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A study on tibial eminence avulsion fracture treated with minimally invasive Endobutton fixation and its functional outcome

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Abstract
Displaced tibial eminence avulsion fractures warrants a surgical intervention. Newer studies have indicated the superiority of arthroscopic fixation with intra articular button with its different tensioning material. Management of such patients of low socioeconomic population is a different challenge altogether in view of lack of resources, arthroscopic trained personnel and economic constraints. Authors describe a new technique of fixation using intraarticular button (Endobutton) and polyester 5 (Ethibond) in a peculiar fashion.
To describe the technique and to evaluate its outcome. We aimed to determine whether this fixation method could be an optimal alternative to address this fracture in such circumstances.
It is a retrospective analytical study evaluating subjective as well as objective outcome using Lachman & pivot shift test, Range of motion (ROM); functional outcome using Lysholm knee scoring scale, ability to return to work & level of satisfaction on a 10 point scale. Radiological union and limb length discrepancy (LLD) was also assessed.
The study suggested that this is a simple and effective technique with acceptable results. The study also indicates that our technique has the potential to be an optimal alternative to address this fracture in the said population. Further, it should intrigue surgeons to further evaluate and adapt the technique.

Keywords: Tibial eminence, button, endobutton

Introduction
Tibial eminence avulsion fractures predominantly occur in children and young adults [1]. It accounts for 1-5% of anterior cruciate ligament (ACL) injuries [2]. It is most commonly caused by road traffic accident (RTA), sports injuries and fall, and the most common mechanism is hyperflexion and rotation of the knee. Patients usually present with pain, swelling and decreased range of motion. Meyers & McKeever [3]. Type 3&4 being displaced fractures may result in nonunion, mal-union, knee instability and loss of knee extension. ACL, although usually has its nourishment intact from a branch of middle geniculate artery[4],may atrophies due to loss of tension caused by detachment of tibial eminence fragment thus, a definite early surgical intervention is warranted [5].
Various fixation methods [6-9] are evaluated in studies including fixation using screws, Kirschner wire, staples and sutures, both as an open surgery as well as arthroscopic. However, they are described to be associated with several complications like fragment breakage, implant breakage, loosening and migration and limited range of motion.[5,8,9,10,11] Newer studies have indicated the superiority of fixation with intraarticular button with its different tensioning material [12, 13].
The success of arthroscopic management for such fractures is well established for its minimal morbidity. However, it has a long learning curve and demands sophisticated instruments, resources and skilled. Still, a large fraction of population in developing countries like in south Asian region are in low socioeconomic strata for whom sophisticated healthcare facilities are out of reach. Management of patients from such population with tibial eminence fracture at a setup which either lacks arthroscope or trained surgeons or is unaffordable or has a very long waiting list, is a challenge. Also, most of them are young adults being the breadwinner of the family for whom delayed or denied treatment can have grave financial implications.

Thus, it is imperative to derive a method of fixation which can optimally address the problem.

The purpose of the present study was to describe an innovative, easy and economical method of fixation and evaluate its outcome with subjective and objective assessment. We aimed to determine whether this fixation method could be an optimal alternative to address this fracture in such circumstances. We applied this technique with open surgery, however it can possibly be applied with arthroscopic surgery as well. To our knowledge, no previous study has described or evaluated this unique technique of fixation with intraarticular button using #5Ethibond in a peculiar fashion in any open or arthroscopic surgery.

Materials and Methods

It is a hospital based non comparative, retrospective longitudinal analytical study done at GMC, Kota, India. Hospital data were analyzed and patients were called for follow up. The patient had given the informed consent preoperatively. All 29 patients with Meyer & McKeever grade 3 and 4 fractures admitted during April 2018-February 20 had undergone this operation and were initially considered for the study. Exclusion criteria were associated bony or ligamentous injury in and around the ipsilateral knee, reduced or abnormal mobility of the knee prior to the injury, any abnormality of either limb which may influence the final assessment. A diagnosis was made after clinical and radiological evaluation. All surgical procedures were performed under spinal or general anaesthesia.

Surgical technique

In supine position with knee in flexion, fracture was approached with medial parapatellar incision of about 4-6 cm. Intermeniscal ligament retracted anteriorly, fracture surfaces debrided, joint lavaged with normal saline and meticulously evaluated for associated injury. Provisional reduction taken and was fixed with a k wire. Two 1-2 cm skin incisions were made approximately 2-3 cm medial and lateral to the tibial tuberosity. Two guidewires were separately passed from anteromedial (AM) and anterolateral (AL) incisions to the fracture crater just medial and lateral to the center and were further advanced through the fracture fragment. 2.4 mm drill holes were created around them reaching the fracture seat and further through the fragment. For smaller fragments only one hole if possible or no hole at all was created through the fracture fragment. In such cases the holes ended at the fracture seat. A third, transverse hole was created joining the AM and AL incisions.

Now, in cases with small fragment without any hole, two sutures (#5Ethibond) in parallel were passed through the substance of the ACL root nearest to the fragment. For the cases with large fragment with one or two holes, a button mounted with two sutures was placed over the fragment. The mounting of button was such that the two sutures were in parallel i.e. in double layered fashion, first passing through the outer eyes A and D of the button, whereas second suture passing through inner eyes B and C. The button is strategically placed over the fragment in such a way that it does not hinder the knee movement. The sutures were further passed through the drilled holes using a leading loop with a needle bringing suture ends A&B to the AM side and C&D to AL side. A&B were further passed through the transverse hole towards the AL side. Another button was mounted through the suture in similar fashion so that two ends (A, D) of first suture passed through the two outer eye of the button and ends (B, C) passed through the medial eyes. Intra-articular button was pulled to the knee by keeping the ends A and D tight to maintain the device parallel with the sutures. Careful inspection and orientation were performed at that time. Also, full extension of the knee was performed to rule out impingement of the button. Knee was positioned at 30 degree of flexion with continuous posterior drawer maneuver and 5-10 degree of internal rotation. Before tensioning the construct, checking the reduction and rotating the intra-articular button to the desired angle was crucial. Buttons were tightly pressed against the bone with a probe or an artery forceps ensuring no gap in between. After a satisfactory position was obtained, suture ends B&C were tightened and knotted securely to each other. Now ends A&D were tightened and knotted. Furthermore, ends A&C and B&D were knotted separately ruling out any slippage of the knots. K wire was removed. Intraoperative images were taken ensuring the reduction and anterior laxity of the knee was evaluated. Layered closure was done in standard fashion. Cylindrical slab was applied in functional position.

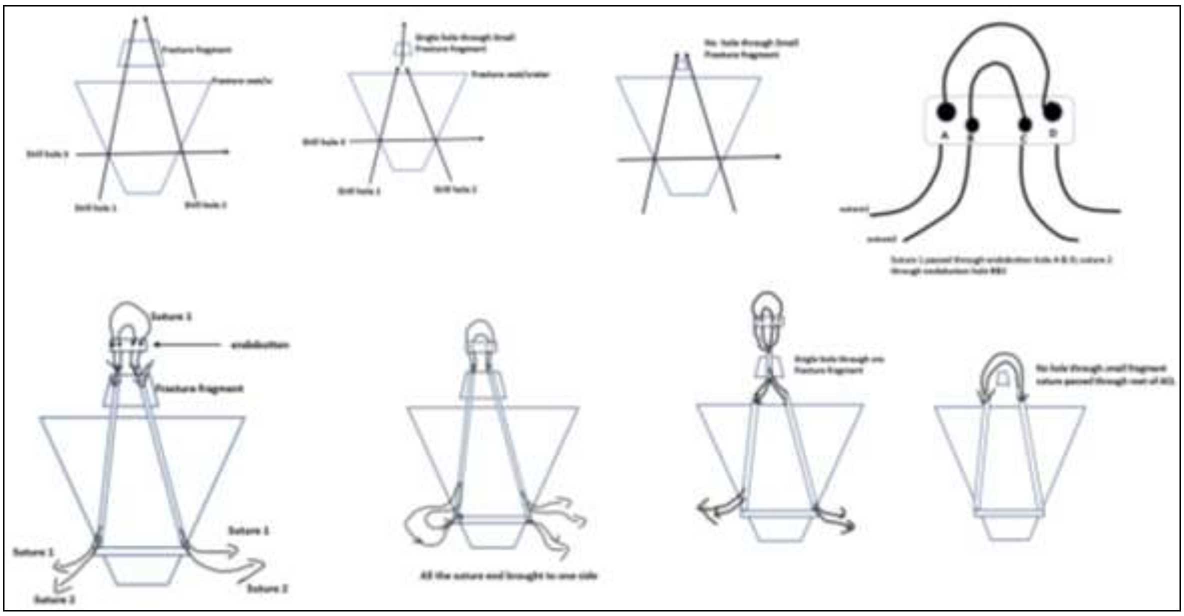

Image 1: Surgical technique

Quadriceps isometric exercise started on first post op day. After around 2 weeks, sutures were removed, 0 to 30degree range of motion (ROM) started with a hinged brace. At around 4 weeks, toe touch and partial weight bearing and ROM from 0-90 degree were allowed and progressively increased as per the tolerance of the patient. At around 2 months brace was removed, full weight bearing and complete ROM started.

Data collection

Patients hospital data were collected in a standardized protocol and the evaluation at the final follow up of all the patients were done by two separate independent research assistant who otherwise did not participate in the study. These assistants were trained by one of the authors. Data collected included detailed patient characteristics. All the patients fulfilling the inclusion criteria were called for follow up. Objective clinical evaluation using Lachman test, pivot shift test and ROM were done. Functional outcome using Lysholm knee scoring scale, ability to return to work and also radiological union were evaluated. Limb length discrepancy (LLD) was measured using bilateral Xray. Overall satisfaction was assessed by having patients to rate their satisfaction level on 1 to 10 scale; 1 being the least level of satisfaction and 10 being the highest.

Results

Although all 29 patients were considered initially, two were excluded out for not meeting the inclusion criteria. Additionally, 2 patients were lost to follow up and one patient had another RTA sustaining fracture patella of the index limb 10months postoperatively. They were excluded from the final evaluation, and thus, final assessment was done for a total of 24 patients.

Out of 27 patients 22(81.5%) were male and 5(18.5%) were female. Mean age was 19±4.16 years (range 14 – 33). Mode of injury was RTA in 21(77.5%), sports injury in 4(15 %) and rest 2(7.5%) had a history of fall from height. 16(60 %) had right side injury whereas 11(40 %) had that in left side. All were operated within a week of injury with an average delay of 4.5 days except two who had presented late (2 weeks and 3 weeks post injury). Intra articular button was used in 17(71%) patients while in rest 7(29%) it was not used as the fracture fragment was too small. Mean follow up period was 25 months (range 18-31m). Radiological examination showed that there were eighteen type-III A fractures, two type-IIIB fracture, and four type-IV fracture [4].

At final follow up, Lachman and pivot shift test were negative in all the patients. The mean active flexion was 136°±4.8° (range130°–145°) whereas average knee active extension was −2.2°±3.4° (−10° to 0°). ROM was identical with healthy side in all patients. Mean Lysholm score was 94.2±4.2 (range 84-100), of which 8 (33.3%) had good score whereas 16 (66.7%) had an excellent score. Their average satisfaction level was 9.1±0.8. All the patients had a complete functional recovery and all of them returned to work between 6 weeks to 3 months without any work modification. Radiological union was evident in all patients. None of the patients had LLD defined as a discrepancy of more than 15mm between both legs at the time of the final follow up. The mean leg-length discrepancy was 1.1±1.3mm (range0–4mm). 3 patients had knee stiffness initially which improved with physiotherapy. One patient who had first presented 3weeks postinjury, had a lag on active extension but had full passive extension. It improved with regular quadriceps strengthening exercises. Healing of one of the distal incisions was delayed by 1 week in 1 patients however, there were no wound complications of the main incision.

Table 1: Complications

Complications	No. of pt.	Grade 3	Grade 4
Knee stiffness	3	2	1
Extensor lag	1	1	0
Infection	0	0	0
Implant failure	0	0	0
Loss of reduction	0	0	0

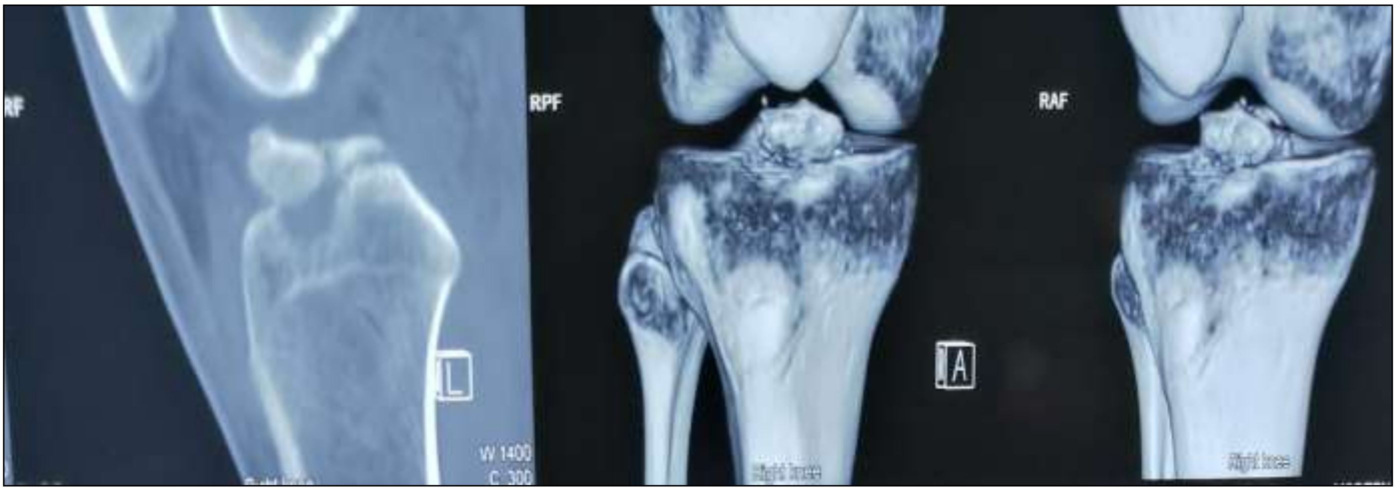

Image 2: Pre op radiograph

Image 3: Pre op radiograph

Image 4: Post op radiograph

Image 5: Clinical image

Discussion

Selecting a method of fixation in such population needs some special considerations like (a)its economical acceptance, (b)ability to allow early return to work, (c)ability to be performed at a simple setup by a surgeon with basic orthopaedic training and (d)its possible complications if not well treated. Most commonly used techniques are screw fixation and suture fixation, both showing satisfactory results [14, 15]. Screw fixation, although yields strong purchasing power & robust fixation [10, 11] it can only be applied on a large fragment. Other disadvantages are possible fracture fragmentation, screw impingement during extension & need of secondary removal procedure [1, 14]. It can also lead to physeal disruption or arrest in younger patients. In our technique, the smaller diameter (2.4mm) of the drill compared with the previously reported 3.5–4.5mm prevented physeal disturbance.

Newer studies have described good results with the technique of passing suture through the ACL substance in small or comminuted fracture and passing directly through the fragment of adequate size. Hunter and Willis[16] in a retrospective study reported the superiority of suture fixation over cannulated screws. There was a 44% reoperation rate in the screw fixation group, while it was just 13% in the suture fixation group, primarily to treat stiffness with closed manipulation.

Recent studies have inclination towards intraarticular button fixation which avoids cut through by the sutures and ensures larger implant-bone interface [13, 17]. Binnet *et al*. [18] highlighted the advantage of button technique to fix a very small fragment with the ACL without comminution and impingement. Sekiya Takatoku *et al*. [12] reported that fixation with endobutton by arthroroscopic method was strong enough to allow early rehabilitation with vigorous exercise. Pape and Giffin [13] described a technique which was later used by Menisoglu *et al*. [19] with modification of using a smaller 2.4mm drill guide and reported good outcome in a 69months long follow up. Similar to Menisoglu *et al*. [19] study none of our patients required reoperation pertaining to the complication of primary surgery.

In aforementioned techniques, a drill hole was created from the anteromedial aspect of the proximal tibia to the top of the fragment and through the ACL bundles and the suture was passed through them [13, 19]. Whereas, the authors technique was unique as (a) they used the Ethibond in double layer (b) passed it to the either side of the proximal tibia (c) the number of holes in the fracture fragment depended on its size (d) the drill was never passed through ACL. Theoretically it addresses disadvantages of previous techniques such as (1) sutures through a single hole when tightened, could result in angulation and elevation of the other end of a large eccentric fragment. (2) Even slight rotation may lead to loss of anatomical reduction, more evident in larger fragments. Fixation with two holes diverging to each other gives two point fixation, restricting even slight rotation. (3) Drilling through ACL seemed too invasive. (4) Double layered suture confers more strength needed for elder patients. The authors believed that the surgery is not just about restoring the ACL attachment to the tibia and they focused more on the stable fixation of the fragment in anatomical position. As the fracture heals, it will progressively complement the sutures to counter the distracting force of ACL.

The tensioning material used varied in different studies, few used #5 Ethibond in single layer with no report of snapping of suture [13, 19]. In situ forces of ACL was found to be 169N for normal walking in adults, which increased to a maximum of 445N while descending stairs whereas, ascending stairs as well as ascending or descending a ramp generated below 100N force [20, 21]. Also, the maximum load to failure for #5 Ethibond in single layer was found to be 247±10 N which will be doubled for double layer [22]. Thus, authors believed that fixation with #5 Ethibond in double layer would be strong enough even in elder patients to allow early mobilization. They never experienced snapping of the suture in their study.

McLennan [23]. In 1982, first advocated the advantages of arthroscopic treatment for tibial eminence fractures in terms of minimal morbidity. Since then, it has become a common practice. However, it also has certain drawbacks like being an expensive treatment, long learning curve and need of sophisticated instruments and resources. For certain population it is still out of reach. Additionally, it can also be associated with inability to achieve anatomical reduction in some cases, soft tissue entrapment between fragments, and possible tethering of fragment by an attached anterior horn of the lateral meniscus [23].

In contrast to that open reduction can be done at a basic orthopaedic center, without needing arthroscopic expertise & facilities and is less expensive. So, it has all the more practical relevance in developing countries like India. It has further advantages like it allows direct visualization of the fracture, ensures anatomical reduction and easy and accurate placement of the implant. It also gives more freedom to assess the position of the button and orientation of the holes at which the reduction is most stable and avoids impingement. In old fractures open surgery allows us well to assess and freshen the fracture margin which facilitates the union process.

With respect to Menisoglu *et al*. [19] method of arthroscopic intraarticular button fixation, our results are comparable. The mean lysholm score at final follow up was 95.7±6.6 in theirs vs 94.2 ± 4.2 in ours, evaluated as excellent in both. In both the studies, no knee instability, no LLD, no malalignment and full ROM were found at final follow up. In their study all the patients were satisfied and had no complications whereas in our study we quantitatively evaluated satisfaction to be 9.1 out of 10. Three patients having initial stiffness was attributed to poor compliance to rehabilitation schedule which improved with physiotherapy. The extension lag in one patient was possibly due to muscle weakness. All our patients primarily used Indian toilets which required them to squat for a significant period of time and thus achievement of full ROM was not difficult.

The cross-sectional area of 2.4mm holes created in our study was approximately a quarter of that of a 4.5mm and thus smaller holes avoid breakage of fragments and premature physeal closure in young patients [12]. The growing cartilage was only minutely damaged [19]. None of our patients developed any deformity or growth disturbance around knee.

Ours is a government hospital receiving a huge number of patients from low socioeconomic strata. Considering the limited resources, economic constraints and necessity to operate, we had to find an optimal solution. Backing with the mentioned references, this technique was applied on a few of the patients. Excellent early results encouraged us to continue with the same. Button and Ethibond used were easily available and affordable. Although we used this method of fixation with open surgery, it probably has the potential to be adapted with arthroscopic fixation.

The study design and findings have several strengths. (1) It has adequate sample size for describing a new procedure. Having comparable results in most of the patients indicates that it is reproducible. (2) Mean duration of follow up is 25months which, in view of usual time for complete fracture union, is believed to be long enough for the fracture to reach its final outcome. (3) Parameters of outcome evaluation were subjective as well as objective conferring it more reliability. (4) All the patients admitted with this diagnosis during this period were operated by the same method. So selection bias is ruled out. Also the research assistants did not otherwise participate in the study and thus, further ruling out the bias. It is important to consider our potential weaknesses. (1) Follow up duration is not long enough to define the long term complications like migration of button and osteoarthritis. (2) Few patients were lost to follow up as it is inevitable in any longitudinal study. (3) It is not a multicentric randomized comparative study which could have made the conclusions firm.

Conclusion

Our study results suggested that this is a simple and effective technique for treatment of tibial eminence avulsion fracture without need of advanced arthroscopic setup and is comparable to other studies. We did not find evidence that this is better than arthroscopic method of button fixation. The implications of our results are twofolds. (1) It is evident that our method has the potential to be an optimal alternative to address this fracture in the said population. (2) In view of encouraging results, the technique deserves a multicentric comparative study to further determine its merits.

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