Brunei International Medical Journal

OFFICIAL PUBLICATION OF
THE MINISTRY OF HEALTH
AND
UNIVERSITI BRUNEI DARUSSALAM

Volume 18 2 January 2022 (28 Jamadilawal 1443H)

CLINICAL AND RADIOLOGICAL OUTCOME AFTER TIBIAL TUBEROSITY AVULSION FRACTURES IN ADOLESCENTS.

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ABSTRACT

Introduction: Avulsion fractures of tibial tuberosity are rare and account for 3% of all epiphyseal injuries. This retrospective study was done to assess clinical and radiological outcome of these injuries in Brunei Darussalam. **Materials and Methods:** Fourteen patients who were treated for tibial tuberosity avulsion fracture in Raja Isteri Pengiran Anak Saleha (RIPAS) Hospital between 2010 to 2020 were assessed clinically and radiologically. Patient's age, gender, mechanism of injury, side involved, and treatment and any complication of treatment were recorded. Fractures were classified using the Ogden classification. **Results:** All 14 patients were adolescent males whose fractures resulted from landing from a high jump, jogging, running or sprinting during football or kicking during *sepak takraw* and *wushu*. All fractures were treated by open reduction and internal fixation. Outcome was rated as excellent in 8 and fair in 6 patients due to residual pain from prominent screw or limitation of movements. No significant difference was found in the outcome of patients between different fracture types. **Conclusion:** Tibial tuberosity avulsion fractures are rare. Satisfactory outcome was consistently obtained by open reduction and internal fixation. Few patients had residual problems but this did not have any negative impact on their outcome.

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Brunei Int Med J. *2022;18:1-8*

ISSN 1560 5876 Print
ISSN 2079 3146 Online

Online version of the journal is available at www.bimjonline.com

Brunei International Medical Journal (BIMJ)
Official Publication of
The Ministry of Health
and
Universiti Brunei Darussalam

ISSN 1560-5876 Print
ISSN 2079-3146 Online

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Acknowledgements

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ABSTRACT

Introduction: Avulsion fractures of tibial tuberosity are rare and account for 3% of all epiphyseal injuries. This retrospective study was done to assess clinical and radiological outcome of these injuries in Brunei Darussalam. **Materials and Methods:** Fourteen patients who were treated for tibial tuberosity avulsion fracture in Raja Isteri Pengiran Anak Saleha (RIPAS) Hospital between 2010 to 2020 were assessed clinically and radiologically. Patient's age, gender, mechanism of injury, side involved, and treatment and any complication of treatment were recorded. Fractures were classified using the Ogden classification. **Results:** All 14 patients were adolescent males whose fractures resulted from landing from a high jump, jogging, running or sprinting during football or kicking during *sepak takraw* and *wushu*. All fractures were treated by open reduction and internal fixation. Outcome was rated as excellent in 8 and fair in 6 patients due to residual pain from prominent screw or limitation of movements. No significant difference was found in the outcome of patients between different fracture types. **Conclusion:** Tibial tuberosity avulsion fractures are rare. Satisfactory outcome was consistently obtained by open reduction and internal fixation. Few patients had residual problems but this did not have any negative impact on their outcome.

Keywords: Adolescent, Avulsion, Salter-Harris Fractures, Tibia fractures, Tibial tuberosity fracture.

INTRODUCTION

Most commonly quoted figures in literature suggest that avulsion fracture of tibial tuberosity make up 0.4 to 2.7% of paediatric fracture and less than 3% of all epiphyseal injuries.[1,2] These are typically seen in boys more often than in girls with a ratio of 10:1 and around the age of 14 years. [1]

Pretell-Mazzini *et al* in 2016 published a systematic review on tibial tubercle fractures in a cohort of pediatric patients, with a mean age at surgery of 14.6 years, between 1970 and 2013.[3] According to Ogden Classification described later, Type III was the most common type with associated injuries noted in 4.1 % cases. Compartment syndrome was seen in

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3.57% of cases. A total of 98% of cases were treated surgically and equal number of patients returned to preinjury activity and knee range of movements, irrespective of the fracture type. The overall complication rate was 28.3% with bursitis due to prominent implant being the most common in more than 50% of cases. Since the publication of the above review, few cases series have been added to the literature with similar observations. [4,5]

This study was done to look at the epidemiology, management and outcome of treatment of avulsion fracture of the tibial tuberosity in Brunei Darussalam where this information is lacking.

MATERIALS AND METHODS

Patients with avulsion fracture of the tibial tuberosity treated at Raja Isteri Pengiran Anak Isteri Saleha (RIPAS) Hospital between 2010 to 2020 were included for retrospective study. Of the 15 patients, adequate information could be obtained on 14 cases and they agreed to take part in the study. Demographic details were obtained from patient's electronic medical records after 2013.

All the cases were treated by open reduction and internal fixation using various implants based on the pattern of injury and surgeon's preference. Postoperatively the limb was immobilized in extension for 8 to 12 weeks followed by range of motion and strengthening exercises. Return to play was allowed when adequate strength and full range of movements were achieved.

Clinical evaluation: Nine patients out of fourteen were available for clinical review done by the senior author. One patient had his review done by email because he was overseas while in the remaining 4 it was based on the last recorded notes in the Brunei Health Information Management System (Bru-HIMS). The clinical outcome was graded as per criteria used by Abalo *et al* given in Table I.[6]

Table I: Clinical evaluation criteria.

Results	Criteria
Excellent	Full range motion, asymptomatic, full activity
Fair	<10°decreased range of motion, symptomatic with vigorous activity, full activity
Poor	>20°decreased range of motion, symptomatic with daily or minimal activity

Radiographic evaluation: Preoperative radiographs were available for nine patients out of the fourteen. These were used for the classification of injury using the Ogden Classification.[7] (Table II and Figure 1) In the remaining, the type of fracture was determined from their operatve records or immediate post-operative or most recent radiograph. Follow-up radiographs were used to detect any deformities such as genu recurvatum compared to the uninjured side.

The data was analysed using R Studio Version 3.6.2 for Asus. Descriptive statistics is used to present the various epidemiological variables. Frequency and percentages were calculated for categorical data. Fisher's exact test was used to compare outcomes between different fracture types. A *p*-value of less than 0.05 was considered as significant.

Table II: Table II. Classification of tibial tuberosity avulsion fractures (Ogden *et al*.)[7]

Type	Description
IA	Fracture distal to the junction of ossification centre of proximal tibial epiphysis and tibial tubercle
IB	Same as Type IA + comminution of fracture fragment
IIA	Fracture extending to the junction between proximal tibial epiphysis and tibial tubercle
IIB	Same as Type IIA + comminution of fracture fragment
IIIA	Fracture extending into the joint through proximal tibial epiphysis with displacement
IIIB	Same as Type IIIA + comminution of fracture fragment

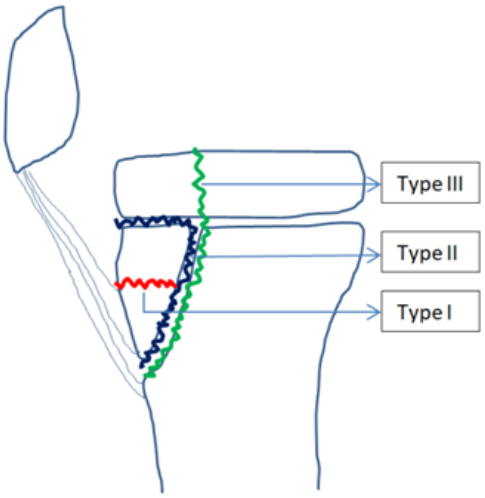

Figure 1: Schematic diagram for Ogden Classification.[7] (Click on image to enlarge)

The study was approved by the joint committee of the Institute of Health Sciences Research Ethic Committee and the Medical and Health Research Ethics Committee.

RESULTS

The clinical and epidemiological features are summarized in Table III. All 14 patients were boys with an average age at the time of injury of 13.8 years (range 12 to 16 years). The median follow up was 24 months (range 7 to 120 months). The right side was involved in 9 and left in 4 cases.

All patients were treated with open reduction and internal fixation (ORIF). The method of fixation was based on the type of fracture and surgeon's preference. The various types of fractures and methods of fixation used are given in Table III. (Figure 2 and Figure 3)

Additional injuries noted were partial avulsion of patellar tendon (Case 7) in association with Type IIIB fracture (Figure 4) and medial meniscal avulsion (Case 13) in association with Type IIIA fracture. These were treated with additional procedure of repair using suture anchor (Figure 2) and medial meniscal repair respectively. Case 2 underwent arthroscopy at the time of removal of implants for knee pain related to medial synovial plica.

The average return to play was 28.5 weeks (range 12 to 48 weeks). Implant removal was done in 7 patients by the time of last follow-up.

Excellent outcome was observed in 8 cases while the remaining had fair outcome. In 3 cases the fair outcome was due to anterior knee pain from the prominent screw in patients who did not undergo removal of implant while in 3 cases it was due to terminal limitation of knee flexion. One case was rated as fair due to limitation of movements as the follow-up was only 8 months after surgery and patient was still attending rehabilitation. Some degree of persistent wasting of quadriceps was noted on critical assessment in 5 cases but with no effect on the strength of the quadriceps. There was no difference in the outcome between different fracture types (Table IV).

Complications noted at follow up included pain from prominent screw (3 cases) and limitation of movements (2 cases) giving a complication rate of 36%. None of the patients developed compartment syndrome. On followup radiographs none of the cases had evidence of growth disturbance in the form of genu recurvatum.

DISCUSSION

We have reported successful clinical and radiological outcome in 14 cases of tibia tuberosity avulsion fractures treated in Brunei Darussalam. Complication like pain from prominent screw and limitation of flexion were noted in 36% of cases. The findings of the present study concerning the age and gender distribution, mechanism of injury, method of internal fixation and satisfactory outcome in all

Table III: Patient demographics and clinical data (n=14)

Case	Age at injury	Gender	Fracture type	Side	Injury mechanism	Treatment	Implants	Return to Play (weeks)	Removal of Implants	Follow-up (months)	Clinical outcome
1	13	M	IB	R	Landing from high jump	ORIF	2 screws	12	Yes	48	Excellent
2	13	M	IIIA	R	Running	ORIF	2 screws	48	Yes	48	Excellent
3	14	M	IB	R	Running during football	ORIF	2 screws	24	No	24	Excellent
4	12	M	IIIA	R	Running	ORIF	2 screws	52	Yes	24	Excellent
5	13	M	IIIB	L	Fall from height	ORIF	2 screws Buttress plate / 3 screws	No data	Yes	24	Excellent
6	15	M	IIIB	R	Jogging	ORIF	2 screws	48	No	12	Excellent
7	15	M	IIIB	L	Running	ORIF	3 screws	28	Yes	36	Excellent
8	13	M	IB	L	*Kicking during Sepak takraw*	ORIF	2 screws Buttress plate / 2 screws	24	No	8	Fair
9	14	M	IB	R	Fall from height	ORIF	1 screw	12	Yes	12	Fair
10	16	M	IIA	R	Sprinting	ORIF	1 screw	48	No	120	Fair
11	15	M	IIA	R	Running during football	ORIF	2 screws	32	No	96	Fair
12	14	M	IIIA	L	Running during football	ORIF	2 screws	12	No	96	Fair
13	13	M	IIIA	R	Running during football	ORIF	2 screws	24	No	7	Excellent
14	14	M	IIIB	R	Kicking during w*ushu*	ORIF	3 screws, 3 wires	No data	Yes	11	Fair

M = Male; R = Right; L = Left; ORIF = Open reduction and internal fixation.

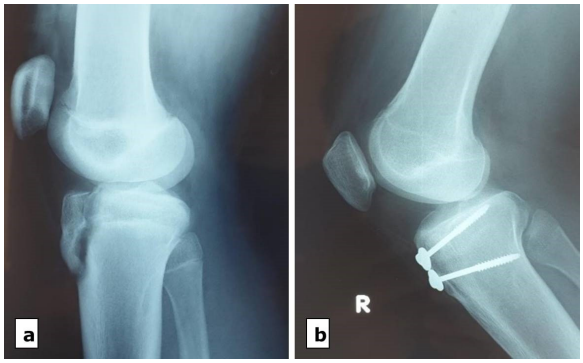

Figure 2: Case 2 a) Preop: Type IIIA fracture, b) Postop: fixation done by 2 screws. (Click on image to enlarge).

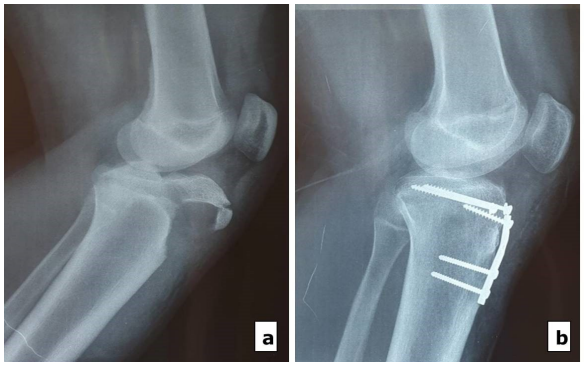

Figure 3: Case 5 a) Preoperative - Type IIIB fracture, b) Postoperative - fixation done by screws and buttress plate. (Click on image to enlarge).

cases is in agreement with the literature. [3, 5]

Ogden *et al* described the development of tibial tubercle in 4 stages namely cartilaginous, apophyseal, epiphyseal and osseous. [8] After the apophyseal stage, with the maturity of secondary centre for ossification of the tubial tubercle, the fibrocartilage is replaced by columnar hypertrophic cartilage from proximal to distal direction. This is a weaker zone of cartilage which fails under tensile stress just before or during the physiologic epiphysiodesis stage, typically seen in girls between 10 to 15 years and in boys between 11 to 17 years.

Boys are more likely to sustain avulsion fracture of tibial tuberosity with a male to female ratio of 10:1. [1, 3, 9] This has been explained on the basis of later physiologic epiphysiodesis in boys. Also due to larger

Table IV: Fracture types and outcome.

Fracture Type	n	Excellent n (%)	Fair n (%)	*p*-value[a]
Ogden IB	4	2 (50.0)	2 (50.0)	0.53
Ogden IIA	2	-	2 (100.0)	
Ogden IIIA	4	3 (75.0)	1 (25.0)	
Ogden IIIB	4	3 (75.0)	1 (25.0)	

Fisher's exact test

body frame and stronger quadriceps, there is higher stress on the tibial tubercle in boys. [10, 11] In the literature, there is a predominance of left-sided tibial tuberosity avulsions. [11] Bolesta and Fitch (1986) hypothesised that this preponderance may be due to the affected adolescents leading with their left leg in sports.[12] In our study, there were more right-sided fractures. However, this study had a small sample size to determine if there is any preponderance on the left or right side.

Consistent with the present study, tibial tuberosity avulsion fractures are reported with various sports ranging from basketball, high jump to football, gymnastics etc. and 2 mechanisms have been proposed; i. knee flexion with contracting quadriceps as occurring during landing from a jump or ii. powerful contraction of quadriceps against a fixed foot as seen during jumping. [9] It is suggested that the type of resulting fracture and intra-articular involvement depends on the degree of knee flexion at the time of injury. [3, 4] Type III fractures are the most common injury reported in review of avulsion fractures of tibial tuberosity.[3] In the present series 8/14 cases had type III injury.

The aim of treatment of avulsion fracture of tibial tuberosity is to obtain satisfactory reduction and healing. The non-displaced fractures are treated by non-weight bearing immobilization for about 6 weeks. Checa Betegon *et al* (2019) and Mo and Wang (2020) have reported successful conservative treatment of even Type IV fractures and reserved

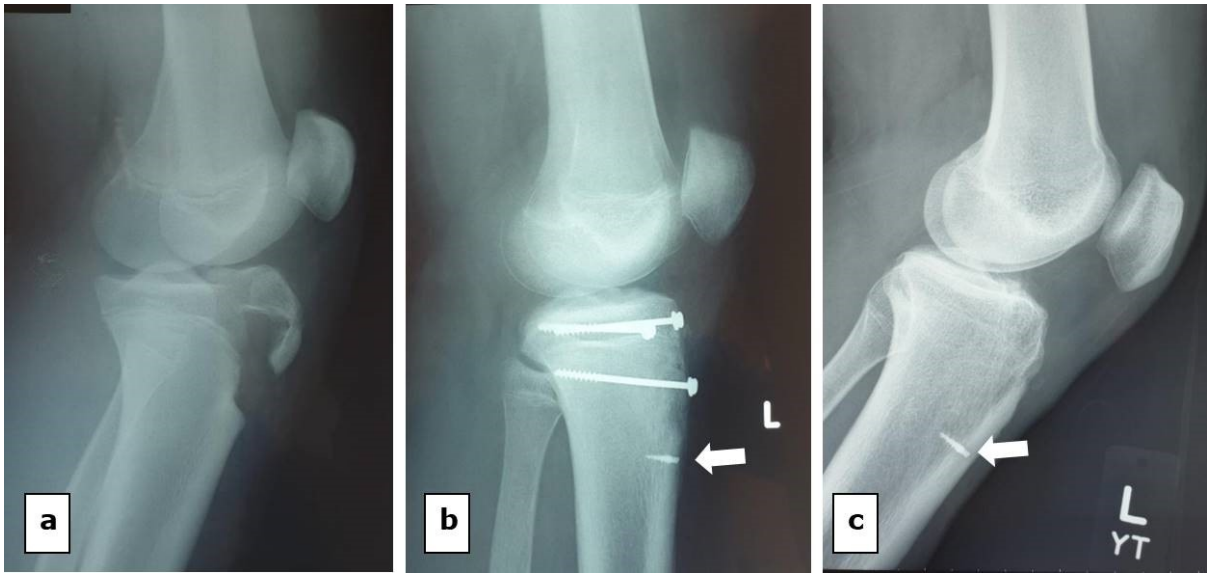

Figure 4: Case 7 a) Pre-op: Type IIIB fracture with partial avulsion of patellar tendon, b) Post-op: fixation done by 3 screws, tendon repair by using suture anchor (arrow), and c) last follow-up after removal of screws.

surgery for cases where satisfactory closed reduction could not be obtained. [4, 5] In case of displaced fractures, surgery is indicated with a view to obtain good reduction with restoration of articular component and extensor mechanism as well as address associated intra-articular injury. [1, 3, 9] Various methods of fixation reported in the literature include cancellous screws with or without washers, Kirschner wires, tension band wiring, suture repair of tendon avulsion and supplemental buttress plate fixation. [1] Arkader *et al* (2019) reported similar results with unicortical and bicortical screw fixation. [13] Most authors have reported good clinical outcome after treatment of avulsion fractures of tibial tuberosity irrespective of the type. [3, 5] All the patients in the present study underwent open reduction and internal fixation with a variety of internal fixation devices.

Various associated injuries have been reported with avulsion fracture of tibial tuberosity. These range from soft tissue or periosteal damage, patellar tendon rupture, distal pole of patella fracture, capsular or coronary ligament disruption, meniscal or articular cartilage injury. [1, 14, 15] Patellar tendon avulsions and meniscal tears have been reported in 10 -20 % of avulsion fractures of tibial tuberosity. [5] Associated injuries are seen with marked displacement and with type III or IV fractures. [9, 14] CT scan has been recommended to obtain greater details on the injury while MRI is used in cases of suspected meniscal injury. [2, 14] Arthroscopy or arthrotomy has been suggested if the intra-articular involvement is recognized pre-opreratively. [14] We had 2/14 cases (14%) one each with meniscal tear and partial patellar tendon avulsion which were diagnosed intra-operatively and needed additional procedure.

Patients can start to return to sports activities after an estimated period of 2-3 months for Type I and II fractures. The duration is longer for Type III-V fractures, ranging from three to six months after the injury.[1, 11] Most patients are able to return to daily activities at 29 weeks on average with excellent range of motion.[2] This matches the patients in our study (28.5 weeks), though there were a few who took longer possibly due to inadequate rehabilitation. Adolescents who had Type III fractures were advised against participating in sports involving high muscle load for four to six months. They are required to have a full range of motion of the knee, ap-

propriate lower limb strength and proper endurance before returning to play. [9]

Compartment syndrome has been reported in the acute phase and is more common with Type III and IV fractures. [2] Other reported complications include anterior knee pain, neurovascular deficits, leg-length discrepancy, genu recurvatum, malunion or nonunion, patella infera, refracture and deep vein thrombosis. [1, 2, 6] Occasional anterior knee pain was present in three of our patients. The non-removal of implants may be a cause of the pain for all three patients. The subcutaneuous prominent screw may be the cause of pain on kneeling in some cases. [2, 3] Genu recurvatum is theoretically a possible complication for tibial tuberosity avulsion fractures. However it is uncommon accounting for only 4% of cases.[2]

Some limitations of the study should be mentioned. The retrospective design meant that there was some missing information and in a few cases with more than 8 years followup, there may be recall bias. Some pre-operative, post-operative, and recent radiographs were not available. However, it is unlikely to have affected the classification of the injury. Following our results, we recommend further studies to include the patient's BMI to study the association between occurrence of injury and BMI as noted by Shin *et al*.[16]

CONCLUSION

Tibial tuberosity avulsion fractures in adolescents are rare and can be treated successfully by ORIF, leading to satisfactory outcomes, regardless of fracture type. Complications following operative fixation included anterior knee pain and limitation of flexion which can be avoided by routinely recommending removal of screws and ensure adequate rehabilitation till full return of function.

ACKNOWLEDGEMENTS

We thank Staff Nurse Mohiddin bin Haji Abu Bakar (Orthopaedic Department) for his assistance in recruiting the patients and data collection.

CONFLICTS OF INTEREST

There are no conflicts of interest among authors in this study.

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