The incidence and severity of shoulder dislocation among rugby players are very high, and the injuries occur as a result of various mechanisms such as tackling, breakdown, falling, and scoring during competition. Our previous study demonstrated that 67% of primary anterior shoulder dislocation in rugby players occurs during tackling. Depending on the situation, there are various types of tackles in rugby: arm tackle (the tackler stops the ball carrier by using his or her arms), jersey tackle (the tackler stops the ball carrier by pulling his or her jersey), shoulder tackle (the tackler initially contacts the ball carrier with his or her shoulder then takes hold of the opponent's body), and tap tackle (the tackler dives to touch the ankle or foot of the ball carrier).

Several studies that analyzed tackling in rugby players using video records have described that an anterior shoulder dislocation may occur when the tackler's elbow is positioned straight at the time of impact with the ball carrier and the arm is forcibly moved in the posterior direction. In this situation, during contact, the affected shoulder is subjected to a combination of horizontal abduction or abduction and external rotation. However, the characteristics of tackling that lead to primary anterior shoulder dislocation in rugby have not been well investigated, and several factors may be involved.
The aims of this study were to use video analysis to investigate the characteristics of tackles that lead to shoulder dislocation when a player performs a one-on-one tackle, as well as to show the relevance of the mechanisms of injury and the morphological damage of the glenoid based on image findings. We hypothesized that these rugby tackles could be characterized and various factors might be related, and that there may be a relationship between the mechanisms of injury and the morphological damage of the glenoid.

METHODS

Eleven elite rugby players who sustained primary anterior shoulder dislocation or subluxation due to one-on-one tackling between 2001 and 2014, and diagnosed in our hospital, were included in the present study (Table 1). The inclusion criteria were a definitive diagnosis of primary anterior shoulder dislocation or subluxation with objective imaging studies in our institution and no history of previous surgery on the affected shoulder. Athletes were excluded from the study if the injury occurred in a tackle that involved more than 2 players, if the videos could not be analyzed due to insufficient image quality, or if the players had previous history of anterior shoulder dislocation to the affected side of the shoulder. The study was approved by the institutional review board of our hospital. Video recordings were obtained either from the players themselves or from the staff of their team. Two authors (N.M., T.K.), a senior orthopaedic surgeon and the other a physical therapist, who have covered a professional rugby team together for more than a decade, reviewed all the injuries recorded in the video in blinded fashion. When the judgment was not consistent, the final decision was achieved through a discussion among 3 reviewers (N.M., T.K., T.M.).

Because we believe that assessing the mechanisms of the injury is essential, each tackle was evaluated by our original assessment system modified from the past reports,3,6,9 which was designed to categorize the tackle into 1 of 3 types—hand tackle, arm tackle, or shoulder tackle (Table 2). Each tackle was also divided into 3 phases—approach, impact, and postimpact. Then, the distance between the players in the approach phase, the shoulder and the head position in the impact phase, and the direction of shoulder motion in the angle of abduction, horizontal abduction, and external rotation in the postimpact phase were analyzed.

The shape of the glenoid on the affected side was classified into 3 types—intact, erosion, and bone defect—based on the reconstructed clockface image from computed tomography (CT), and the humeral head was examined by one of the authors (T.K.), who was blinded to the patient data, to determine whether a Hill-Sachs lesion was present. According to a past report,11 the orientation of the glenoid defect was also evaluated in each shoulder and was defined as a line passing through the center of the glenoid and perpendicular to the defect margin, expressed as degrees from the long axis (Figure 1). For statistical analyses, a Fisher exact test was applied to examine any correlation between the tackle types and the degree of glenoid bone loss. A Kruskal-Wallis test was also applied to determine the significant differences in the orientation of the glenoid defect for each type of tackle. All analyses were processed by using SPSS for Mac software program (version 21; IBM Corp). P < .05 was considered statistically significant.

RESULTS

A total of 11 tackles that led to primary anterior shoulder dislocation were evaluated by our assessment system (see Table A1 in the Appendix for details). Interrater reliability of the assessment between the 2 authors was relatively high (k = 0.85-1.0) (see Table A2 in the Appendix). Of these, the numbers of hand, arm, and shoulder tackles were 4, 4, and 3, respectively. The characteristic of hand tackle injuries (n = 4) was that most of the ball carriers changed their running course just before the approach phase of the tackle (Figure 2). Thus, tacklers failed to close the distant ball carrier in the approach phase and caught the ball carrier with full arm extension in the impact phase. These situations resulted in the shoulder oriented at a humerothoracic angle of >90° of abduction; after the impact of the tackle, the shoulder was horizontally abducted in all the cases.

In arm tackle injuries (n = 4), the characteristics of the tackles were similar to those of hand tackles (Figure 3). The tacklers could not make contact with the ball carrier at an appropriate site of the shoulder because they could not get close enough; they came into contact with the ball carrier between the forearm and upper arm and eventually could not stop the ball carrier’s movement completely, although the tackler sometimes brought the ball carrier to the ground. At the time of impact (and injury), the humerothoracic angle was approximately 90° of abduction with external rotation, followed by horizontal abduction after the impact.

In contrast to the 2 tackles mentioned above, several different points were noted in the shoulder tackle injuries (n = 3) (Figure 4). The tacklers successfully approached, and their shoulder came into contact with the midline of the torso of the ball carrier. In all cases, however, it was noted that the tacklers placed their lowered head in front of the ball carrier. At the time of the injury, the humerothoracic angle was approximately 90° of abduction with neutral rotational position; the shoulder was subsequently horizontally abducted in all cases.

The assessment of the shape of the glenoid on the injured side revealed bone defect in 4 cases and erosion in 4 cases, while Hill-Sachs lesions in the humeral head were observed.

### TABLE 1
Participant Demographics (N = 11)

| Category                        | Mean ± SD |
|--------------------------------|-----------|
| Age, y, mean ± SD              | 25.3 ± 5.9|
| Height, cm, mean ± SD          | 180.7 ± 9.4|
| Weight, kg, mean ± SD          | 93.8 ± 13.6|
| Body mass index, kg/m², mean ± SD | 28.6 ± 2.5|
| Grade (collegiate/professional), n/N | 5/6      |
| Side of the affected shoulder (right/left), n/N | 4/7      |
| Position (forwards/back), n/N   | 4/7       |
in 9 cases (81.8%). No relationship was observed between the type of tackle and the shape of the glenoid on the affected shoulder ($P = .55$). There was also no significant difference in the orientation of the glenoid defect among the 3 types of tackles ($P = .67$) (Table 3).

**DISCUSSION**

Regarding rugby game defense strategy, Hendricks and Lambert$^5$ and Hendricks et al$^6$ reported that the arm tackle and the jersey tackle had lower success rates than the shoulder tackle. They recommended that coaches should encourage players to improve their footwork during tackling and to focus on maintaining a square body position when making shoulder contact in order to decrease the risk of injury and to perform a successful tackle. Other reports$^2,3,12$ have mentioned that anterior shoulder dislocation occurs due to the levering force caused by a forcible backward movement from abduction of the shoulder joint.

**TABLE 2**

**Description of Tackle Characteristics**

| Term                                      | Explanation                                                                 |
|-------------------------------------------|-----------------------------------------------------------------------------|
| Approach phase                            |                                                                             |
| Orientation of tackler in relation to ball carrier (Hendricks et al 2014$^6$) | In front Tackler and ball carrier moving head-on toward each other           |
|                                           | Side Tackler moving in from the ball carrier’s side                         |
|                                           | Oblique Tackler moving into ball carrier at an angle                        |
|                                           | Behind Tackler chasing ball carrier toward own try-line                     |
| Leading leg                               | Same Ipsilateral side of the shoulder contact                               |
|                                           | Opposite Contralateral side of the shoulder contact                         |
| Distance between the leading leg of tackler and target (Hendricks et al 2014,$^6$ modified) | Near Within a half body length of ball carrier                             |
|                                           | Moderate Within one body length of ball carrier                             |
|                                           | Distant Greater than one body length from ball carrier                      |
| Head position (Hendricks et al 2014,$^6$ modified) | Up and forward Toward the ball carrier                                      |
|                                           | Down Toward the ground                                                     |
| Impact phase                              | Hand tackle First contact point of tackler to ball carrier is between the hand and forearm |
|                                           | Arm tackle First contact point of tackler to ball carrier is between the forearm and upper arm |
|                                           | Shoulder tackle First contact point of tackler to ball carrier is between the shoulder and neck |
| Head placement (Hendricks et al 2014$^6$) | Above Tacker’s head higher than ball carrier’s body during contact           |
|                                           | Beside Tacker’s head next to ball carrier’s body during contact              |
|                                           | In front Tacker’s head in front of ball carrier’s body during contact        |
|                                           | Behind Tacker’s head at the back of ball carrier’s body during contact       |
| Position of shoulder joint at impacta     | Abd $<90^\circ$ Shoulder joint of tackler is located $>90^\circ$ at the moment of impact |
|                                           | Abd $= 90^\circ$ Shoulder joint of tackler is located $\approx 90^\circ$ at the moment of impact |
|                                           | Abd $>90^\circ$ Shoulder joint of tackler is located $<90^\circ$ degree at the moment of impact |
|                                           | ER Shoulder joint of tackler is located in external rotation at the moment of impact |
|                                           | Ntrl Shoulder joint of tackler is not located in external or internal rotation at the moment of impact |
|                                           | IR Shoulder joint of tackler is located in internal rotation at the moment of impact |
| Postimpact phase                          | Abd The upper arm of tackler moved abduction after impact                    |
|                                           | H.abd The upper arm of tackler moved horizontal abduction after impact       |
| Leg drive (McIntosh et al 2010$^9$)       | ER The upper arm of tackler moved external rotation after impact             |
|                                           | Active With leg drive and forward momentum                                  |
|                                           | Passive Without leg drive and forward momentum                              |
| Tackle result (Hendricks et al 2014$^6$)  | Unsuccessful Identified when ball carrier is able to offload ball, or break an attempted tackle |
|                                           | Successful Tackler prevents ball carrier from progressing toward his try-line |

$^a$Shoulder angle and movement is shown at angle of the upper arm to the trunk. Abd, abduction; ER, external rotation; H.Abd, horizontal abduction; IR, internal rotation; Ntrl, neutral.
opposing player with their shoulder to minimize the risk of anterior shoulder dislocation.

In the present study, the characteristics of the tackles were evaluated from 11 videos that captured primary anterior shoulder dislocation. We categorized the tackles based on the initial site of impact with the ball carrier, and several characteristics could be pointed out in each tackle type. In cases of hand and arm tackles (n=8), the tackler failed to align his body to the ball carrier in the approach phase, which resulted in an incomplete tackle with unfavorable shoulder orientation in the subsequent contact phase. In these situations, the levering force that occurred during forcible horizontal abduction in the glenohumeral joint appears to result in anterior shoulder dislocation.

In case of the shoulder tackle (n=3), the tacklers successfully kept their body position square to the ball carrier in the approach phase, and the subsequent contact occurred firmly with their shoulder. It was noted, however, that the tacklers placed their lowered head in front of the ball carrier in all 3 cases. These characteristics were apparently different from the other 2 tackle types. In this type of

**Figure 1.** The orientation of the glenoid defect (angle a).

**Figure 2.** Case of the hand tackle. (A) Cognition: Tackler (TC; asterisk) stands face to face with ball carrier (BC) who has changed his running course just before the frame. (B) Approach: TC attempts to catch the distant BC with full arm extension. (C) Impact: TC touches the BC with his hand. (D) Outcome: TC’s shoulder orientation is forced to full abduction and horizontal abduction by the BC’s moment.

**Figure 3.** Case of the arm tackle. (A) Cognition: Tackler (TC; asterisk) stands face to face with ball carrier (BC). (B) Approach: TC attempts to catch the distant BC by diving. (C) Impact: TC impacts the BC by his arm. (D) Outcome: TC’s shoulder orientation is forced to horizontal abduction by the BC’s moment.
injury, we assumed that tackler’s inappropriate posture with lowered and contralaterally rotated head influences the glenohumeral joint via scapula orientation, which seems to be a primary factor in the cause of anterior shoulder dislocation. It remains unknown whether the mechanism of the shoulder tackle involves levering force or direct arm contusion to the glenoid.

In the present study, the tackles that led to primary shoulder dislocation were categorized into 1 of 3 types for the purpose of addressing these mechanisms in detail, as described above. To verify whether the mechanisms of each tackle type were consistent, we examined bone injury of the affected shoulder by using reconstructed CT images. Regarding the CT image examinations, even though 72.7% of the athletes had a glenoid lesion, no significant difference in the degrees and orientations were found between tackle types. It seems that a part of these results was due to small sample size, which is a major limitation of this study, although the high-quality images of primary shoulder dislocation during tackling are difficult to take. Thus, a future study with a larger population might enable indication of the force on the glenoid during tackling.

In addition to the major limitation described above, another limitation is that the present study was based on

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**TABLE 3**

Summary of the Tackle Types and Computed Tomography Findings

| Tackle Type, n | Glenoid Rim Morphology | Mean Degrees of Glenoid | Hill-Sachs Lesion, n (%) |
|---------------|------------------------|-------------------------|--------------------------|
|               | Intact | Erosion | Bone Defect | 94.3 | 9/11 (81.8) |
| Hand, 4       | 1      | 2       | 1           | 93.2 | 4 (100.0) |
| Arm, 4        | 2      | 0       | 2           | 92.3 | 4 (100.0) |
| Shoulder, 3   | 0      | 2       | 4           | 92.3 | 2 (66.7)  |
| Total, 11     | 3      | 3       | 4           | 92.3 | 9/11 (81.8) |

*No significant difference in the glenoid rim morphology between the 3 types (Fisher exact test \( P = .55 \)).

*No significant difference in the orientation of the glenoid defect between the 3 types (Kruskal-Wallis test \( P = .67 \)).
the collected videos that were recorded from a single video camera, which meant that we could not accurately measure the angle of the shoulder. Thus, to determine the mechanism of primary anterior shoulder dislocation, we would need to perform an investigation using multangle video recordings or a different experimental approach, such as a 3-dimensional motion analysis.

CONCLUSION

Although the precise mechanism of primary anterior shoulder dislocation could not be estimated from this single-view analysis, our study demonstrated that failure of individual tackling that leads to injury is not uniform and can be caused by 2 main factors: failure of approach followed by extended arm position or inappropriate posture of the tackler at the impact, with lowered head in front of the opponent. These findings indicate that injury mechanisms should be assessed in each type of tackling because it remains unknown whether external force to the glenoid is different in each mechanism during shoulder dislocation.

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REFERENCES

1. Bohu Y, Klouche S, Lefevre N, et al. The epidemiology of 1345 shoulder dislocations and subluxations in French Rugby Union players: a five-season prospective study from 2008 to 2013. Br J Sports Med. 2015;49:1535-1540.
2. Crichton J, Jones DR, Funk L. Mechanisms of traumatic shoulder injury in elite rugby players. Br J Sports Med. 2012;46:538-542.
3. Fuller CW, Ashton T, Brooks JH, Cancea RJ, Hall J, Kemp SP. Injury risks associated with tackling in rugby union. Br J Sports Med. 2010;44:159-167.
4. Headey J, Brooks JH, Kemp SP. The epidemiology of shoulder injuries in English professional rugby union. Am J Sports Med. 2007;35:1537-1543.
5. Hendricks S, Lambert M. Tackling in Rugby. Int J Sports Sci Coach. 2010;5:117-135.
6. Hendricks S, Matthews B, Roode B, Lambert M. Tackler characteristics associated with tackle performance in rugby union. Eur J Sport Sci. 2014;14:753-762.
7. Kawasaki T, Ota C, Urayama S, et al. Incidence of and risk factors for traumatic anterior shoulder dislocation: an epidemiologic study in high-school rugby players. J Shoulder Elbow Surg. 2014;23:1624-1630.
8. Longo UG, Huijimans PE, Maffulli N, Denaro V, De Beer JF. Video analysis of the mechanisms of shoulder dislocation in four elite rugby players. J Orthop Sci. 2011;16:389-397.
9. McIntosh AS, Savage TN, McCrory P, Frechede BO, Wolfe R. Tackle characteristics and injury in a cross section of rugby union football. Med Sci Sports Exerc. 2010;42:977-984.
10. Roberts SP, Trewartha G, England M, Shaddick G, Stokes KA. Epidemiology of time-loss injuries in English community-level rugby union. BMJ Open. 2013;3:e003998.
11. Saito H, Itoi E, Sugaya H, Minagawa H, Yamamoto N, Tuoheti Y. Location of the glenoid defect in shoulders with recurrent anterior dislocation. Am J Sports Med. 2005;33:889-893.
12. Usman J, McIntosh AS, Quarrie K, Targett S. Shoulder injuries in elite rugby union football matches: epidemiology and mechanisms. J Sci Med Sport. 2015;18:529-533.

APPENDIX

TABLE A1

| Orientation of Tackler Relative to Ball Carrier | Approach Phase | Impact Phase | Postimpact Phase |
|-----------------------------------------------|----------------|--------------|------------------|
| Orientation of Tackler Relative to Ball Carrier | Leading Leg | Distance Between the Leading Leg of Tackler and Target | Head Position | Type of Tackle | Hand Placement | Position of Shoulder Joint at Impact | Main Direction of Shoulder Joint Motion | Leg Drive | Tackle Result |
| 1 In front | Same | Moderate | Up and forward | Hand | Beside | Abd>90°, ER | H. Abd | Passive | Unsuccessful |
| 2 In front | Same | Moderate | Down | Hand | Beside | Abd>90°, ER | H. Abd | Passive | Unsuccessful |
| 3 In front | Same | Distant | Up and forward | Hand | Beside | Abd>90°, ER | H. Abd | Passive | Unsuccessful |
| 4 In front | Same | Distant | Up and forward | Hand | Behind | Abd>90°, ER | H. Abd | Passive | Unsuccessful |
| 5 Oblique | Same | Near | Down | Arm | Beside | Abd=90°, ER | H. Abd | Passive | Successful |
| 6 Oblique | Same | Near | Down | Arm | Beside | Abd=90°, ER | H. Abd | Passive | Successful |
| 7 Oblique | Same | Near | Down | Arm | Behind | Abd>90°, ER | H. Abd | Passive | Unsuccessful |
| 8 In front | Opposite | Moderate | Down | Arm | Beside | Abd>90°, ER | H. Abd | Active | Unsuccessful |
| 9 In front | Opposite | Near | Down | Shoulder | In front | Abd<90°, Ntr | H. Abd | Active | Successful |
| 10 In front | Opposite | Near | Down | Shoulder | In front | Abd<90°, Ntr | H. Abd | Active | Successful |
| 11 Oblique | Same | Near | Down | Shoulder | In front | Abd<90°, Ntr | H. Abd | Active | Unsuccessful |

*Abd, abduction; H. Abd, horizontal abduction; ER, external rotation; Ntr, neutral.*
**TABLE A2**

Interrater Reliability of the Tackle Assessment

| Description                              | κ Value | Concordance Rate (%) |
|------------------------------------------|---------|----------------------|
| Orientation of tackler in relation to ball carrier | 1       | 100                  |
| Leading leg                              | 1       | 100                  |
| Distance between the leading leg of tackler and target | 0.85    | 90.9                 |
| Type of tackle                           | 0.86    | 90.9                 |
| Head position                            | 1       | 100                  |
| Position of shoulder joint at impact     | 1       | 100                  |
| Movement of upper arm after contact      | 1       | 100                  |
| Leg drive                                | 1       | 100                  |
| Tackle result                            | 1       | 100                  |