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CURVED TUNNELS TECHNIQUE FOR MEDIAL PATELLOFEMORAL LIGAMENT RECONSTRUCTION: COMPARING OF FIXATION STRENGTH FOR 3 DIFFERENT TECHNIQUES FOR GRAFT FIXATION AT MEDIAL OF THE PATELLA

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Abstract: ***Purpose**– In this study, we compare the structural properties of 3 different fixation methods for a free tendon graft at the patella in the medial patellofemoral ligament (MPFL) reconstruction under cyclic loading and load to failure testing*: ***double parallel transverse tunnels, double curved tunnels, and suture anchor. Methods: Thirty porcine patella and bovine flexor tendons were divided into three groups (transverse tunnel, curved tunnel, and suture anchor) with ten patellae in each. Patella-tendon constructs were tested to failure. The maximum failure load (N) and stiffness (N/mm) were measured for each specimen of the three fixings. After that, they were analyzed, and statistics were performed with SPSS and significance set at a p-value of < 0.05. Results: The double curved tunnel technique demonstrated the highest maximum load to failure (833.29±191.87N), significantly higher than the double parallel transverse tunnel (619.09±117.1N) and suture anchor groups (349.71±31.37N). Also, the curved tunnel technique demonstrated the greatest stiffness (1060.97±244.3N/mm) with significantly greater stiffness compared to the double parallel transverse tunnel techniques (788.25±149.1N/mm) and suture anchor groups (445.26±39.94N/mm). Conclusion: The double curved tunnel technique was found to be significantly stronger than double parallel transverse tunnel technique and suture anchor fixation when comparing the ultimate failure load and stiffness***.

Keywords*:* MPFL reconstructions, Curved tunnel, Transverse tunnel, Suture anchor, Patellar fixation biomechanics.

I. INTRODUCTION

Patellar dislocation is a common disease in orthopedic surgery. The patellar dislocation can lead to injury and degeneration of the patellofemoral joint, which has a great effect on the daily life of patients. In patients with patellar dislocation, the medial patellofemoral ligament (MPFL) is the most vulnerable soft tissue.

The function of the MPFL is to protect the stability of the patella. Biomechanical studies have shown that the medial patellofemoral ligament is the most important stable structure of the knee and is the most important soft tissue to prevent patellar lateralization. Therefore, the reconstruction of (MPFL) in the patients with patellar dislocation has become the main treatment.

At present there are many surgical methods for (MPFL) reconstruction, each having advantages and disadvantages. However, few studies have reported on the biomechanical properties of the medial patellofemoral ligament after reconstruction. Injury to the medial patellofemoral ligament (MPFL) has been acknowledged recently as the major lesion responsible for patellar dislocation [1-4]. The medial patellofemoral ligament (MPFL) is the major restraint of patellar lateralization, and the ligament is approximately always ruptured in case of patellar dislocation [5]. The medial patellofemoral ligament (MPFL) is the prime passive restraint in opposition to the patella lateralization [3, 6-9]. Over the past few years, reconstruction of the MPFL using a soft tissue graft has become a focus of attention, showing good results in a clinical trial [10-14]. The medial patellofemoral ligament (MPFL) is one of the main checkreins in opposition to patella dislocation. It donates 53% to 60% of medial constraint [9, 15-17]. Multiple techniques for reconstruction of the MPFL have been described in the literature with good results; however, there is no assent as to which technique provides for the best clinical outcome [5, 18-21].

II. MATERIALS AND METHODS

Specimens

30 Fresh-frozen mature porcine patella and 30 Bovine flexor tendons were used for our study; the specimens were randomly divided into three group (10 patellae for each group) Bovine flexor tendons were used as tendon grafts. After harvesting, specimens were kept at (-80 c°) and

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thawed before testing at room temperature. We used water to keep specimens moist during testing. The tendons were prepared, resulting in a tendon graft with a diameter of 5 mm, using a tendon sizer for anterior cruciate ligament reconstruction, and a length of approximately (190-220) mm.

Study Groups

Method 1 (double parallel transverse tunnel): In this method two parallel tunnels were drilled into the medial aspect of the patella, the first tunnel was drilled in the middle aspect until it exited from the lateral side using a 5.5-mm drill bit while the other one was drilled 15-mm towards the upper pole. The graft was passed through the tunnel from the medial patella then it was passed back from the other tunnel, and then the two ends for graft were sutured to each other in the medial side of the patella (Figure 1. A)

Method 2 (double curved tunnel): In this method two semi-tunnel were drilled with 15 mm depth into the medial aspect of the patella using the patella aiming device, then two tunnels were drilled into the anterolateral (closer to the anterior) of patella until meeting the end of the previous tunnels, this tunnel with the previous tunnel made a curved tunnel. The graft was passed through these two tunnels like method 1. (Figure 1. B)

Method 3 (Suture Anchors): In this method, we fixed the tendon to the medial aspect of the patella using two 3.0*12-mm titanium suture anchors for each (Super Revo® FT and ThRevo® FT) with the nonabsorbable braided suture passed around the graft and secured with a series of 6 surgeon's knots (Fig 1. C).

In all specimens, the graft length from the medial aspect of the patella to free ends was the same for all (55mm), which is equivalent to the length of the intact MPFL in vivo [10, 17]. So, the sutured end length was 35mm for all (Fig 2).

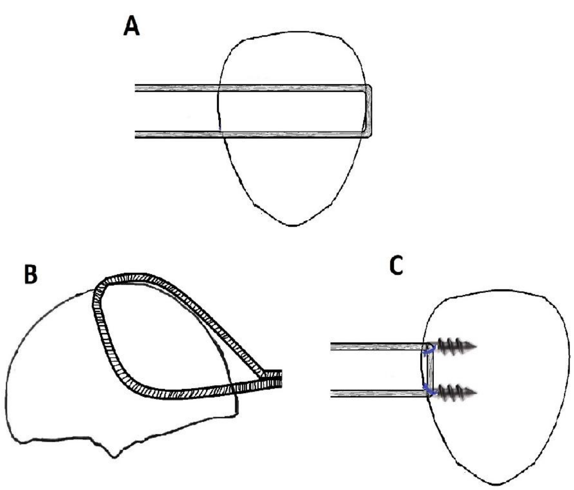

Fig 1. Schematic drawings of the groups tested:

A: double parallel transverse tunnels

B: curved tunnels

C: 2 screws suture anchors

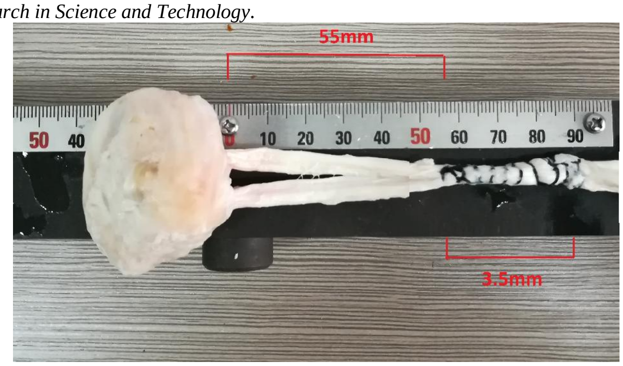

Fig. 2. the graft length from the medial aspect of the patella to free ends was the same for all (55mm), the sutured end length was 35mm for all.

In all groups, after fixation of the tendon graft to the patella, the free ends of each graft were sutured together to form a loop then held by a special soft tissue clamp connected to the testing machine (Fig 3). A fixed distance was kept between the patellae and the soft tissue clamp of the testing machine to standardize the force applied to the fixation site. Patella-tendon constructs were tested using a mechanical testing system (Trapezium X Materials Testing Software, Shimadzu, Japan) [5]. Testing was performed at room temperature, and specimens were kept moist during the testing to prevent drying [1].

Fig 3. The specimen in the material testing machine (MTS). The patella is fixed to the base of MTS, the free ends of the graft are fixed to the upper lope of MTS.

III. STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS Statistics; version 24 a. Dunnett t-tests treat one group as control and compare all other groups against it. The mean difference is significant at the 0.05 level.

Results

The double curved tunnel group demonstrated the highest maximum load (833.29±191.87N), significantly higher than the double parallel transverse tunnels group (619.09±117.1N) or suture anchor groups (349.71±31.37N). Also, the curved tunnels group demonstrated the greatest stiffness (1060.97±244.3N/mm) with significantly greater stiffness compared to the double parallel transverse tunnels group (788.25±149.1N/mm) or suture anchor groups (445.26±39.94N/mm). Two (20 %) specimens failed at the patellar side due to patellar fracture in all groups. The other specimens for groups 1 and 2 failed at the graft mid-substance. The other specimens for group 3 failed at sutures of the suture anchor (Figure 6,7,8).

Table 1. The three groups maximum load to failure, and stiffness

Group	maximum load to failure	Stiffness
Transverse tunnels	619.09±117.1N	788.25±149.1N/mm
Curved tunnels	833.29±191.87N	1060.97±244.3N/mm
Suture anchor	349.71±31.37N	445.26±39.94N/mm

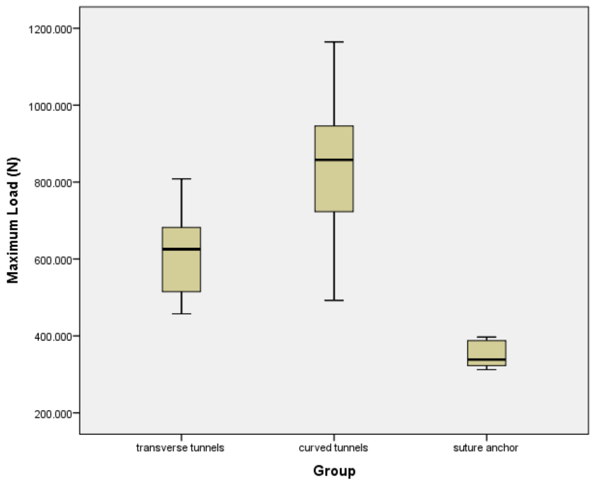

Fig 4. Maximum Load to failure (N) Stem-and-Leaf Plot for Group

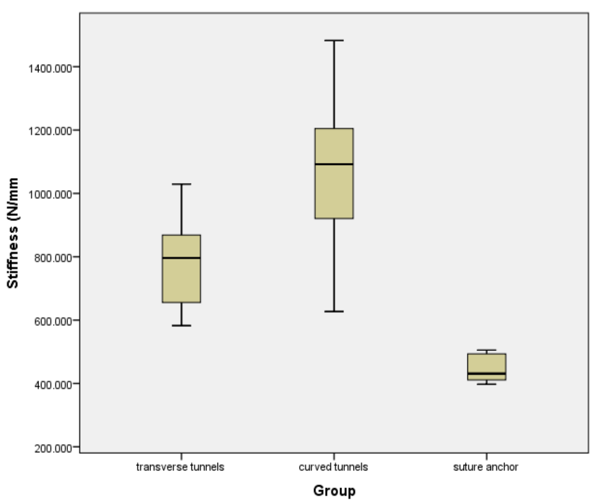

Fig 5. Stiffness (N/mm) Stem-and-Leaf Plot for Group

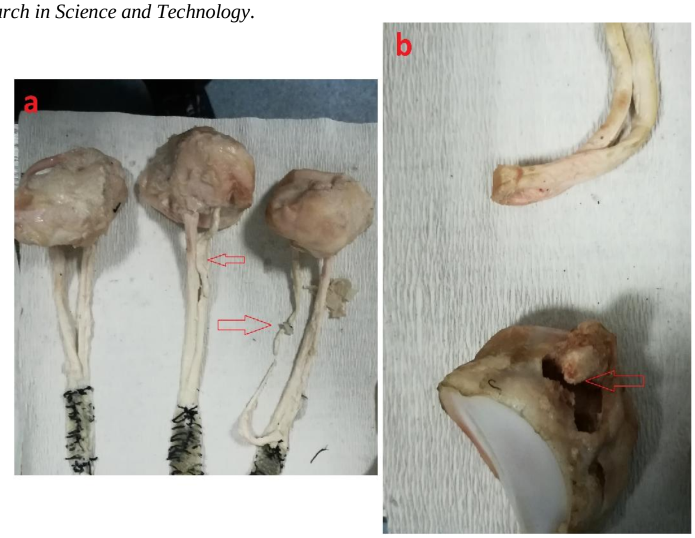

Fig 6. transverse tunnel: (a) the failure occurred in tendon graft. (b) the failure occurred in bone.

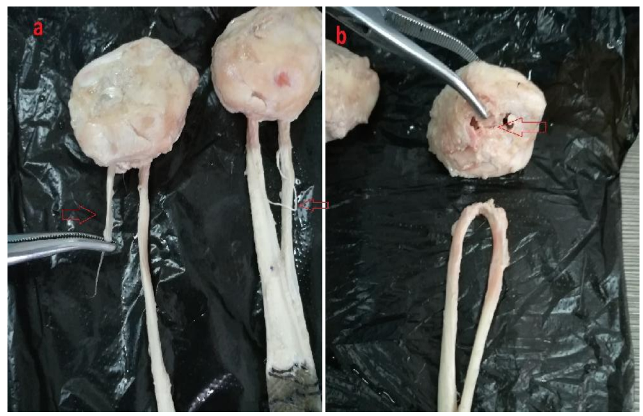

Fig 7. Curved tunnel: (a) the failure occurred in tendon graft. (b) the failure occurred in bone.

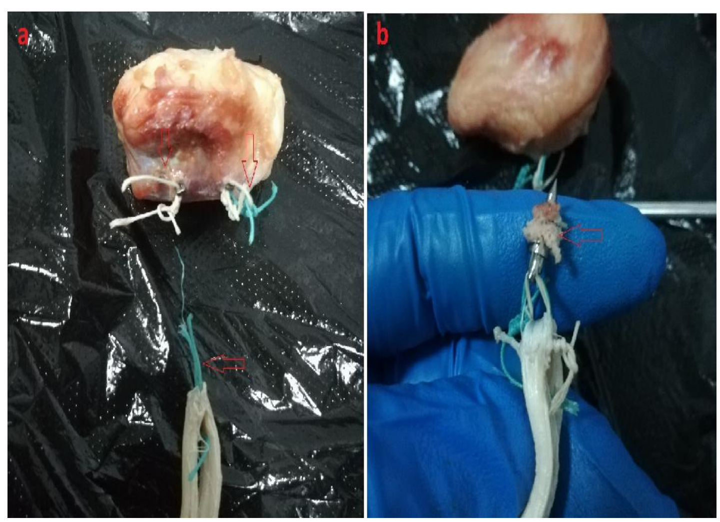

Fig 8. Suture anchor: (a) the failure occurred in sutures. (b) the failure occurred in bone.

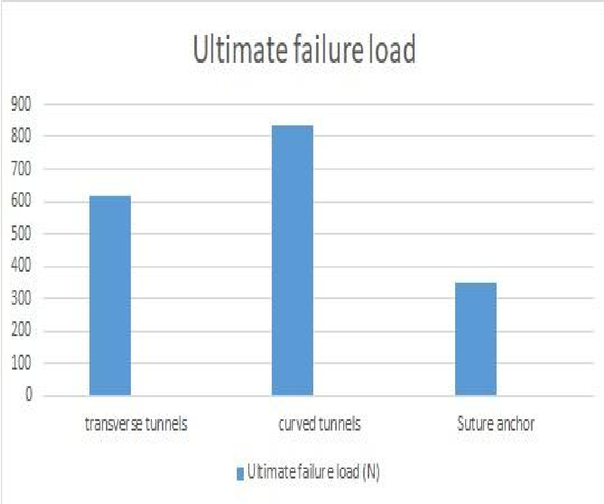

Fig 9. The mean Maximum Ultimate failure load (N) of the different methods of reconstruction

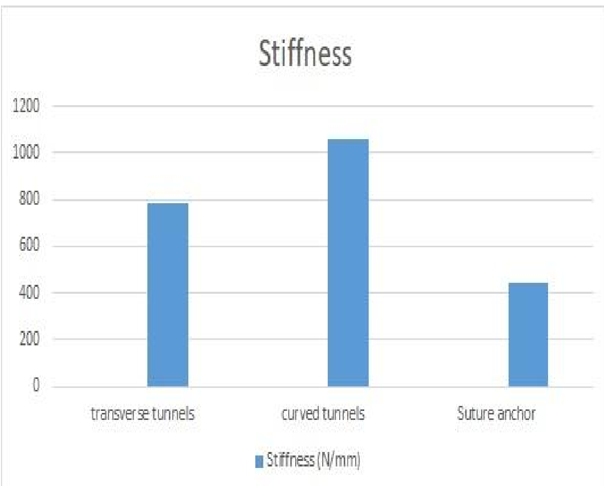

Fig 10. The mean Stiffness (N/mm) of the different methods of reconstruction

VI. DISCUSSION

In general, this study demonstrates that the patellofemoral ligament (MPFL) reconstruction by the Bone tunnel methods was better than the suture anchor method, where it was noted that the load failure and stiffness were higher in bone tunnel methods compared to the suture anchor method.
Many MPFL techniques exist, and it is unclear which technique is preferable if any. Certainly, there are many issues that must be considered when choosing which techniques would be best, including ease of use, complication rates (e.g., patellar fracture, recurrent), and cost [1, 22, 23].

It should be kept in mind that the exact fixation strength required for a successful MPFL reconstruction is unknown [1, 24]. Up to now, there has not been a consensus as to which method of patellar fixation of an MPFL graft provides the best clinical outcome. Current clinical studies have demonstrated good outcomes with multiple different fixation techniques. However, these studies are limited by small numbers and short follow-ups [11, 18, 25-29]. Bio-mechanical studies have demonstrated that the medial patellofemoral ligament (MPFL) is the main constraint against the patellar lateralization[10, 17]. The Injury to this structure often occurs in traumatic patellar dislocation which leads to recurrent dislocation [10, 30].

One of the most important constraints of this study may be the use of porcine patella, even with porcine bone has been used in multiple studies assessing different fixation techniques for free tendon grafts in the knee joint [10, 31-33].

In this study, only suture anchor fixation had the smallest reading of the three methods by measuring with the mechanical test system (MTS) when comparing the loading failure and the stiffness. While the double curved tunnel method had the biggest reading. All this shows that the curved tunnel method is the best mechanical fixation of the three methods.

Patients with recurrent patellar instabilities, the MPFL reconstruction is indicated for them. There is no agreement related to the choice of the graft, fixation, graft positioning, and the tension [5].

The patellar fracture was a specific complication due to this technique, which seems to be owing to infringement of the anterior cortex while drilling the transverse tunnels, the tunnels or accompanying bone pathologies like patella Alta and trochlear dysplasia, resulting in more dependence on the reconstructed MPFL, so secondary patellar fracture [5, 21, 34, 35].

In the current biomechanical study, the human patellofemoral ligament (MPFL) strength was found to be 208 N ± 90, and just ‘‘through the tunnel technique’’ approximated the human medial patellofemoral ligament (MPFL) strength was compared with other techniques like blind tunnel and suture anchor reconstruction. But in that study follow united reconstruction including the femoral side, failure was a result of graft slippage past the interference screw, which it was different from the current study [5, 24].

In our study, the prevailing failure mode in the tunnel group and the curved group was graft breakage, in addition to that in the previous two groups, 20% of specimens were tunnel fracture. While The suture breakage was the prevailing failure mode in the anchor suture group with a load to failure, but by comparison between the three methods, we found that the curved tunnel had the longest load failure and the biggest stiffness from the three methods. The main limitation of this study was that the experiment was performed in vitro instead of vivo.

V. CONCLUSION

The double curved tunnel fixation to the medial patella in medial patellofemoral ligament reconstruction surgery was found to be significantly stronger than double parallel transverse tunnel and suture anchor fixation when compared use ultimate failure load and stiffness.

VI. ACKNOWLEDGMENT

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Conflicts of interest

We have no conflicts of interest to declare in association with this paper.

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