

# Is Quadriceps Tendon Bone Autograft (QTB) a Better Graft than Bone Patellar Tendon Bone Autograft (BPTB) for ACL Reconstruction? - A Randomized Single Blinded Study

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**Abstract:** *Though ACL tear is one of the extensively studied sports injuries, there are no definitive guidelines in its management. There is debate on the choice of graft selection, method of fixation and technique used for reconstruction rather than the need for a surgery. This single blinded study compared the outcome of ACL reconstruction with autologous Bone Patellar Tendon Bone Graft (BPTB) and an autologous Quadriceps Tendon Bone (QTB) graft, and temporal variation of the results over a period of 12 months. The results of this study were comparable with similar international studies. Functional results were comparable between BPTB and QTB groups, but QTB group had less graft site morbidity.*

**Keywords:** Anterior cruciate ligament, reconstruction, bone patellar bone graft(BPTB), quadriceps tendon bone(QTB) graft

## 1. Introduction and Background

The primary function of the ACL is to prevent anterior translation of the tibia relative to the femur. Other functions of the ACL include resisting internal rotation of the tibia and varus or valgus stress of the tibia in the presence of collateral ligament injury.<sup>1</sup> Rupture of ACL is one of the most common ligamentous injuries of the knee with an incidence of 35 out of 100,000 population worldwide.<sup>2</sup> The incidence of reconstruction of the anterior cruciate ligament has been reported as high as 75,000–100,000 per year in the USA.<sup>3</sup> Worldwide, it is most commonly caused by sports injuries, however in India, it is mainly caused by road traffic accidents.<sup>4</sup>

Anterior cruciate ligament (ACL) injury is very frequent, not only in professional athletes but also—increasingly often—in people who practice sports regularly. Conservative treatment usually fails to eliminate recurrent symptoms during the return to activities. Additionally, with subsequent instability episodes, patients may show an accelerated onset of degenerative joint changes and meniscal injuries. ACL reconstruction aims to eliminate symptoms and prevent such degenerative joint changes.<sup>5</sup> ACL reconstruction restores the stability of the knee joint and protects the menisci and joint surfaces from further damage,<sup>6</sup> and prevents worsening of existing chondral lesions as well as occurrence of newer lesions. Reconstruction of the ACL may also alter the incidence of osteoarthritis in the longer term.<sup>6</sup> Also, ACL does not have the potential to adequately heal by itself when torn, therefore surgical ACL reconstruction is generally the treatment of choice.

Techniques of ACL reconstruction have evolved tremendously over the past 30 years. Even as graft choices

and fixation devices and methods continue to evolve and improve, several principles remain integral to successful ACL reconstruction. These include surgical technique, tunnel placement, timing of surgery and postoperative rehabilitation protocols.<sup>7</sup>

The autologous grafts most frequently used for anterior cruciate ligament (ACL) reconstruction are the central one-third of the bone-patellar tendon-bone (BPTB) and the hamstring (semitendinosus and gracilis, STG).<sup>8</sup> The central one-third of the BPTB is a commonly used graft because of its strength and associated short healing period.<sup>8,9</sup> However, the use of a BPTB graft can cause anterior knee pain, pain on kneeling, patellar tendon rupture, patellar fracture, and fat pad herniation.<sup>8-12</sup> The use of the hamstring tendons (HT) avoids disruption of the extensor mechanism but can lead to hamstring muscle weakness, requires a longer amount of time for incorporation into the bone tunnels, and may induce ACL agonist weakness and disruption of the protective ACL proprioceptive arc.<sup>8-12</sup>

The quadriceps tendon autograft (QTA) is becoming a popular graft for primary and revision ACL reconstruction.<sup>13</sup> The QTA is easy to harvest,<sup>14-15</sup> can be obtained with or without a patellar bone block, is adequately thick to accommodate an expanded tibial tunnel in revision operations, produces fewer donor site problems than if the patellar tendon is harvested,<sup>15-118</sup> has excellent mechanical characteristics,<sup>13, 15, 17, 18</sup> is attributed with a larger cross-section area when compared to the patellar tendon,<sup>14, 16, 19, 21</sup> and induces minimal quadriceps inhibition after the quadriceps harvest.<sup>20</sup> The residual strength of the extensor mechanism is less impaired by central QTA harvest than by harvest of a BPTB graft.<sup>13</sup> QTA is an alternative to BPTB, especially in patients who spend much time on their knees or who require deep flexion of the knee,<sup>14, 16, 19, 21</sup> but fixation

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issues remain.

BPTB autografts produce more pain than HT autografts both in the immediate postoperative period as well as in the long term.<sup>22</sup> Harvest site symptoms such as tenderness, irritation, and numbness were significantly more common in the BPTB patients.<sup>22</sup> HT autograft is usually recognized to produce the least donor site morbidity, especially compared with the BPTB.<sup>22</sup>

The use of quadriceps patellar tendon bone (QTPB) autografts has increased in recent years because they minimize donor-site morbidity including anterior knee pain, while providing adequate mechanical strength as a graft.<sup>23</sup> Several reports have suggested a biomechanical test for quadriceps tendon is comparable to that for BPTB.<sup>23</sup> The quadriceps tendon has the anatomic characteristics to produce a graft whose length and volume are both reproducible and predictable, while yielding a graft with a significantly greater intra articular volume than a patellar tendon graft with a similar width.<sup>24</sup> QTPB allograft achieved good clinical outcome with no difference compared with QTPB autograft. QTPB allograft for ACL reconstruction is promising alternative to selected and compliant patients. Long-term followup needs to further evaluate the clinical outcomes and complications including re-rupture rate.<sup>23</sup>

Anatomic positioning of the tunnels in ACL reconstruction has proved to be better in terms of knee stability and graft function compared with isometric and vertical positioning of the tunnels. The transtibial technique was considered the standard technique for femoral tunnel creation. However, there were concerns regarding the ability to place the tunnels in anatomic positions because the femoral tunnel position is constrained by the tibial tunnel. To improve tunnel positioning, there have been several efforts to modify the technique, such as making the starting point of the tibial tunnel more medial and proximal for oblique trajectory of the femoral tunnel. However, there were also other problems like a shorter tibial tunnel and widening of the intra articular aperture of the tibial tunnel with these modifications. A modified transtibial technique,<sup>25</sup> that consists of simple manoeuvres during the femoral tunnel guide insertion that enable anatomic positioning of the tunnels. The technique also allows sufficient tunnel length to be obtained for fixation, and the tunnel widening is minimal.

Though there are only few prospective or randomized studies comparing QTB and BPTB autografts, they do not have long term follow up. The quadriceps tendon is the least studied and least used autograft for ACL reconstruction, although interest in and use of quadriceps tendon seems to be increasing. When compared to BPTB, QTB has less or minimal graft site morbidity. In this background, this randomized single blinded controlled study was to compare knee stability, kneeling pain, harvest site pain, sensitivity loss, and subjective clinical outcome after primary ACL reconstruction with either BPTB or QTB autografts by modified transtibial technique.

## 2. Aim and Objectives

### 2.1 Aim of this study

To compare the functional outcome of Anterior Cruciate Ligament (ACL) reconstruction using an autologous Bone Patellar Tendon Bone (BPTB) graft and an autologous Quadriceps Tendon Bone (QTB) graft using modified transtibial technique.

### 2.2 Objectives of this study

#### Primary objective-

To assess and compare the functional outcome of Anterior Cruciate Ligament (ACL) reconstruction using an autologous Bone Patellar Tendon Bone (BPTB) graft with an autologous Quadriceps Tendon Bone (QTB) graft using modified transtibial technique.

#### Secondary objective-

- 1) To assess and compare the temporal variation of the scores over a period of time during follow-up till 12 months post-surgery between two groups.
- 2) To assess and compare the additional injuries after arthroscopic evaluation like meniscal tears, synovial pathologies and chondral defects and to evaluate their effects on functional outcomes.

## 3. Materials and Methods

**Study Site:** Department of Orthopaedics, Sri Sathya Sai Institute of Higher Medical Sciences, Prasanthigram, Anantapur district, Andhra Pradesh.

**Study Design:** A prospective, single blind, randomized comparative Study.

**Study Period:** 18/06/16 to 17/12/17 - 18months.

**Study Population:** ACL injured patients who required surgery were selected based on the inclusion criteria and were divided into GROUP- 1 for Quadriceps Tendon Bone (QTB) graft & GROUP- 2 for Bone Patellar Tendon Bone (BPTB) graft each comprising of 25 patients .

**Sample size determination:** Using results of a previous study by Lund et al.<sup>27</sup> and based on the following formula,<sup>26</sup> 25 patients were selected in each group.

#### Number of observations in each of the two groups (N):

Calculation based on the formula,<sup>26</sup> using a previous study by Lund et al.<sup>27</sup>

where  $\mu_1$  and  $\mu_2$  are the mean outcome in the control and experimental group respectively,  $\sigma$  is the standard deviation, and

$$f(\alpha, \beta) = [\Phi^{-1}(\alpha) + \Phi^{-1}(\beta)]^2$$

$\Phi^{-1}$  is the cumulative distribution function of a standardized normal deviate.  $\mu_1 - 70$ ,  $\mu_2 - 84$ ,  $\alpha - 5$ ,  $\beta - 95$ ,  $\sigma - 13$  respectively

Minimum of 46 patients were required to have a 95% chance of detecting, as significant at the 5% level, an increase in the primary outcome measure from 70 in the control group to 84

in the experimental group. So, 50 patients were included with 25 in each group in this study.

#### Inclusion criteria:

- 1) Young Adults (20 – 45 yrs.)
- 2) Patients with chronic ACL Injury.
- 3) Patients with ACL injury associated with Meniscal Injuries.
- 4) Patients with ACL injury associated with Chondral Defects upto Grade3.

#### Exclusion criteria:

- 1) Patients with acutely injured Knee.
- 2) Patients with history of previous Knee surgeries.
- 3) Patients with infection of the Knee.
- 4) Patients with degenerative joint disease of the Knee.
- 5) Patients with multi ligamentous knee instability.
- 6) Patients with stiff Knee with deformity.
- 7) Patients with associated metabolic disorders.
- 8) Patients with associated inflammatory disorders.

#### Method of Data Collection

50 patients were selected based on the inclusion criteria and exclusion criteria on the day of admission.

Plain radiographs - anteroposterior (AP) and Lateral views of the knee, MRI Knee , and relevant preoperative investigations were done for all the patients

They were randomized into GROUP - 1, GROUP - 2 each comprising of 25 patients. GROUP 1 patients underwent ACL Reconstruction with Quadriceps Tendon Bone (QTB) & GROUP 2 patients underwent ACL Reconstruction with Bone Patellar Tendon Bone (BPTB).

Method of randomization used was: achieved by computer-generated randomization chart. At website [www.random.org](http://www.random.org) > Numbers > Random sequence generator, was obtained after noting smallest and largest value as 1 and 25 in 2 columns.

**Functional outcome scores** were assessed by the same physiotherapist within this time period of 18 months with a minimum follow-up of 1 year based on:

- 1) MODIFIED CINCINNATI KNEE RATING SYSTEM,<sup>28</sup>
- 2) TEGNER LYSHOLM KNEE SCORE,<sup>29</sup>
- 3) IKDC SUBJECTIVE KNEE EVALUATION SCORE.<sup>30</sup>

Operative procedures

#### Instruments:

- 4 mm 30 degrees angled Arthroscope.
- Water pump, Light Source & Arthroscopic cart.
- Arthroscopic cart with LED monitor
- ACL Reconstruction Set, Bone-Patellar Tendon-Bone Graft
- Motorised Shaving system & RF probes & System.
- Standard Graft Preparation station
- Power Drill and Titanium Interference screw.

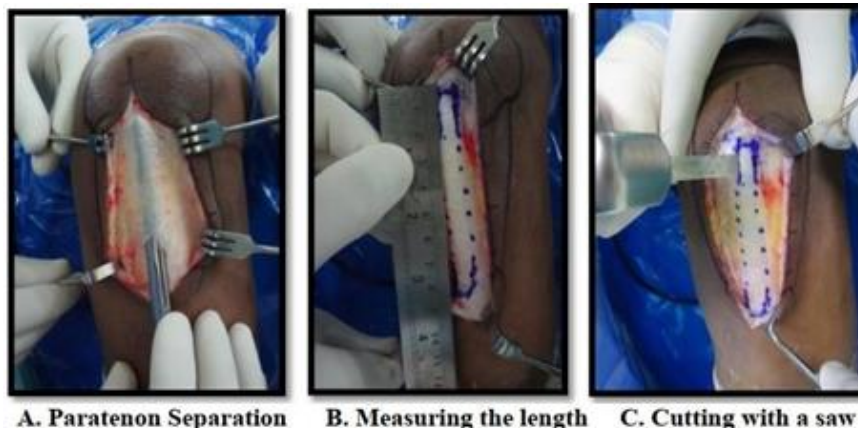
#### Graft Harvesting:

##### BPTB graft harvesting

- Longitudinal midline incision from the lower half of patella extending distally 12 cms was given.
- Soft tissue dissection was done.
- Paratenon incised and patellar tendon exposed
- Required length was marked over the tendon
- 1cm wide graft with proximal and distal bone of 2.5 cms was harvested.
- Bone edges trimmed around 8 - 9 cm long graft obtained.
- Graft was prepared using 2-0 Ethibond suture by transfixing stitches
- Width of the graft assessed on both patellar and tibial sides.

##### QTB graft harvesting

- Longitudinal midline incision from the upper half of patella extending proximally 12 cms was given.
- Quadriceps tendon exposed
- Required length was marked over the tendon
- 1cm wide graft with distal bone of 2.5 cms was harvested.
- Bone edges and soft tissue edges trimmed around 8 - 9 cm long graft obtained.
- Graft was prepared using 2-0 Ethibond suture by transfixing stitches
- Width of the graft assessed on both patellar and Tibial sides.
- Sometimes accidentally enter suprapatellar pouch may be entered, which has to be meticulously repaired.



A. Paratenon Separation

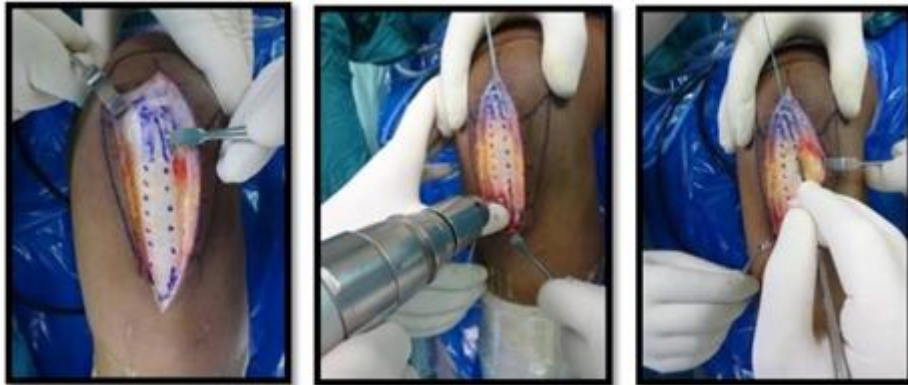
B. Measuring the length

C. Cutting with a saw

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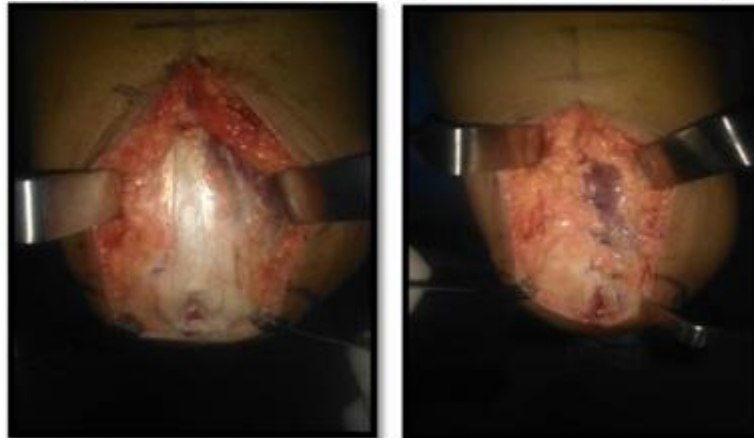
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D. Separating with osteotome

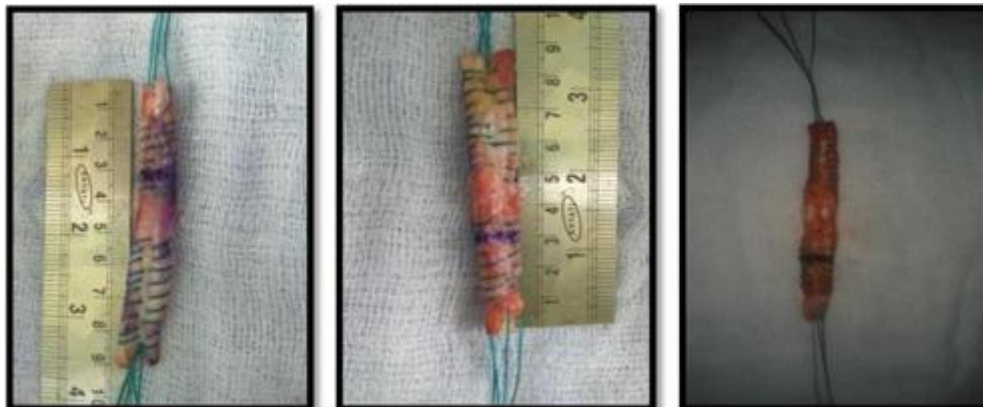
E. Making drill holes

F. Removing the graft



G. After removal

H. After closure



I. Prepared Grafts

Steps of BPTB graft harvesting



A. Marking

B. Dissection



C. Measure



D. Cutting with saw



E. Removing with Osteotome



F. Removing Graft



G. After removal of graft



H. Closure



I. Prepared Graft

#### 4. Results

##### Steps of QTB graft harvesting

This study group included 50 patients who underwent Arthroscopic ACL reconstruction, with QTB autograft in 25 patients and with BPTB autograft in 25 patients using Modified Transstibial Technique with a minimum follow-up period of 1 year.

##### Demographics

##### Age distribution

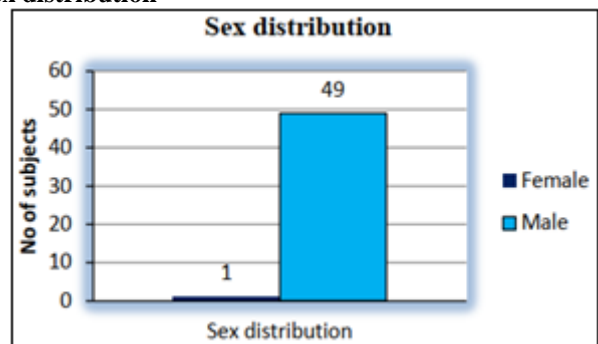
Randomization	N	Mean	SD	Mean Difference (95% CI)	t	df	p-value
QTB	25	30.24	6.91	-0.64	-0.32	48	0.75
BPTB	25	30.88	7.19	(-4.65, 3.37)			(NS)

##### Independent Sample t test

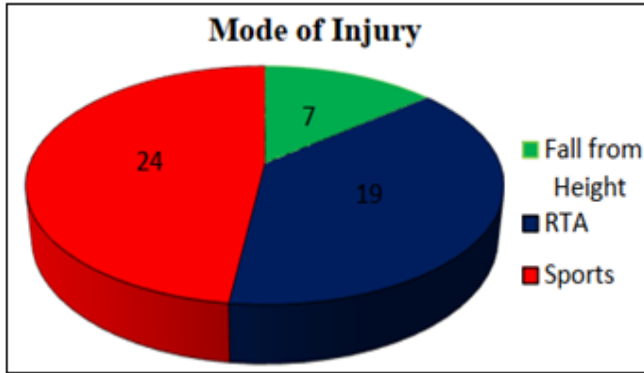
\*p<0.05 Statistically Significant

p>0.05 Not Significant, NS

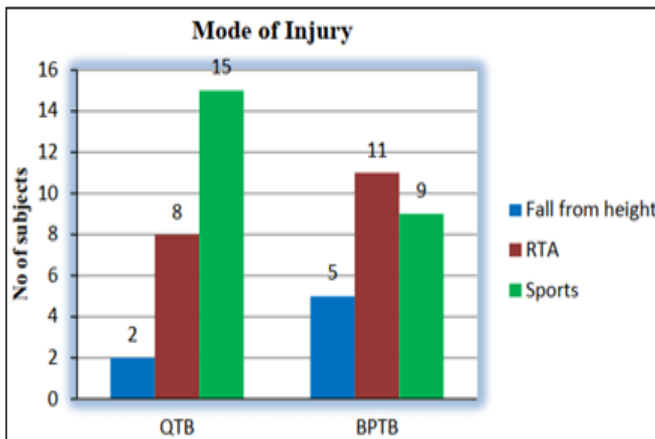
##### Sex distribution



Mode of injury

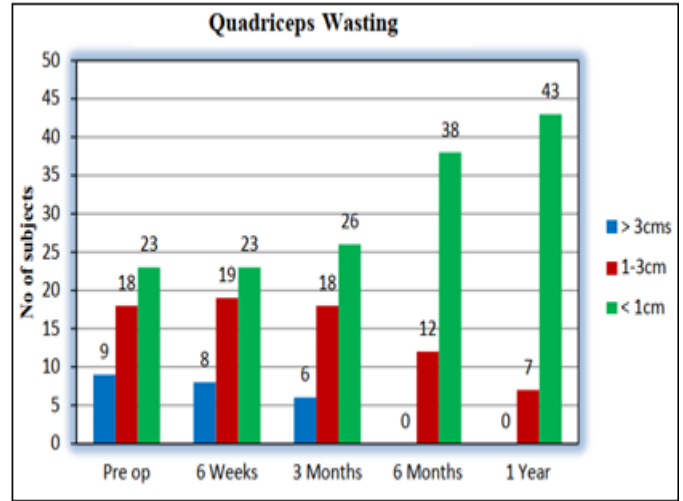


In our study, most of the patients sustained ACL tear due to sporting activities, with 24 patients (48%), followed by Road traffic accidents, with 19 patients (38%). There is no statistically significant difference between study groups, with a p-value of 0.21.



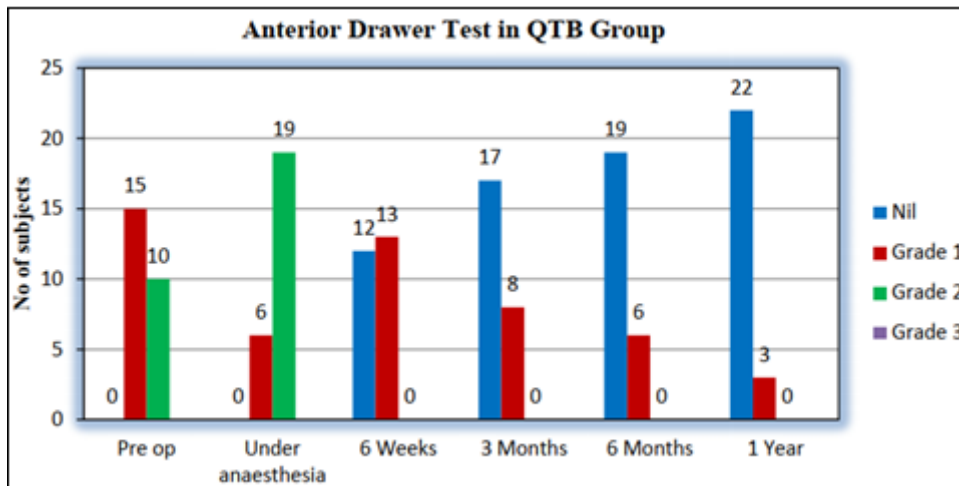
Comparison of Quadriceps wasting at each interval between study groups

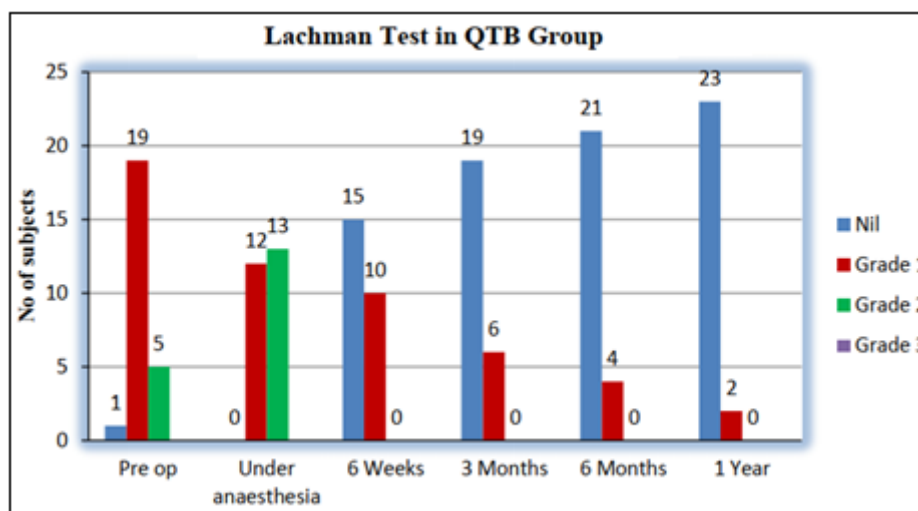
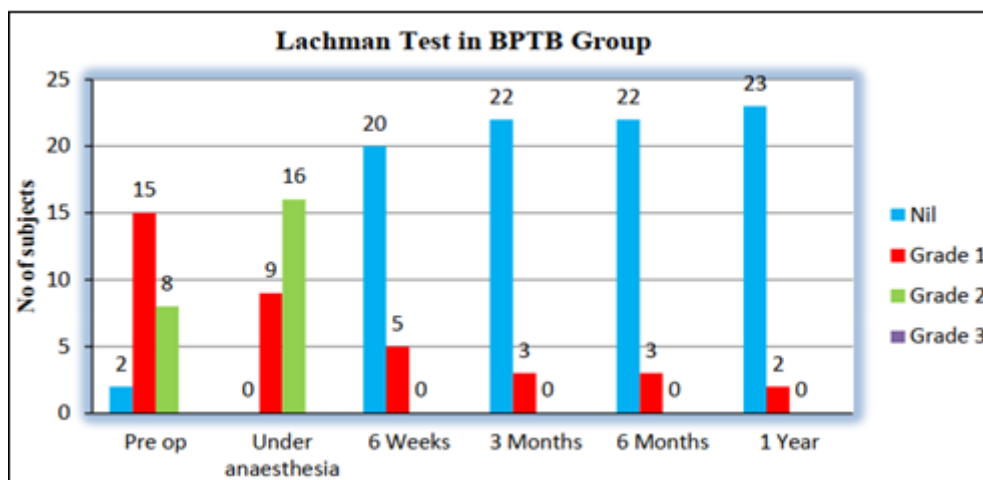
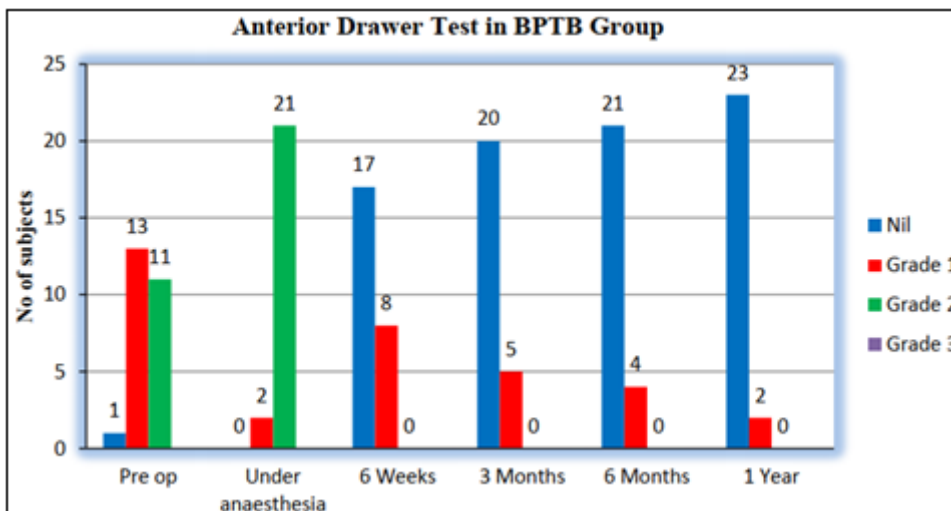
- Pre operatively there are 9 patients with > 3cms of quadriceps wasting. But after 1 year, there was no patient with quadriceps wasting > 3cms.
- There is no statistically significant difference between the study groups.

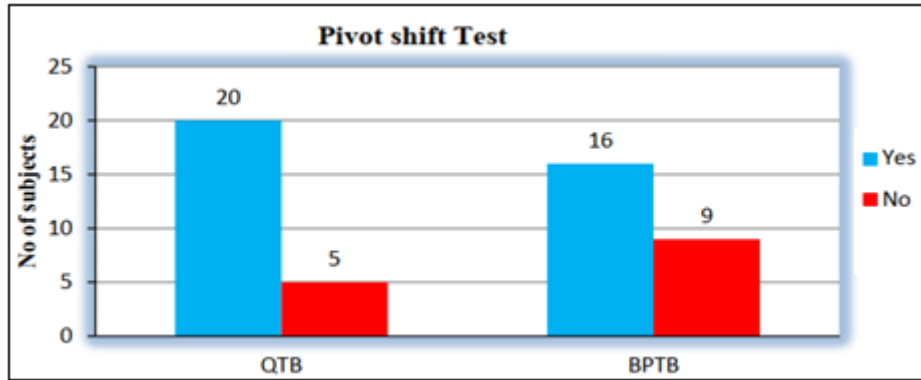


Instability tests

Anterior Drawer test and Lachman test were performed on all patients as part of the postoperative follow-up assessment in all visits.

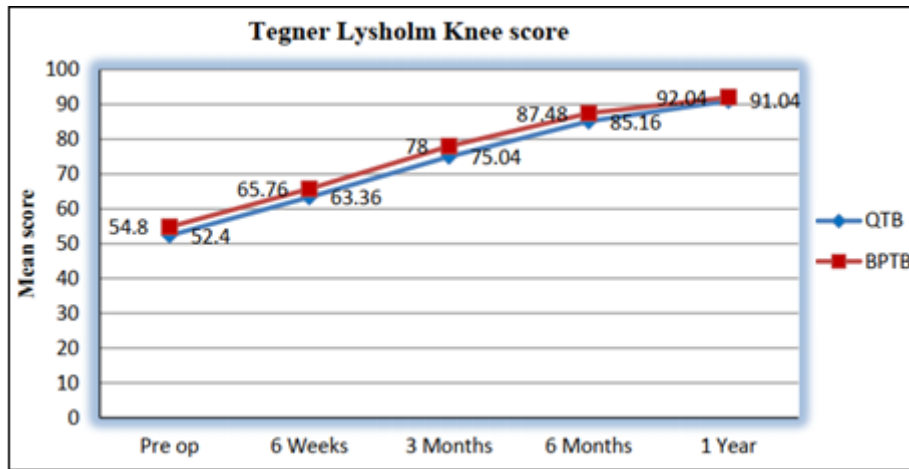






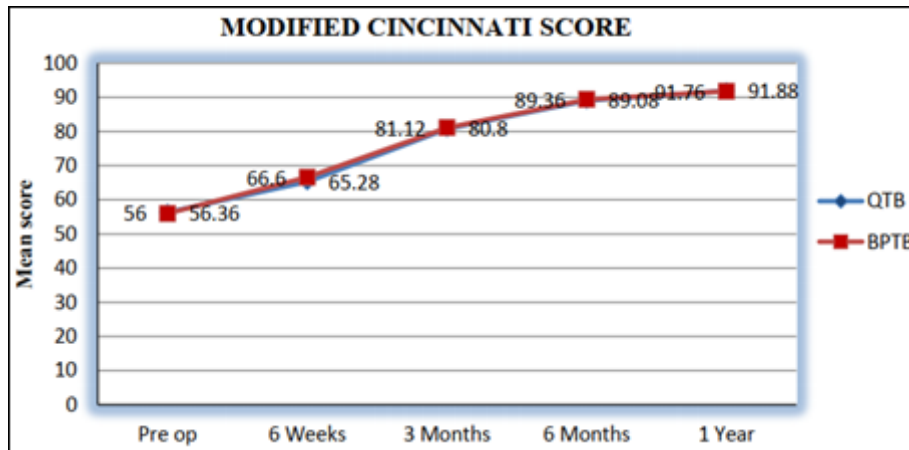
Pivot shift test -QTB group had 80% of patients and BPTB group had 64% of patients with positive Pivot shift test. During final follow up at the end of 1 year ,none of the

**Tegner Lysholm Knee Score**



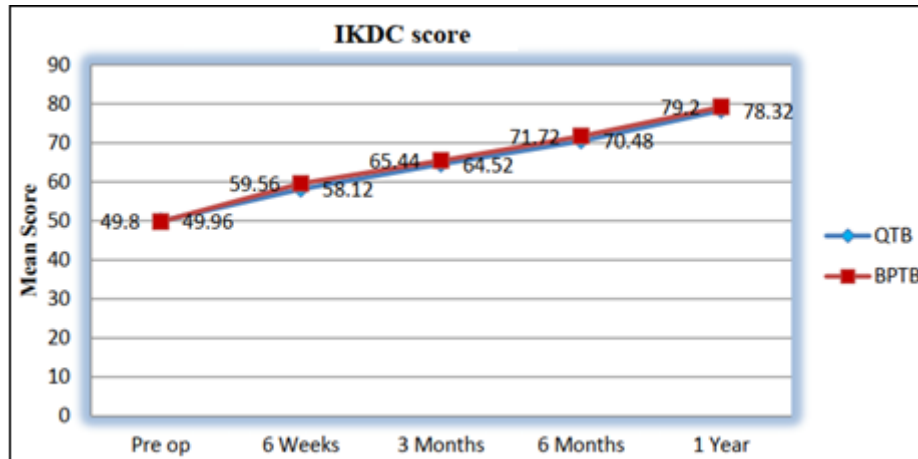
Comparison of Tegner Lysholm Knee score between the study group at each time interval. Statistically significant difference between the preoperative score and subsequent follow up scores till 1 year of post operative periods in both group

**Modified Cincinnati Score**

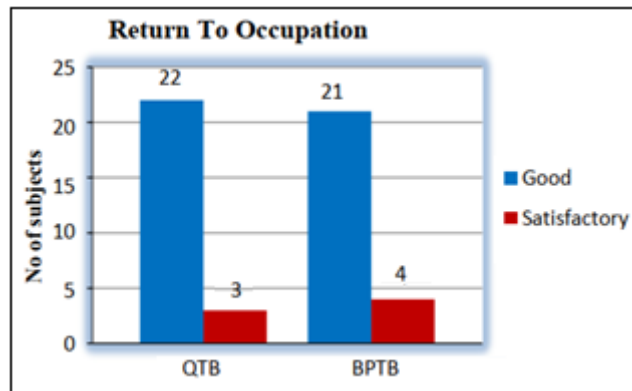
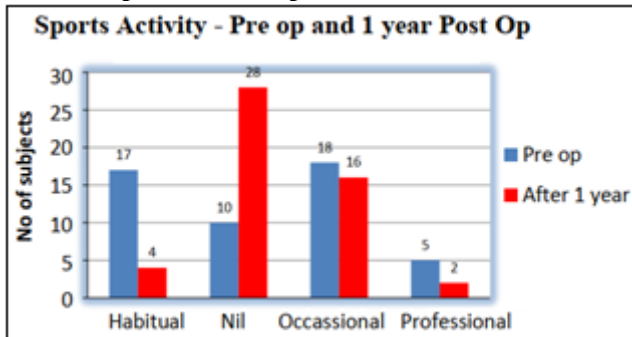


Comparison of modified Cincinnati Scores between the study groups at each time interval No statistically significant difference is found in scores between the 2 groups



**IKDC score**

Comparison of IKDC scores between the study groups at each time interval, no significant differences found

**Return to sports and occupation**

Majority of patients who were involved in high sporting activities successfully returned to their pre injury status. *The above results were compared to international standard studies (Lund et al<sup>27</sup>, Kim et al<sup>31</sup>, Han H et al<sup>16</sup>, Gorschewsky et al<sup>32</sup>) and were found to be comparable.*

**5. Results**

- Tegner Lysholm score, International Knee Documentation Committee score, Modified Cincinnati score were improved at final follow-up in both the groups. However, statistical difference was not shown.
- Though functional outcomes are comparable QTB group had less graft site morbidity.
- At the end of 1 year of follow-up, the results of all the patients were tabulated and evaluated, which revealed

significant functional improvement in the patients as evidenced by return to their pre injury status noted in > 90% of patients in the study group

**6. Complications**

- 18 patients had leakage of water during surgery as a result of breaching suprapatellar pouch, 1 case had superficial infection, 1 case had laxity and 2 patients had graft site tenderness in the QTB autograft group.
- 4 patients had anterior kneeling pain, 6 patients had numbness, hypoesthesia around graft harvest site, 3 patients had graft site tenderness and 2 patients had laxity among the BPTB autograft group.

**7. Conclusion**

- Performed under Ideal conditions, ACL Reconstruction with Modified Transtibial technique is a safe & effective technique.
- ACL Reconstruction using QTB autograft gave equally good clinical results in terms of stability and the functional scores when compared to BPTB autograft group, but with less graft morbidity like anterior kneeling pain and hypoesthesia.
- Graft harvesting in both BPTB and QTB group is technically challenging, however the chances of accidentally breaching suprapatellar pouch is very high in QTB group.
- Although QTB autograft has a single bone plug, it provides a strong and firm graft which facilitates reasonably good fixation using a soft interference screw

**8. Limitations of the present study**

- 1) The comparison between the two techniques couldn't be age and activity matched.
- 2) Lack of instrumented tension of the graft intra operatively.
- 3) Only subjective clinical assessment of patients due to non-availability of KT 1000 arthrometer.
- 4) Relatively short follow-up period to comment on the development of Degenerative changes in the knee.
- 5) The sample size of 50 patients, in spite of being statistically significant puts restriction in concluding and

generalizing the outcome for a wider population. A larger sample size with a longer follow-up of 5 years would have given a better comparison of the two techniques and the re-rupture rate.

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