Precise risk factors for Osgood–Schlatter disease

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Authors:
Junsuke Nakase, M.D., Ph.D., Department of Orthopaedic Surgery, School of Medicine, Kanazawa University, Kanazawa, Japan.

Kenichi Goshima, M.D., Ph.D. Department of Orthopaedic Surgery, Toyama municipal hospital, Toyama, Japan.

Hitoaki Numata, M.D. Department of Orthopaedic Surgery, School of Medicine, Kanazawa University, Kanazawa, Japan.

Takeshi Oshima, M.D. Department of Orthopaedic Surgery, School of Medicine, Kanazawa University, Kanazawa, Japan.

Yasushi Takata, M.D. Department of Orthopaedic Surgery, School of Medicine, Kanazawa University, Kanazawa, Japan.

Hiroyuki Tsuchiya, M.D., Ph.D., Department of Orthopaedic Surgery, School of Medicine, Kanazawa University, Kanazawa, Japan.

Corresponding author:
Junsuke Nakase
13-1 Takaramachi, Kanazawa 920-0934, Japan
Tel: ＋81-76-265-2374
Fax: ＋81-76-234-4261
E-mail: nakase1007@yahoo.co.jp

ABSTRACT

Introduction A number of studies have examined the risk factors for Osgood-Schlatter disease (OSD). Studies on risk factors have not necessarily accurately demonstrated the risk factors of this disease because they were not prospective cohort studies or the populations in the studies were not categorized by the skeletal maturation of the tibial tuberosity. We can identify the precise risk factors for OSD by performing a prospective cohort study of a group of asymptomatic patients in particular times of adolescent using ultrasonography. In the present study, we aimed to investigate the precise risk factors for OSD.

Methods For all examinations, we used a 3-stage classification for tibial tuberosity development observed on ultrasonography: sonolucent (stage S), individual (stage I), and connective stages (stage C). Among 150 players with 300 knees, we included 37 male players with 70 knees at asymptomatic stage I on the first examination. We re-examined the included knees 1 year after the first examination and compared 10 knees with OSD (OSD group) and 60 knees without OSD (control group). Height, body weight, Body mass index, tightness of the quadriceps femoris and hamstring muscles, muscle strength during knee extension and flexion were assessed during the first medical examination.

Results The incidence of OSD was 14.3% in this 1-year cohort study. A significant difference was found in body weight, quadriceps muscles tightness and muscle tightness and strength during knee extension between the 2 groups. The precise risk factors for OSD were increased quadriceps femoris muscle tightness and strength during knee extension and flexibility of the hamstring muscles using logistic regression analysis.

Conclusions This information may be useful for teaching quadriceps stretching in preadolescent male football players with stage I.

Keywords
Osgood-Schlatter disease, Risk factor, Prospective cohort study, Muscle tightness

Introduction

Osgood–Schlatter disease (OSD), which is named after the physicians who first described it in 1903 [12, 14], is a traction apophysitis of the tibial tuberosity caused by repetitive strain on the quadriceps femoris muscle. The theory of traction apophysitis and traumatic avulsion of the secondary ossification center of the tibial tuberosity was supported by Ehrenborg [5, 6] and Ogden [11]. A number of studies have examined the risk factors for OSD. Studies on risk factors have not necessarily accurately demonstrated the risk factors of OSD because they were not prospective cohort studies or the populations in the studies were not categorized by the skeletal maturation of the tibial tuberosity.

Ehrenborg described 4 radiological stages of tibial apophysis maturation: the cartilaginous, apophyseal, epiphyseal, and bony stages [4]. This classification is regularly used in radiological evaluations. Ultrasonography is useful for the visualization of orthopedic conditions, especially soft tissue diseases, and it is particularly effective in the early diagnosis of OSD [16]. Early detection of OSD and conservative treatment can enable an early return to sporting activities [7, 8]. Ultrasonographic features of OSD include pretibial soft tissue swelling, cartilage swelling, fragmentation of the ossification center of the tibial tuberosity, thickening at the insertion of the patellar tendon, and inflammation of the deep infrapatellar bursa [1].

Using ultrasonography, we developed a novel classification system of skeletal maturation of the distal attachment of the patellar tendon [10]. The sonolucent stage (stage S) is characterized by the presence of a large amount of apophyseal cartilage. The individual stage (stage I) is characterized by the presence of apophyseal cartilage within an “individual ossicle.” The connective stage (stage C) is characterized by the connection of the secondary ossification and tibial epiphysis (Figure 1). We encountered 2 cases in which the patients developed OSD although they had not presented any subjective or objective knee symptoms during stage I on medical examinations performed 1 month previously. In both of these patients, ultrasonographic findings at disease onset were characteristic of OSD [2]; the secondary ossification center was avulsed. These results suggest that OSD is caused by overuse in the period of stage I. This theory supported with previously report [1] and the tibial tuberosity changes dramatically in the short period between these stages. Therefore, we can identify the precise risk factors for OSD by performing a prospective cohort study of a group of asymptomatic patients in stage I. In the present study, we aimed to investigate the precise risk factors for OSD.

Materials and methods

In the present study, among 150 male soccer players (mean age, 12.6 ± 1.6 years; range, 9–15 years) with 300 knees who practiced soccer daily for 2 hours, we included 37 players (mean, 11.2 ± 1.1 years) with 70 knees at asymptomatic stage I in the first examination. Twenty-eight knees in stage S, 160 knees in stage C, 40 knees affected by OSD, and 2 knees showing completion of tibial tuberosity development on ultrasonography at the first examination were excluded. We re-examined the included knees approximately 1 year after the first examination. HI VISION Avius (Hitachi Aloka Medical Corporation; Tokyo, Japan) and MyLabFive (Esaote; Genoa, Italy) ultrasound machines were used with a high-resolution linear probe (mean frequency, 12 MHz; range, 10–14 MHz) that was calibrated based on a musculoskeletal model. The players were informed of the aims of the study and the procedures involved, and they provided written informed consent along with their parents. The study was reviewed and approved by the university's ethics committee.

We compared 10 knees with OSD (OSD group) and 60 knees without OSD (control group) during a second medical examination (approximately 1 year after the first examination). To confirm the diagnosis of OSD, a patient had to fulfill all of the following clinical criteria: pain with direct pressure on the tibial apophysis; pain before, during, and after physical activities; enlargement or prominence of the tibial apophysis; pain along with resistance during knee extension; and pain during jumping. The following ultrasonographic findings were also required: delamination tear/fracture of the tibial tuberosity apophysis, deep infrapatellar bursitis, and superficial infrapatellar bursitis. Height, body weight, body mass index, tightness of the quadriceps femoris and hamstring muscles, muscle strength during knee extension and flexion evaluated in the first medical examination were compared between the OSD and control groups. The height of each study participant was measured using a portable stadiometer with 0.1-cm graduations. To assess the tightness of the quadriceps femoris and hamstring muscles, heel-buttock distance (HHD; mm) in the prone position and straight-leg-raise angle (SLR; degrees) in the supine position were measured, respectively.

Tightness of the quadriceps femoris and hamstring muscles was measured using the following method: one examiner applied increasing force on the subject's lower limb until just before the point of resistance. As the first examiner continued to apply the force, the second examiner recorded

measurements using a ruler and goniometer. The same examiner recorded all the measurements of lower limb muscle tightness. To assess muscle strength during knee extension and flexion, a hand-held dynamometer (μTAS-F1; ANIMA Co., Tokyo, Japan) was used with each subject in the seated position. We based this measurement technique on the results of a recent systematic review, which found that the dynamometer was a reliable and valid instrument for the assessment of muscle strength in a clinical setting [15]. No special warm-up exercises were performed before the procedures. One practice trial was performed to measure muscle strength in each of the lower limbs during knee extension and flexion. Subsequently, muscle strength measurement was initiated during knee extension. After a 30-s rest period, muscle strength was measured during knee extension in the other limb. Thereafter, muscle strength was measured during knee flexion. All the measurements were recorded by 1 examiner. A dynamometer was placed on the distal third of the tibia while recording the measurement during knee extension and on the Achilles tendon area while recording the measurement during knee flexion. The maximum muscle strength was measured over 10 seconds. All measurements were obtained 3 times, and the mean value of the 3 trials was used for the statistical analysis.

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences 19.0 (SPSS Inc., Chicago, IL, USA). We compared 10 knees with OSD and 60 knees without OSD. Height, body weight, body mass index, tightness of the quadriceps femoris and hamstring muscles, muscle strength during knee extension and flexion assessed during the first medical examination were compared using Student *t*-test. Items with P values less than 0.2 were considered as independent variables by logistic regression analysis (simultaneous). OSD onset was considered the dependent variable. The level of significance for all statistical analyses was set at $\alpha = 0.05$.

Results

The incidence of OSD was 14.3% in this 1-year cohort study. Body weight and quadriceps femoris muscle tightness were significantly greater in the OSD group than in the control group (Table 1). The precise risk factors for OSD were increased quadriceps femoris muscle tightness and strength during knee extension and flexibility of the hamstring muscles using logistic regression analysis (Table 2).

Discussion

Studies on the risk factors for OSD have not necessarily demonstrated the precise risk factors for this disease accurately because they were not prospective cohort studies or because the study populations were categorized by age. Bone maturity is a highly individual process, and it is difficult to identify an exact risk factor only by chronological age. In the present study, we focused on the developmental stage of the tibial tuberosity to prospectively investigate the occurrence of OSD in players with stage I disease who had no symptoms at the time of the initial examination. The most important finding of our analysis was that increased quadriceps femoris muscle tightness and muscle strength during knee extension and flexibility of the hamstring muscles are risk factors for OSD. The results concerning quadriceps femoris muscle tightness were consistent with those of earlier reports [3]. OSD is a traction apophysitis of the tibial tubercle caused by overload/microfractures in the attachment of the patellar tendon [1, 8]. The repetitive strain, in turn, is caused by the strong pull produced by the quadriceps femoris muscle during sporting activities. Several studies have examined the importance of rectus femoris shortening [3, 7]. The quadriceps femoris muscle contracts eccentrically during the stance phase of running until the beginning of propulsion, when the knee reaches its highest level of flexion [13]. Shortening of the rectus femoris may substantially affect the biomechanical function of the knee with respect to the lever arm, peak torque, and discharge of compressive forces at 30° and 60° [7]. We think that OSD develops when the muscular strength involved in performing a knee extension increases in the presence of shortening of the quadriceps femoris muscle. On the other hand, regarding the hamstrings flexibility as a risk factor of OSD. The femoral neck detorsion that occurs around 5 years of age may influence muscle insertion, volume, and fatigue. At present, it is difficult to arrive at a conclusive explanation for the origin of OSD. The most important aspect for the prevention of OSD is improvement of the flexibility of the quadriceps femoris muscle.

In a 5-year cohort study, Kujala identified 68 (16.5%) cases of OSD in a sample of 412 young athletes [9]. In another study, de Lucena reported an OSD prevalence of 13.0% (124 individuals) in a sample of 956 adolescents who engaged in some sporting activity [3]. In the present study, the incidence of OSD was 12.9%, which is similar to the incidence reported in earlier studies. These results suggest that OSD develops within 1 year of stage I onset. In future studies, we plan to perform long-term follow-up of the patients studied.

This study has several limitations. One limitation is that the quadriceps femoris tightness was measured using HHD. The measured values could have changed depending on the muscle tone in the gluteal area, which would have prevented an accurate measurement. Furthermore, test-retest reliability for HHD and the SLR angle was not confirmed. Although the development of OSD is multifactorial, we only investigated height, body weight, body mass index, tightness of the quadriceps femoris and hamstring muscles, and muscle strength during knee extension and flexion. However, leg alignment, ankle ROM, and hip ROM were not investigated, and it is possible that these are additional risk factors for OSD. However, the findings of the present study are meaningful because this was a prospective cohort study that categorized the developmental stage of the patients' tibial tuberosity using ultrasonography, and included only players who might newly develop OSD. And we did not investigate the alignment of lower limb. The clinical relevance of our study findings is that proactive measures should be instituted and quadriceps-stretching practices should be promoted among preadolescent male football players with stage I of tibial tuberosity development.

Conclusions

In conclusion, the precise risk factors for OSD were increased quadriceps femoris muscle tightness and muscle strength during knee extension and flexibility of the hamstring muscles. This information may be useful for teaching quadriceps stretching in preadolescent male football players with stage I.

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Legends of figure and tables

Fig. 1 Ultrasonographic classification of tibial tuberosity development

Sonolucent stage

Individual stage

Connective stage

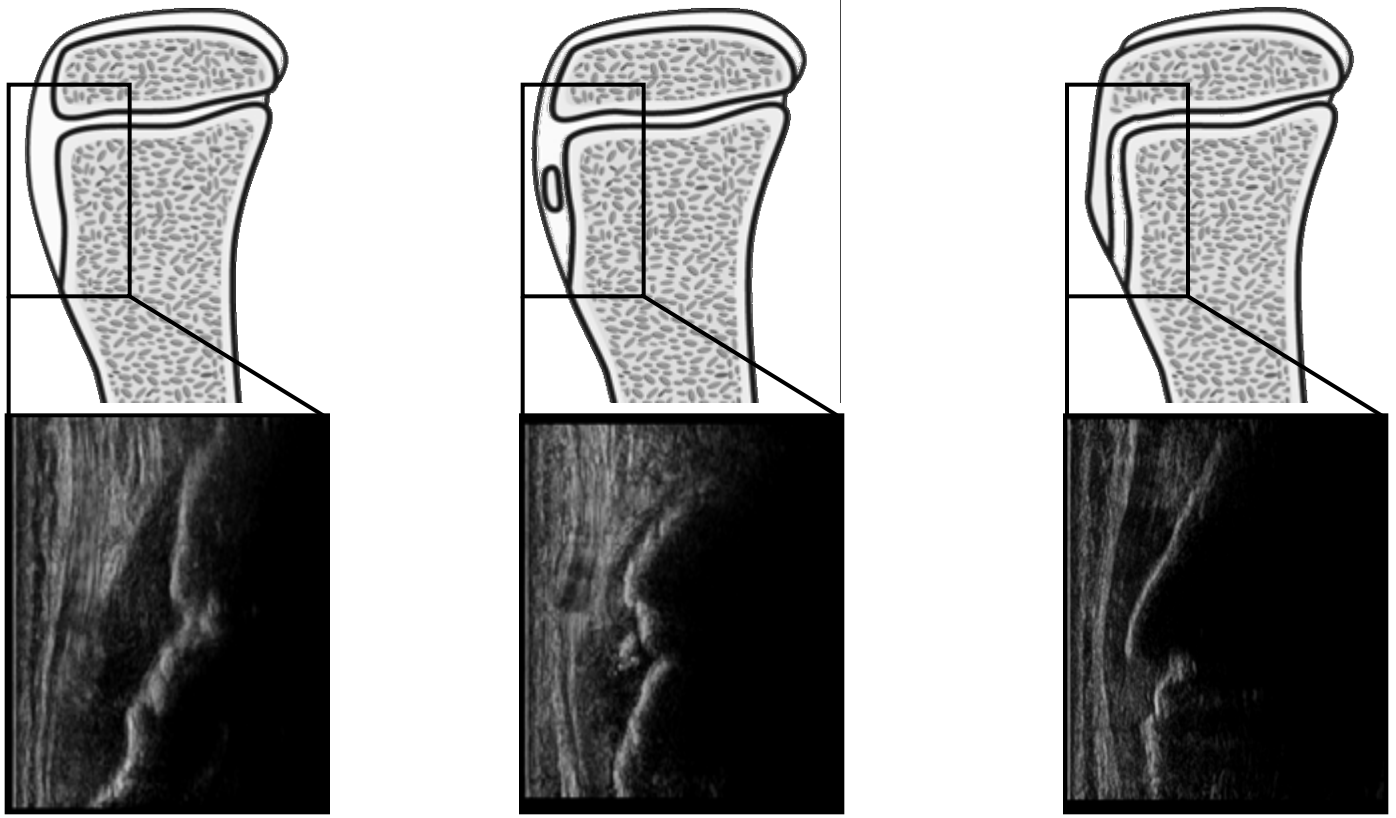

Figure 1

Table 1. Results of Student's *t*-test analysis

	OSD group (n=10)	Control group (n=60)	P value
Height (cm)	150.7±8.6	145.9±6.6	0.12
Body weight (kg)	38.5±4.5	34.4±4.2	0.02
BMI (kg/m^2)	19.8±2.0	20.6±1.5	0.23
SLR (°)	76±16	70±10	0.13
HHD (mm)	72±38	14±22	0.001
Strength of knee ext. (N)	247±36	216±53	0.03
Strength of knee flex. (N)	142±21	131±28	0.19

OSD, Osgood–Schlatter disease, SLR, straight-leg-raise;
HHD, heel-buttock distance

Table 2. Results of the logistic regression analysis

	Standard partial regression coefficient	SE	P value	Odds ratio	95% confidence interval
Height（cm）	0.167	0.13	0.206	1.182	0.912 — 1.532
Body weight（kg）	-0.813	0.529	0.124	0.443	0.157 — 1.249
SLR（° ）	0.194	0.097	0.047	1.214	1.003 — 1.469
HHD（mm）	0.223	0.105	0.033	1.250	1.019 — 1.535
Strength of knee ext.（N）	0.054	0.025	0.028	1.055	1.006 — 1.107
Strength of knee flex.（N）	0.048	0.047	0.316	1.049	0.956 — 1.151

SE, standard error; SLR, straight-leg-raise; HHD, heel-buttock distance