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Case Report

Is Vitamin D Low in Tibia Tuberosity Avulsion Fractures? -

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ABSTRACT

Background: Vitamin D is important during the developmental phases of bone maturity. Tibia tuberosity fractures are an uncommon sports injury caused by contraction of the quadriceps muscles against the tibia tuberosity. It is hypothesized that bone fragility is a part of this injury due to the indirect mechanism.

Objective: The purpose of this study is to assess 25(OH) vitamin D levels in pediatric tibia tuberosity fractures.

Methods: Twelve male patients aged 13-16 years old underwent treatment for tibia tuberosity avulsion fracture and had 25(OH) vitamin D levels collected. The mean 25(OH) vitamin D level was compared to a pre-existing cohort of 662 healthy control patients and 369 patients with other fracture types from the same demographic area.

Results: Mean 25(OH) vitamin D level in the study group was 22.38 ng/ mL + 6.46 (range, 14-29.9 ng/ mL). The healthy control group had a mean 25(OH) vitamin D level of 27.9 ng/ mL + 9.1 (p - value 0.01). The control group of other fracture types had a mean 25(OH) vitamin D level of 27.5 ng/ mL + 8.9 (p - value 0.017). All tibia tuberosity avulsion fracture patients had 25(OH) vitamin D level below the Endocrine Society recommended values (40-60 ng/ mL). Five patients (38.5%) had 25(OH) vitamin D levels < 20 ng/ mL.

Conclusions: Low 25(OH) vitamin D levels may contribute to avulsion fractures at the ligament-bone interface. Future studies should be larger to validate these findings and explore the importance of bone health in tibia tuberosity fractures.

Keywords: Tibia tuberosity; Vitamin D deficiency; Pediatric fracture; Avulsion fracture

INTRODUCTION

Sufficient vitamin D levels are vitally important during the developmental phases of bone maturity, such as adolescence. However, a study of 6,275 children aged one to 21 performed by the national health and nutrition examination survey revealed that approximately 70% of children have 25(OH) vitamin D level below 30 ng/ mL [1]. In a recent study of children aged two to 18, there was increased probability of a surgical fracture with 25(OH) vitamin D level less than 40ng/ mL (the optimal fracture fragility threshold) along with mechanism of injury and force [2]. Studies have examined the role of vitamin D deficiency in pediatric fractures but not tibia tuberosity fractures [2-5].

Tibia tuberosity development starts with a cartilaginous tuberosity which then progresses to apophyseal, then to epiphyseal, and finally to a bony tuberosity. This predisposes the tibia tuberosity to avulsion type injury. Tibia tuberosity avulsions fractures represent less than 1% of all pediatric fractures with the greatest incidence tending to be among males between the ages of 12 to 15 years [6,7]. These patients commonly present with sudden onset of knee pain after sprinting or jumping. They have a deficiency in the extensor mechanism [8]. Avulsion occurs with either violent contraction of the quadriceps during extension (jumping) or with acute passive knee flexion versus contracting the quadriceps (landing after a jump). The mechanism of this injury is indirect and typically involves an eccentrically contracted quadriceps muscle versus bone at the tibia tuberosity [7,9,10]. Therefore, one can surmise that there is a role for bone fragility in the risk of this injury.

There is an increasing trend towards vitamin D deficiency due to avoidance of the sun. Children tend to play outdoors less, wear more clothing and use sun screen extensively. Vitamin D requirements vary from 400 units in children less than one year of age to greater than 4000 units per day depending on the individual's absorption. Requirements are about 2000 units per day for the average adult. Childhood is the optimum time to maximize peak bone mass since 40% of peak bone mass is attained during four peri-pubertal years. During this time period, there is an increase in trabecular thickness, medullary cavity expansion, and cortical thickness [11]. Vitamin D deficiency is linked to inability to mineralize growing bones, bone disease through secondary hyperparathyroidism, inability to reach peak bone mass, and delayed healed or non-unions in fractures.

The purpose of this study was to assess serum 25(OH) vitamin D levels in patients with tibia tuberosity avulsion fractures comparing 25(OH) vitamin D to previously published non-fracture and other fracture type controls from the same community [2]. The hypothesis was that in order for the muscle and tendon unit to be strong enough to cause this type of avulsion fracture, patients will have lower serum 25(OH) vitamin D levels versus controls.

METHODS

This is a retrospective case review of twelve male patients aged 13-16 years old with pediatric tibia tuberosity avulsion fractures treated from 2012 to 2016. This was undertaken with the understanding and written consent of each subject and was reviewed and approved by the Institutional Review Board. All patients had 25(OH) vitamin D levels collected at the time of fracture. Each fracture was classified using the Mosier classification (Table 1) [8]. This group was compared to a healthy group of pediatric patients and patients with other fracture types from a previously published study from the same community with similar demographics [2].

All data was de-identified and input into a microsoft excel spreadsheet (Microsoft Corporation, Redmond, Washington) for

Table 1: Mosier classification of tibial tuberosity fractures and distribution of fracture type.

Type	Description	Surgical Management	Study group distribution of fracture type
1A	Fracture distal to junction of the tibial growth plate and tuberosity	-	
1B	Comminution of fracture fragment along with 1A description	+	
2A	Fracture extends to junction of proximal tibial physis	+/-	2 (16.7%)
2B	Comminution of fracture fragment along with 2A description	+/-	1 (8.3%)
3A	Fracture into joint through the epiphysis of tibial with displacement of fracture fragment	+	1 (8.3%)
3B	Comminution of fracture fragment with same description as 3A	+	6 (50%)
4	Fracture extends transversely through growth plate with fracture fragment displacement	+	2 (16.7%)

statistical analysis. The statistical software graph pad prism version 5.01 (GraphPad Software Inc., La Jolla, California), was used for all statistical calculations. Statistical comparisons between both cohorts was performed using t-test to determine if there was a difference in mean 25(OH) vitamin D levels. A *p* - value of less than 0.05 was considered significant.

RESULTS

This group included twelve patients (13 fractures), all male, with a mean age of 14 years with the following racial distribution: three Hispanic (25%), four African American (33.3%), five Caucasian (41.7%). Demographics for the pre-existing group of 662 healthy controls had a mean age of 12.2 years, 50% male, with the following racial distribution: Caucasian 80.6%, African American 9.4%, Asian 9.7%. Ethnic distribution in this group is 22.8% Hispanic. The control group of other fracture types (n = 369) had a mean age of 10.7 years, 50% male, with the following racial distribution: Caucasian 85.8%, African American 8.5%, Asian 4.4%. Ethnic distribution in this group is 11% Hispanic.

The mean 25(OH) vitamin D levels in the study group was 22.38 ng/ mL + 6.46. Fracture type and associated injuries are presented in table 2. The pre-existing group of healthy controls had a mean 25(OH) vitamin D level of 27.9 ng/ mL + 9.1 ($p = 0.001$). The mean 25(OH) vitamin D level in the group of patients with other fracture types was 27.5 ng/ mL + 8.9 (*p* - value 0.017). Using t-tests, the mean vitamin D level in the healthy control group and group of patients with other fracture types is significantly higher than in the tibia tuberosity fracture group (*p* - value 0.001, 0.017).

All values were below 30 ng/ mL in the tibia tuberosity fracture patients. The healthy control group had 67% of the population with levels below 30 ng/ ml ($p = 0.004$). Five patients (38.5%) within the cohort had 25(OH) vitamin D levels below 20 ng/ mL compared to 18% within the healthy control group.

Table 2: Tibial tuberosity fracture cohort data.

Number	Age	Vit D	Fracture Type	Surgery?	Associated Injuries
1	15	28.1	2A	Y	none
			3B	Y	patella tendon avulsion
2	16	14.9	3B	Y	patella tendon avulsion
3	14	29.9	3B	Y	patella tendon avulsion
4	13	29.9	2A	N	none
5	16	27.6	3A	Y	patella tendon avulsion
6	13	19.6	2B	Y	none
7	15	14	3B	Y	none
8	15	22.9	4	N	none
9	14	26.5	3B	Y	tibial plateau fracture; patella tendon avulsion
10	16	25.8	3B	Y	patellar dislocation
11	14	13	4	Y	trapped medial meniscus
12	14	16.4	3B	Y	patella tendon avulsion
MEAN	14	22.4			

DISCUSSION

All patients with tibia tuberosity fractures had 25(OH) vitamin D levels below the recommended value of 40 ng/mL as per the Endocrine Society. All patients were insufficient with 38.5% in the deficient range <20 ng/ mL. It is possible that higher levels of 25(OH) vitamin D have potential benefit in preventing injury, although not directly shown in this review. Interestingly, all patients with tibia tuberosity fractures were male while the healthy controls and the controls with other fracture types were 50% male. This was a small retrospective study, with the possibility of selection bias. Although fracture severity was classified, correlation with 25(OH) vitamin D levels was not significant.

All tibia tuberosity fracture patients had low 25(OH) vitamin D. This brings into question the role of Vitamin D with regard to strength of bone and the ligament-bone interface. Future studies should be larger to help further validate these findings and to explore the importance of bone health status in patients with tibia tuberosity fractures.

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