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Management of Tibial Spine Avulsion Fractures by Open Reduction with Minimally Invasive Endo Button Fixation: A Functional Outcome Study

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Abstract:-

Background : Tibial spine avulsion fractures mostly occur in adolescents and young adults. Displaced fractures lead to non-union and increased knee instability which need surgical intervention for optimal functional outcomes. We conducted this prospective study to evaluate functional results obtained after open reduction with endo-button fixation via minimal incision in tibial spine avulsion fractures. Open procedure was performed to prove that even without arthroscopic methods, fixation of tibial spine can be done with comparable results.

Introduction: Displaced tibial eminence avulsion fractures warrants a surgical intervention. Newer studies have indicated the superiority of arthroscopic fixation over other surgical options but the management of patients falling under low socioeconomic status is a different challenge for treatment altogether because of lack of resources, arthroscopic trained personnel and equipments and economic constraints. In our study, we describe a new technique of fixation using intraarticular button (Endobutton) and polyester 5 (#5 Ethibond) in a peculiar fashion.

Aim: 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.

Materials and methods: The prospective study included 35 patients having tibial spine avulsion fractures referred to a tertiary health care centre in South Rajasthan were selected for this study. Classification of anterior tibial spine (ACL avulsion) a fracture done by Meyer and Mckeever. Patients having Meyer and McKeever type 3 and 4 were included in the study. Functional and clinical outcome measured with Lysholm knee score at final follow up.

Results: We had excellent results in 23 cases (65.71%), good in 12 cases (34.28%) according to the Lysholm score. Bony union was achieved in all patients within 3 months. All patients had a complete functional recovery and were able to return to work and to resume their activities after 6 weeks and 3 months respectively. At final follow up, the mean Lysholm score was 94.2±4.2.

Conclusion: 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 with limited orthopaedics setup and instrumentation to further evaluate and adapt the technique.

I. INTRODUCTION

In adults, tibial eminence avulsion fracture is a synonym for anterior cruciate ligament (ACL) rupture.]. Itaccounts for 1-5% of anterior cruciate ligament (ACL) injuries. It is most commonly causedby road traffic accident (RTA), sports injuries and fall. The most prevalent injury mechanism is hyperflexion and rotation, which may occur when a skier falls back when landing after a jump. Swelling, discomfort, and reduced range of motion are among the patient's symptoms. As commonly seen with significant anterior cruciate ligament (ACL) damage, the Lachman or anterior drawer test is positive.Meyer's and McKeever classified these fractures as type I (nondisplaced or little displaced), type II (elevated fractures with intact posterior half of eminence), type IIIa (totally displaced eminence fractures without rotation), and type IIIb (displaced eminence fractures with rotation). Zaricchanged that categorization such that a comminutedfracture is classed as type IV. Meyers & McKeeverType 3&4 being displaced fractures mayresult in nonunion, mal-union, knee instability and loss of knee extension. ACL, althoughusually has its nourishment intact from a branch of middle geniculate artery,may atrophy due to loss of tension caused by

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detachment of tibial eminence fragment thus, a definite earlysurgical intervention is needed.Some writers advocated using computed tomography (CT) or magnetic resonance imaging as supplementary diagnostic imaging to confirm the diagnosis and assess concomitant soft-tissue injury. Various fixation methods 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, implantbreakage, loosening and migration and limited range of motion. Newer studies haveindicated the superiority of fixation with intraarticular button with its different tensioningmaterial.The success of arthroscopic management for such fractures is well established for its minimalmorbidity. 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 southAsian region are in low socioeconomic strata for whom sophisticated healthcare facilities areout of reach. Management of patients from such population with tibial eminence fracture at asetup which either lacks arthroscope or trained surgeons or is unaffordable or has a very longwaiting list, is a challenge.Open reduction with endobutton fixation with a small incision produces comparable outcomes to arthroscopy while requiring less specialised equipment and personnel. The purpose of the present study was to describe aninnovative, easy and economical method of fixation andevaluate its outcome with subjective and objectiveassessment after open reduction with endobutton fixation by minimum incision in tibial spine avulsion fractures.To our knowledge, no previous study hasdescribed or evaluated this unique technique of fixation withintraarticular button using #5Ethibond in a peculiar fashion inany open or arthroscopic surgery.

II. MATERIALS AND METHODS

After receiving clearance from the protocol review committee and the institutional ethics committee, this research was carried out at the Department of Orthopaedics, Government Medical College, Kota, India.It was a hospital based, prospective, functional outcome based study done at Government Medical College, Kota , India .A total of 35 patients with Meyer & McKeever grade 3 and 4 fractures admitted during February 2020-February 2023 had undergone this operation and were considered for the study.Hospital data were analysed and patients were called for follow up. The patient had given the informed consent preoperatively. Inclusion criteria consisted of patients having tibial spine avulsion fractures Types 3 and 4 Meyer and McKeever. Exclusion criteria were patients having associated bony or ligamentous injury in and around the ipsilateral knee, patients suffering from ipsilateral meniscal injury,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.

III. SURGICAL TECHNIQUE

After MRI evaluation, informed consent was taken for surgery. After spinal anesthesia the patient was placed on the supine position on the operative table . 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 using 2.4 mm cannulated drill bit, 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 site. 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. Intraarticular 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 intraarticular 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. Quadriceps isometric exercise started on first post op day. Sutures were removed on 12th -15th postoperative day. The knee brace is worn for a total of 8 weeks and held in extension during first two weeks, with gradually

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increased range of motion. Weight- bearing is recommended after suture removal postoperatively. Partial weight bearing recommended after suture removal and full weight bearing. After 4 weeks postoperatively ,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. Regular follow up of all cases was done at 6 weeks, 3 months, 6 months, 9 months and one year. At each follow up patients were evaluated clinically using the Lysholmscore and radiologically with appropriate X-rays.

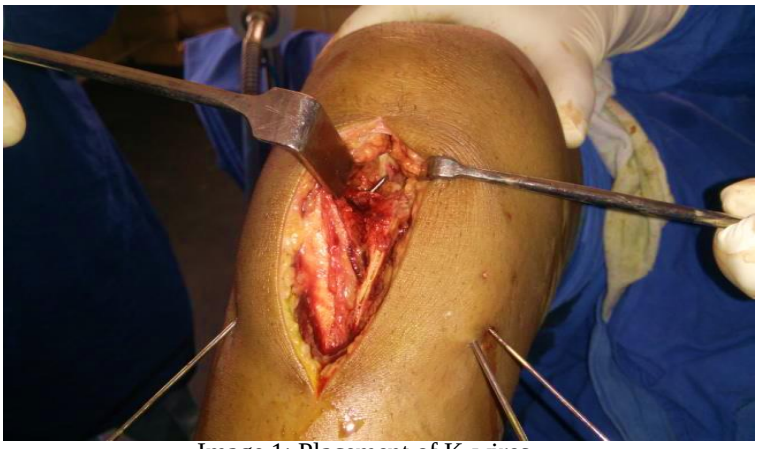
Image 1: Placement of K-wires

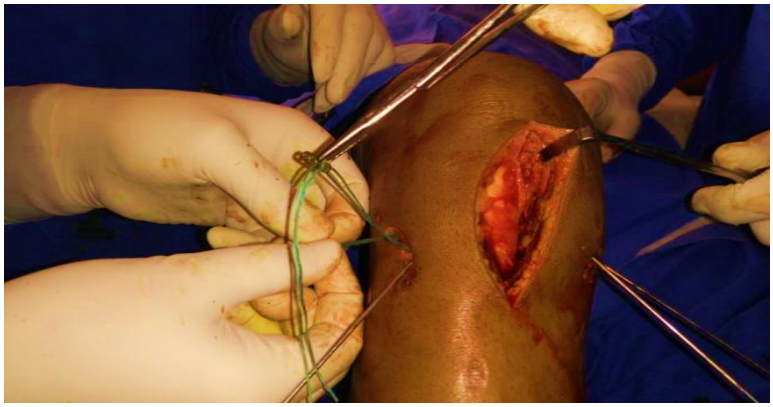
Image 2: Pushing endobutton through the drilled hole in the tibia

IV. RESULTS

Although all 40 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 postoperatively and died unfortunately. They were excluded from the final evaluation, and thus, final assessment was done for a total of 35 patients. Out of 35 patients 29(82.8%) were males and 6(17.2%) were females. Mean age of patients at the time of was 19±4.16 years (range 14 – 33). Mode of injury was RTA in 25 (71.4%), sports injury in 6 (17.1 %) and rest 4 (11.5%) had a history of fall from height. 21 (60 %) patients hadright side injury whereas 14 (40 %) had that in left side.All the patients 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). Radiological examination showed that there were 25 (71.5 %) type-III A fractures, 3 (8.5%) type-IIIB fracture, and 7 (20%) type-IV fracture.Intra articular button was used in 31 (88.6%) patients while in rest 4 (11.4%) it was not used as the fracture fragment was too small. Mean follow up period was 25 months (range 18-31m).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. Mean Lysholm score was 94.2±4.2 (range 84-100), of which 23 (65.7%) had an excellent scorewhereas 12 (34.3%) had good score. 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. No joint stiffness was observed at follow up. Full flexion was obtained after the procedure and no restriction in ROM was observed. 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 Limb Length Discrepancy (defined as a discrepancy of more

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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 3 weeks post injury, 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 of the patients however, there were no wound complications of the main incision.

Table 1: Outcome of the patients

Outcome(Scorerange)	Numberofpatient	Percentage
Excellent(94-100)	23	66
Good(84-93)	12	34
Fair (65-83)	0	0
Poor(<65)	0	0

Image 3: Complete active knee flexion by the patient

Image 4: Complete active knee extension by the patient

Image 5: Preoperative CT scans showing tibial spine avulsion fractures

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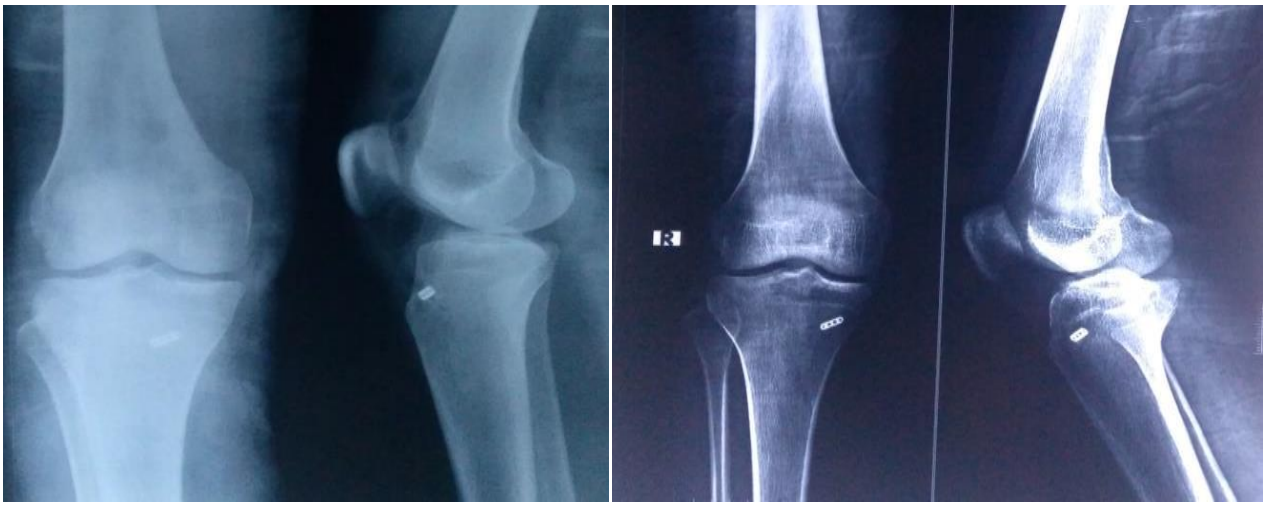

Image 6: Post-operative x-rays showing endobutton placement

V. DISCUSSION

Selecting an ideal method of fixation in a population of low socio-economic status needs somespecial considerations like (a)its economical acceptance,(b)ability of the patients to return to workearly, (c)to beperformed at a simple setup by a surgeon with basicorthopaedic instruments,training and skills (d) possible complications of surgery if not performed properly. Most commonly used techniques are screwfixation and suture fixation, both showing satisfactory results[14, 15]. Screw fixation, although yields strong purchasingpower & robust fixation [10, 11] it can only be applied if thefragmentis large enough to not get fragmentedby the use of drill. Other disadvantages include possible screw impingement during extension & needof secondary removal procedure [1, 14]. It can also lead tophyseal disruption or growth arrest in younger patients. In ourtechnique,we useda small 2.4mm diameter of the drill comparedwith the previously used 3.5–4.5mm drills , which causedphysealdisturbance. Thus, no physeal injury was observed in our study.. Pape andGiffin [13] described a technique which was later used byMenisoglu et al. [19] with modification of using a smaller2.4mm drill guide and reported good outcome in a 69monthslong follow up. Hunter and Willis[16] in aretrospective study reported the superiority of suture fixationover cannulated screws. There was a 44% reoperation rate inthe screw fixation group, while it was just 13% in the suturefixation group, primarily to treat stiffness with closedmanipulation.Recent studies have shown inclination towards intraarticular buttonfixation which avoids cut through by the sutures and ensuresa larger implant-bone interface [13, 17]. Binnet et al. [18]highlighted the advantage of button technique to fix a verysmall fragment with the ACL without comminution andimpingement. Sekiya Takatoku et al. [12] reported that fixationwith endobutton by arthroroscopic method was strong enoughto allow early rehabilitation with vigorous exercise Similar to Menisoglu et al. [19] study none ofour patients required reoperation pertaining to thecomplication of primary surgery.In aforementioned techniques, a drill hole was created fromthe anteromedial aspect of the proximal tibia to the top of thefragment and through the ACL bundles and the suture waspassed through them [13, 19]. Whereas, the authors techniquewas unique as (a) they used the Ethibond in double layer (b)passed it to the either side of the proximal tibia (c) the numberof holes in the fracture fragment depended on its size (d) thedrill was never passed through ACL. Theoretically itaddresses disadvantages of previous techniques such as (1)sutures through a single hole when tightened, could result inangulation and elevation of the other end of a large eccentricfragment. (2) Even slight rotation may lead to loss ofanatomical reduction, more evident in larger fragments.Fixation with two holes diverging to each other gives twopoint fixation, restricting even slight rotation. (3) Drillingthrough ACL seemed too invasive. (4) Double layered sutureconfers more strength needed for elder patients. The authorsbelieved that the surgery is not just about restoring the ACLattachment to the tibia and they focused more on the stablefixation of the fragment in anatomical position. As thefracture heals, it will progressively complement the sutures tocounter the distracting force of ACL.The tensioning material used varied in different studies, fewused #5 Ethibond in single layer with no report of snapping ofsuture [13, 19]. In situ forces of ACL was found to be 169N fornormal walking in adults, which increased to a maximum of445N while descending stairs whereas, ascending stairs aswell as ascending or descending a ramp generated below100N force [20, 21]. Also, the maximum load to failure for #5Ethibond in single layer was found to be 247±10 N which willbe doubled for double layer [22]. Thus, authors believed thatfixation with #5 Ethibond in double layer would be strongenough 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 ofarthroscopic treatment for tibial eminence fractures in termsof minimal morbidity. Since then, it has become a commonpractice. However, it also comes with certain drawbacks like being anexpensive treatment, long learning curve and need ofsophisticated instruments and resources. For certainpopulation it is still out of reach. Additionally, it can also beassociated with inability to achieve anatomical reduction insome cases, soft tissue entrapment between fragments, andpossible tethering of fragment by an attached anterior horn ofthe lateral meniscus [23].In contrast to that open reduction can be done at a basicorthopaedic center, without needing arthroscopic expertise &facilities and is less expensive. So, it has all the more practicalrelevance in

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developing countries like India. It has furtheradvantages like it allows direct visualization of the fracture,ensures anatomical reduction and easy and accurateplacement of the implant. It also gives more freedom to assessthe position of the button and orientation of the holes at whichthe reduction is most stable and avoids impingement. In oldfractures open surgery allows us well to assess and freshen thefracture margin which facilitates the union process.With respect to Menisoglu et al. [19] method of arthroscopicintraarticular button fixation, our results are comparable. Themean lysholm score at final follow up was 95.7±6.6 in theirsvs 94.2 ± 4.2 in ours, evaluated as excellent in both. In boththe studies, no knee instability, no LLD, no malalignment andfull ROM were found at final follow up. All our patients primarilyused Indian toilets which required them to squat for asignificant period of time and thus achievement of full ROMwas not difficult.The cross-sectional area of 2.4mm holes created in our studywas approximately a quarter of that of a 4.5mm and thussmaller holes avoid breakage of fragments and prematurephyseal closure in young patients [12]. None of our patientsdeveloped any deformity or growth disturbance around knee.Ours is a government hospital receiving a huge number ofpatients from low socioeconomic strata. Considering thelimited resources, economic constraints and necessity tooperate, we had to find an optimal solution. Backing with thementioned references, this technique was applied on a few ofthe patients. Excellent early results encouraged us to continuewith the same. Button and Ethibond used were easilyavailable and affordable. Although we used this method offixation with open surgery, it probably has the potential to beadapted with arthroscopic fixation.The study design and findings have several strengths. (1) Ithas adequate sample size for describing a new procedure.Having comparable results in most of the patients indicatesthat it is reproducible. (2) Mean duration of follow up is25months which, in view of usual time for complete fractureunion, is believed to be long enough for the fracture to reachits final outcome. (3) Parameters of outcome evaluation weresubjective as well as objective conferring it more reliability.(4) All the patients admitted with this diagnosis during thisperiod were operated by the same method. So selection bias isruled out. Also the research assistants did not otherwiseparticipate in the study and thus, further ruling out the bias.

VI. CONCLUSION

Open reduction and internal fixation of anterior tibial spine (anterior cruciate ligament) avulsion with endobutton provides a satisfactory functional outcome,ease of application of sutures, direct visualization of reduction, stable osteosynthesis which enables early range of motion. This procedure does not require implant removal and allows early weight bearing and rehabilitation. Moreover it has a less learning curve and cost effective modality which provides equally good results with other available modalities.

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