle is to restore the two functional bundles of the ACL • The third principle is that the ACL replacement graft should reproduce the tensioning pattern of the native ACL • The final principle of anatomic ACL reconstruction is to individualise the surgical procedure for each patient every patient and every knee is different, so the same operation should not be performed in every case. [17]

Based on these proposals Efforts were made to determine the native ACL tibial insertion dimensions and anatomy and then restore it .

Rainer Siebold et al in 2012 based on the hypothesis that the restored biomechanical envelope of the knee is a function of the amount of reconstructed insertion site area introduced the ''Modified Insertion Site Table'' that was calculated to achieve a maximum of area restoration of the native tibial ACL footprint such that maximum biomechanical stability can be restored. On similar lines [18], Middleton et al also conducted a prospective pilot study of 45 patients who underwent primary single-bundle anatomic ACL-Reconstruction. Length and width of the native insertion site were measured intra-operatively. Using published guidelines, reconstruction technique and graft choice were determined to maximise the percentage of reconstructed area. Native femoral and tibial insertion site area and femoral tunnel aperture area were calculated using the formula for area of an ellipse. On the tibial side, tunnel aperture area was calculated with respect to drill diameter which is dictated by the graft diameter and drill guide angle. Percentage of reconstructed area was calculated by dividing total tunnel aperture area by the native insertion site area on an average percentage of reconstructed area was 79 ± 13 % for the femoral side, and 70 ± 12 % for the tibial side [19]

But the advantage of complete footprint restoration over partial footprint restoration has to be proven in future biomechanical and clinical studies.

Conclusion

As per the current literature hamstring grafts of less than 8mm in diameter are associated with higher chances of failure and revision surgery, with inconclusive evidence in terms of if progressive increase in graft diameter gives better outcomes whereas graft diameters out of proportion to native ACL lead to another set of complications. In the recent studies attempts are made to restore the native anatomy of the ACL which involves choosing the graft diameter that would serve to recapitulate the natural morphology and biomechanics of the ACL but the clinical implications of the same are yet to be studied.

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