JSES International 8 (2024) 661–666

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Prevalence of osteochondritis dissecans of the capitellum in elementary school baseball players based on ultrasonographic screening: a 15-year overview in Tokushima, Japan

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ARTICLE INFO

Keywords:
Osteochondritis dissecans
Elbow
Screening
Ultrasonography
Baseball
Elementary school

Level of evidence: Level III; Cross-Sectional Design; Epidemiology Study

Background: Although several operative procedures have evolved for capitellar osteochondritis dissecans (OCD), the best outcome is achieved by early detection and conservative treatment. The objective of this study was to clarify changes in the prevalence of capitellar OCD in young baseball players over a long-term period based on consistent criteria in Tokushima, Japan between 2006 and 2020.
Methods: The number of players who underwent screening and the discovery rate of capitellar OCD during the study period were investigated. School grade and radiographic stage were also evaluated.
Results: The confirmation rate was significantly higher when ultrasonographic screening was performed than when screening was based on physical findings (65.8% vs. 1.9%, $P < .001$). The overall incidence of OCD in elementary school players based on ultrasonographic screening was 1.4% during the 10-year study period. Twenty-one (10.8%) of the 195 players identified to have OCD had experienced lateral elbow pain. When classified radiographically, the lesion was stage I in 73.3% of cases, stage II in 24.1%, and stage III in 2.6%. No cases of OCD were diagnosed before the fourth grade. The prevalence rates increased gradually from the fourth grade to the sixth grade.
Conclusion: Ultrasonographic screening could be more effective for detecting capitellar OCD than screening based on physical findings. The overall prevalence of OCD among elementary school players was 1.4% over 10 years. The prevalence rates increased gradually from the fourth grade onwards.

Osteochondritis dissecans (OCD) of the capitellum is primarily a disorder affecting young adolescent baseball players. Untreated cases of OCD may progress, and severe cases are at increased risk for prolonged absence from baseball.[7] Although several operative procedures have been developed for OCD, the outcome is best when OCD is detected early and treated conservatively without surgery. Screening is a powerful tool for identifying players who have OCD at a time when spontaneous healing can be expected with conservative treatment.[2,5,8,10]

Screening for OCD based on physical findings has been performed in Tokushima, Japan, since 1981 and been found to be effective, with most of the players identified by screening being early-stage cases.[4] However, screening based on physical findings alone may miss some cases of OCD because most cases are detected incidentally based on symptoms arising from a medial epicondyle lesion, and complaints of lateral elbow pain are uncommon. Ultrasonography is an inexpensive and portable diagnostic imaging modality that does not involve exposure to radiation and has been used successfully to assess elbow injuries.[2] Over the past 3 decades, ultrasonography has become an accepted method for the diagnosis and documentation of OCD.[2,5,8,10] In 2008, ultrasonographic examination was tentatively initiated by our group as part of screening for OCD at a regional baseball tournament and has been mandatory for players since 2011.

This study was approved by Ethics Committee of the Tokushima University Hospital (approval number: 2680).

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https://doi.org/10.1016/j.jseint.2024.01.011

The objective of this study was to clarify changes in the prevalence of capitellar OCD in young baseball players over a long-term period, based on consistent criteria in Tokushima, Japan, between 2006 and 2020. We hypothesized that ultrasonographic screening would be more effective for detecting OCD than screening based on physical findings and that OCD in elementary school players would be more prevalent in the higher grades.

Materials and methods

Ethical considerations

The study was performed retrospectively and approved by our institutional review board. Informed consent was obtained from the parents of all study participants and their coaches.

Study participants

In Japan, around 40% of elementary school baseball players practiced at least 4 days per week and more than 90% practiced at least 3 hours per day on Saturdays and Sundays.[9] Between 2006 and 2020, 23,153 elementary school baseball players from the first to sixth grade in Tokushima were screened for OCD. In the Japanese school system, elementary school consists of a 6-year program that starts in the first grade and finishes in the sixth grade. First-grade elementary school pupils thus are aged 6-7 years; second grade, 7-8 years; third grade, 8-9 years; fourth grade, 9-10 years; fifth grade, 10-11 years; and sixth grade, 11-12 years. Screening was performed during the regional summer championships. The total number of teams, the percentage of participating teams, and the number of players who were screened each year are shown in Table I. The number of players who underwent screening was approximately 1500 in the early period and increased to about 2000 in 2009. However, since then, this number has gradually decreased owing to the declining birth rate in the area.

Table I
Total number of teams and number of teams that participated in screening for osteochondritis dissecans.

Year	Total teams, n	Participating teams, n	Participating teams, %	Players, n
2006	153	129	84.3	1802
2007	154	138	89.6	1812
2008	150	136	90.7	1698
2009	148	137	92.6	1965
2010	146	127	87.0	1529
2011	143	120	83.9	1441
2012	140	122	87.1	1500
2013	130	113	86.9	1755
2014	125	110	88.0	1656
2015	122	106	86.9	1616
2016	115	96	83.5	1502
2017	115	102	88.7	1328
2018	112	103	92.0	1395
2019	108	86	79.6	1168
2020	104	91	87.5	986

Screening based on physical findings

Player information was collected using a questionnaire followed by physical and radiographic examinations to check for capitellar OCD. The questionnaires were distributed to team coaches, who asked players to complete them with the assistance of their coach and/or their parents. The questionnaire included items on the player's grade and history of elbow pain. Players were asked specifically whether they had any history of elbow pain during the season, whereby "elbow pain" was defined as any condition resulting in elbow pain lasting for $\geq$ 1 week. Any injury that occurred via trauma, including abrasion, bruising, dislocation, and fracture, was excluded. The completed questionnaire, including written confirmation of the participant's understanding of the questions, was returned by mail and reviewed by 3 of the authors (T.M., N.S., and T.I.) for accuracy. If information was found to be inaccurate, the player was followed up to obtain the correct information by phone call. Physical examination of the elbow was recommended for players who complained of elbow pain on the questionnaire. Elbow extension and flexion, tenderness at the medial epicondyle and/or humeroradial joint, and the moving valgus stress test were included in the physical examination. Limitation of range of motion was regarded as positive if the difference between the throwing and nonthrowing arms was more than 5°. Radiographic examination was recommended for players for whom physical examinations showed at least one of the following: limitation of range of motion, tenderness, or valgus stress test. Anteroposterior radiographs of the elbow in 45° of flexion and lateral radiographs were taken. Films were reviewed for capitellar OCD in the office by 2 of the authors (T.M. and N.S.); OCD appears as a radiolucent area in the subchondral bone on the anterior aspect of the capitellum, unlike Panner disease, which is characterized by decreased size and irregular ossification of the entire capitellum. Panner disease was differentiated from OCD in all cases.

Ultrasonographic screening

Fig. 1 shows the flow chart for ultrasonographic screening. Player information was collected using the same questionnaire as that used when screening for OCD based on physical examination. The throwing elbow of each participant was examined by ultrasonography on the playing field. Ultrasonography of the lateral aspect of the elbow was performed by an orthopedic surgeon with 5 years of experience performing elbow ultrasonography (T.I.) or by an ultrasound technician with 6 years of experience performing elbow imaging (S.N.), or less experienced orthopedic surgeons under supervision by (T.I.) or (S.N.). All ultrasound images were obtained using a sonographic diagnostic imaging system (Fazone M; Zonare Medical Systems, Mountain View, CA, USA) with a 5-10−MHz linear array transducer (Fazone CB; Fujifilm, Tokyo, Japan), a portable ultrasonographic system (MyLab Five; Esaote, Genoa, Italy) with a 6-18−MHz linear array transducer, or an ultrasonographic system (M-Turbo; SonoSite, Bothell, WA, USA) with a 6-13−MHz linear array transducer. Fig. 2 shows the method for ultrasonographic screening. Anterior views were acquired with the participant seated and the elbow fully extended. Posterior views were acquired with the elbow fully flexed to obtain an adequate view of the anterior aspect of the capitellum. Both longitudinal and transverse images were obtained on both anterior and posterior views. Fig. 3 shows an example of typical ultrasonographic findings. Subchondral surface irregularity, a break in continuity of the echo line, or a double floor line in the subchondral bone of the capitellum was regarded as an irregularity (Fig. 3*C*).[5,6,8] A cystic appearance of the subchondral bone surface was differentiated from positive findings because a previous study showed that a cystic appearance is a variation of normal development during ossification (Fig. 3 *B* and *E*).[8] Interobserver variability was preliminarily determined using the same images for 100 randomly selected patients. The k coefficient for interobserver reliability of the ultrasonographic examination was 0.82 (95% confidence interval 0.82-0.17; $P < .001$), indicating almost perfect agreement. Players found to have an irregularity on the ultrasonographic examination were advised to undergo a radiographic examination at our clinic within 1 month after ultrasonographic

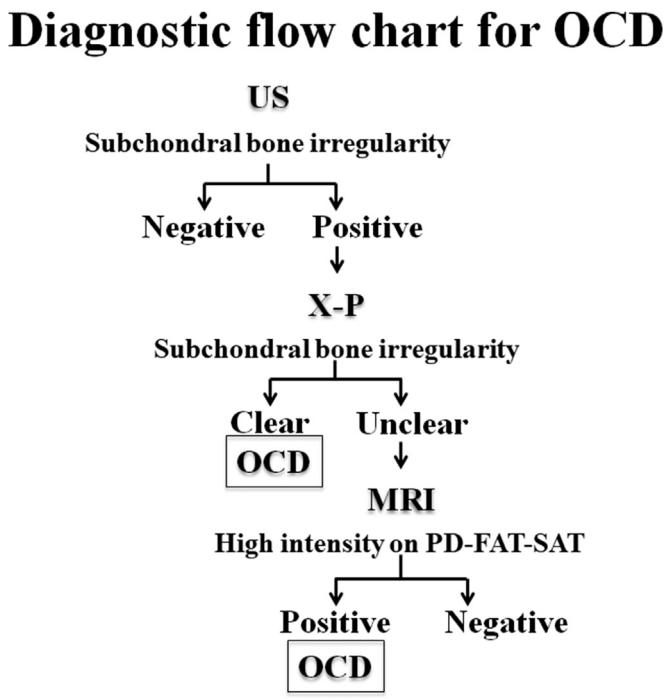

Figure 1 Flow chart of ultrasonographic screening. *OCD*, osteochondritis dissecans; *MRI*, magnetic resonance imaging; *PD-FAT-SAT*, proton density fat-saturated MRI; *US*, ultrasound; *X-P*, plain X-ray.

Statistical analysis

The chi-squared test was used to compare the prevalence and confirmation rate of OCD between screening based on physical findings (2006-2007) and ultrasonographic screening (2011-2012) and the prevalence of OCD by school grade and radiographic classification. All statistical analyses were performed using SPSS for Windows software (version 27; IBM Corp., Armonk, NY, USA). A P value of <.05 was considered statistically significant.

Results

Comparison between screening for OCD based on physical findings (2006-2007) and ultrasonographic findings (2011-2012)

The confirmation rates of OCD during 2006-2007 based on physical findings and during 2011-2012 based on ultrasonographic findings are shown in Table II. The confirmation rate was significantly higher for ultrasonographic screening compared with screening based on physical findings (65.8% vs. 1.9%, $P < .001$). Of the 17 patients in whom OCD was detected based on physical findings, 1 (5.9%) was in fourth grade, 5 (29.4%) were in fifth grade, and 11 (64.7%) were in sixth grade. Of the 52 patients in whom OCD was detected by ultrasonography, 4 (7.7%) were in fourth grade, 18 (34.6%) were in fifth grade, and 30 (57.7%) were in sixth grade. The prevalence rate of OCD in each school grade was not significantly different between screening based on physical findings and ultrasonography ($P = .88$). Based on previously published radiographic classification,[7] 10 (58.9%) of the 17 patients detected to have OCD on physical findings had a stage I lesion, 3 (17.6) had a stage II lesion, and 4 (23.5%) had a stage III lesion. Thirty-nine (75.0%) of the 52 patients in whom OCD was detected by ultrasonography had a stage I lesion, 11 (21.2%) had a stage II lesion, and 2 (3.8%) had a stage III lesion. There was a significantly higher prevalence of stage I or II lesions detected by ultrasonographic screening than by screening based on physical findings ($P = .03$).

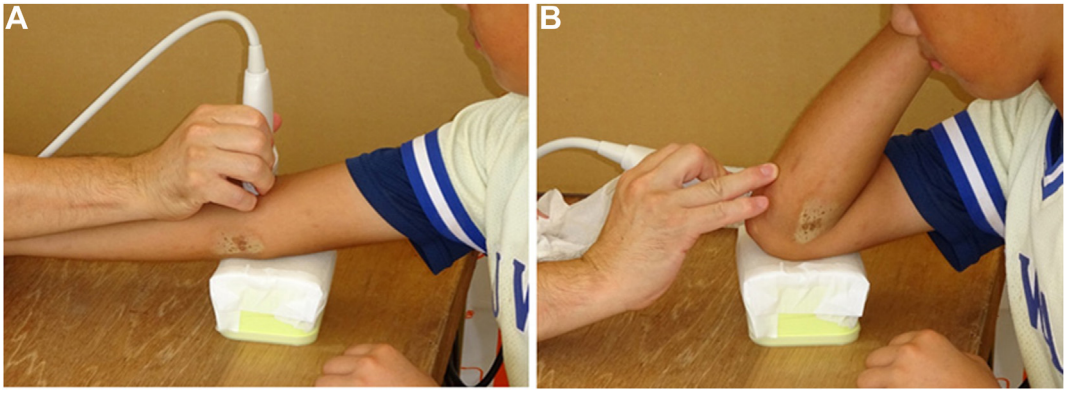

Figure 2 Method for ultrasonographic screening. (**A**) Anterior views were acquired with the participant seated and the elbow fully extended. (**B**) Posterior views were acquired with the elbow fully flexed to obtain an adequate view of the anterior aspect of the capitellum.

examination. Radiography of the elbow was performed in the anteroposterior direction with the elbow extended and flexed at 45° as well as in the lateral and oblique directions. A board-certified musculoskeletal radiologist with 10 years of experience (S.T.) then compared the radiographic and ultrasonographic findings and confirmed the presence of capitellar OCD. As mentioned earlier, Panner disease was differentiated from OCD. For players in whom the radiographic findings were normal or showed only subtle changes, magnetic resonance imaging was recommended to investigate further for OCD.

The number of baseball players who underwent screening and the OCD discovery rate were recorded. We included players previously diagnosed with or currently being managed for OCD. School grade was recorded and the radiographic stage was evaluated using the previously published 3-stage classification.[7] Stage I is characterized by radiolucent areas, stage II by nondisplaced fragments, and stage III by loose bodies and sclerotic change.

Prevalence of OCD in 2011-2020

The prevalence rates between 2011 and 2020 are shown in Table III. In total, 195 of 14,347 elementary school baseball players had OCD. The overall incidence of OCD was 1.4% and ranged from 0.7% to 1.8% during the 10-year study period. Sixty-seven (34.4%) of the 195 players with OCD had experienced elbow pain on the throwing side. Twenty-one players (10.8%) had experienced lateral

Figure 3 Representative ultrasonographic and radiographic findings. (**A-C**) Ultrasonographic findings. (**D-F**) Radiographic findings. (**A** and **D**) Normal capitellum. (**B** and **E**) Variation of normal development. (**C** and **F**) Osteochondritis dissecans.

Table II
Comparison between screening for OCD based on physical findings (2006-2007) and screening based on ultrasonography (2011-2012).

Year	Players, n	Radiographic examination, n	OCD, n	Confirmation rate, %	Year	Players, n	Radiographic examination, n	OCD, n	Confirmation rate, %
2006	1802	482	7	1.5	2011	1441	39	26	66.7
2007	1812	406	10	2.5	2012	1500	40	26	65.0
2006-2007	3614	888	17	1.9	2011-2012	2941	79	52	65.8

OCD, osteochondritis dissecans.

elbow pain. Based on radiographic classification, 143 (73.3%) of the 195 patients had a stage I lesion, 47 (24.1%) had a stage II lesion, and 5 (2.6%) had a stage III lesion. Of 128 players with asymptomatic OCD, 90 (70.3%) had a stage I lesion, 38 (29.7%) had a stage II lesion, and none had stage III lesion.

Prevalence of OCD by school grade

Prevalence rates are shown by school grade in Table IV. None of the patients with OCD were in the first 3 grades. The prevalence rates gradually increased from the fourth to sixth grade. The prevalence rate of OCD in the sixth grade was 2.7%, which was significantly higher than that in the fifth grade ($P < .01$). The prevalence rate of OCD in fifth grade was 1.6%, which was significantly higher than that in the fourth grade ($P = .01$).

Discussion

This study found that ultrasonographic screening could be more effective than screening based on physical findings for detection of capitellar OCD. The overall prevalence of OCD among elementary school players based on ultrasonographic screening was 1.4% during our 10-year study period, and the prevalence rate increased gradually from the fourth grade to the sixth grade.

A unique aspect of this study was the comparison of the OCD rate based on physical findings vs. that based on ultrasonography. OCD of the capitellum is a disorder commonly seen in young baseball players, but few surveys of capitellar OCD have been performed in this age group. Hang et al studied 343 little league pitchers, catchers, and fielders aged 9-12 years and found OCD in 1 player (0.3%) on radiography.[1] The prevalence rate of OCD found by screening based on physical findings in our study was 0.5%, which is almost the same as that in the study by Hang et al.[1] However, in our study, the prevalence rate of OCD found by ultrasonographic screening (1.8%) was significantly higher than that found by screening based on physical findings (0.5%). Combined with the fact that at least 0.7% of our cases were found over a period of 10 years by ultrasonographic screening, these results indicate that ultrasonographic screening is

Table III
Numbers and percentages of players with OCD.

Year	Players, n	OCD, n	OCD, %
2011	1441	26	1.8
2012	1500	26	1.7
2013	1755	26	1.5
2014	1656	23	1.4
2015	1616	23	1.4
2016	1502	11	0.7
2017	1328	12	0.9
2018	1395	15	1.1
2019	1168	21	1.8
2020	986	12	1.2
2011-2020	14,347	195	1.4

OCD, osteochondritis dissecans.

Table IV
Numbers of players with OCD by grade.

Grade	Players, n	OCD, n	OCD, %
6	4361	117	2.7
5	3902	63	1.6
4	3228	15	0.5
≤3	2856	0	0

OCD, osteochondritis dissecans.

more effective for detecting capitellar OCD than screening based on physical findings. In this study, 65.8% of players with positive ultrasonographic findings had OCD and the remaining 34.2% did not (Table II). A previous study found that assessment on ultrasonography is useful but not perfect because 22 of 26 players with positive ultrasonographic findings (84.6%) had OCD and the remaining 4 players (15.4%) did not.[8] Therefore, OCD should be confirmed by additional radiographic examination. In the physical examination group, we examined radiographs from 2 directions (anteroposterior view with the elbow flexed 45° and lateral view), but in the ultrasonographic screening group we examined 4 directions (anteroposterior views with the elbow extended fully and flexed 45° as well as lateral and oblique views) plus magnetic resonance imaging when radiographic findings were normal or showed only subtle changes. This difference in the examination conditions might have affected the difference in prevalence of OCD between the 2 groups. However, we considered that the difference was unlikely to have a major impact. In the physical examination group, radiographic examination was recommended for players with elbow pain. On the other hand, in the ultrasonographic screening group, 65.6% of players with OCD had no elbow pain. Taking these findings into consideration, the difference in methods for confirming OCD would not affect the difference in prevalence of OCD between the 2 groups. Although previous studies suggest that early detection is desirable,[5,7] it is difficult to detect early-stage capitellar OCD because most patients are asymptomatic or minimally symptomatic. In our study, only 10.8% of players identified to have capitellar OCD had lateral elbow pain, although 34.4% had experienced elbow pain on the throwing side (23.6% had medial and/or posterior pain). Asymptomatic or minimally symptomatic patients rarely seek medical attention. Recent improvements in the spatial resolution of ultrasonographic images have enabled more detailed cross-sectional images of OCD of the capitellum to be obtained. Ultrasonographic screening for OCD on the playing field is useful for early detection of OCD and provides an opportunity for successful conservative treatment.[2,3,5,6,8,9] In this study, the percentage of players with a stage I or II lesion indicated for conservative treatment was significantly higher in the group screened based on ultrasonographic findings in 2011-2012 compared with the group screened based on physical findings in 2006-2007 ($P = .03$).

This study specifically investigated the prevalence of OCD of the capitellum in elementary school baseball players aged 6-12 years based on ultrasonographic findings. The overall prevalence of OCD was 1.4%. Two cross-sectional studies that included large numbers of baseball players have investigated the prevalence of capitellar OCD using ultrasonography. One of these studies was performed by Matsuura et al and included 1040 baseball players aged 10-12 years; 2.1% of players were found to have capitellar OCD and 90.9% of affected players had stage I lesions.[8] In the other study, Kida et al found that 3.4% of 2433 baseball players aged 12-18 years had capitellar OCD and that 14.7% of affected players had stage I lesions, 38.2% had stage II lesions, and 13.2% had stage III lesions.[5] These findings suggest that the risk of developing capitellar OCD is highest in players aged ≤ 12 years. Our result (1.4%) is lower than that in the study by Matsuura et al (2.1%).[8] One explanation for this discrepancy is that our study included players aged 6-9 years. When the patients were limited to those in the fourth to sixth grades, the prevalence of OCD was 1.7% (195 cases in 11,491 players). Harada et al identified 2 cases of OCD (1.3%) among 153 players aged 9-12 years by ultrasonographic screening on the baseball practice field.[2] Based on these results, the prevalence of capitellar OCD in elementary school baseball players in Japan is estimated to be 1%-2%.

The etiology of capitellar OCD remains unclear. Matsuura et al followed a group of preadolescent baseball players prospectively to identify risk factors for capitellar OCD[6] and found that players aged 10-11 years were at significantly higher risk than their counterparts aged 6-9 years. However, starting baseball at an earlier age, number of years played, training hours per week, player position, and history of elbow pain were not significantly associated with capitellar OCD. These findings suggested that the symptoms of capitellar OCD are age-specific. Therefore, we compared the prevalence of OCD by school grade and found that there were no patients with OCD before fourth grade and that the prevalence rates increased gradually from the fourth grade to sixth grade. However, Matsuura et al found no significant difference in the prevalence of OCD according to age.[8] A possible explanation for these inconsistent findings is that the study by Matsuura et al was epidemiological in nature and lasted for only 1 year, whereas our present study included players previously diagnosed with or currently being managed for OCD. A question of interest is the grade until which the prevalence rate rises continuously after sixth grade, but unfortunately, no data are available on junior high school players.

Although this study adds new information about capitellar OCD, it has several limitations. First, a technical limitation was that ultrasonography could not detect very slight or very early changes. Second, radiographs were obtained only from players with positive ultrasonographic findings, raising the possibility of false-negative results in screening and radiographic examination. Third, the study had a retrospective cohort design and the results were self-reported by young participants. Recall bias may have been introduced when the players were asked about their history of elbow pain.

Conclusion

This study found that ultrasonographic screening could be more effective for detecting capitellar OCD than screening based on physical findings. The overall prevalence of OCD among elementary school players was 1.4% during our 10-year study period. The prevalence rate increased gradually from the fourth grade to the sixth grade.

Acknowledgments

The authors thank Takenobu Iwase, MD, Department of Orthopaedic Surgery, Tokushima National Hospital, and Shinji Kashiwaguchi, MD, Department of Orthopaedic Surgery, Handa Hospital, for their asssistance in this study.

Disclaimers:

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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