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Local Compressive Strength of the Superolateral and Superomedial Aspects of the Anterior Half of the Talar Dome: A Biomechanical and Histological Study

Ekavit Keyurapan, M.D.*

Suchart Benjarusameerote, M.D.*

Thossart Harnroongroj, M.D.*

Abstract : One cause of osteochondritis dissecans of the talar dome is related to trauma. The lesion occurs at the anterior half of the talar dome. The lateral osteochondritis dissecans is located at the superolateral aspect, while the medial lesion is located at the superomedial aspect. The lateral lesion is more common and its crater is shallower than that of the medial lesion. This study was therefore carried out to determine the local compressive strength of the superolateral and superomedial aspects of the anterior half of the talar dome. Ten pairs of fresh normal cadaveric tali were obtained. Using a universal testing machine, a compressive load was applied through a metal indenter at the superolateral and superomedial aspects of the talar dome until the maximal load was obtained. The maximal load and depth of depression were recorded. Histological studies of the compressive lesion was done using decalcified hematoxylin eosin stain.

The results of the study showed that the superolateral aspect of the talar dome could withstand 1.27 times less compression load than could the superomedial aspect without a significant difference in stiffnesses. Moreover, the depth of depression of the superolateral compressive lesion was shallower than that of superomedial. Histological studies showed that the compressive lesion was a depression fracture. The depression fracture was a free osteochondral fragment surrounded by normal osteochondral tissue. The free fragment included articular cartilage, subchondral plate, and subchondral cancellous bone. The result of this study may explain why the prevalence of the lateral traumatic osteochondritis dissecans is higher, and its lesion crater shallower, than that of the medial aspect of the talar dome.

*Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

เรื่องย่อ : ความแข็งแรงต่อแรงกดที่บริเวณด้าน Superolateral และ Superomedial ของ Anterior Half ของ Talar Dome

เอกวิทย์ เกษราพันธุ์ พ.บ.*, สุชาติ เบญจรัศมีโรจน์ พ.บ.*, ทศศาสตร์ หาญรุ่งโรจน์ พ.บ.*

*ภาควิชาศัลยศาสตร์ออร์โธปิดิกส์, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กรุงเทพมหานคร 10700.

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สาเหตุของ osteochondritis dissecans ของ talar dome มีความสัมพันธ์เกี่ยวเนื่องกับ trauma พยาธิสภาพที่เกิดด้าน superolateral มากกว่าทางด้าน superomedial แต่ crater จะตื้นกว่า ฉะนั้นการศึกษาเปรียบเทียบความแข็งแรงของ talar dome ด้าน superolateral กับ superomedial ซึ่งอาจจะเป็นสาเหตุหนึ่งของอุบัติเหตุการเกิด osteochondritis dissecans ที่แตกต่างกันทั้งสองด้าน กระดูก talus จำนวน 10 คู่จากศพสดถูกนำมาทดสอบด้วยแรงอัดจาก universal testing machine ที่บริเวณ superolateral และ superomedial ของ anterior half ของ talar dome จนกระทั่งได้แรงกดสูงสุด บันทึกปริมาณแรงกดสูงสุดและความลึกของการกด จากนั้นนำ talus ไปศึกษาทางพยาธิสภาพบริเวณที่ถูกแรงกด โดยใช้เทคนิคการย้อม decalcified hematoxylin และ eosin ผลพบว่าด้าน superolateral aspect ของ talar dome ด้านต่อแรงกดน้อยกว่าด้าน superomedial 1.27 เท่าอย่างมีนัยสำคัญทางสถิติ แต่อย่างไรก็ตาม stiffness ของทั้งสองบริเวณที่ถูกกดไม่มีความแตกต่างกัน ความลึกของการกดพบว่าด้าน superolateral ตื้นกว่าด้าน superomedial อย่างมีนัยสำคัญ ทางพยาธิวิทยาพบว่าบริเวณถูกกดเกิด depression fracture และมีชั้นกระดูกอิสระตรงกลางรอยถูกกด ซึ่งประกอบด้วยกระดูกอ่อน subchondral plate และกระดูก subchondral cancellous จากผลการศึกษานำไปใช้อธิบายการเกิด lateral traumatic osteochondritis dissecans มีอัตราการเกิดสูงกว่าและมี crater ตื้นกว่าด้าน medial ของ talar dome

INTRODUCTION

In 1922, Kappis¹ found loose bodies in the ankle and described them as osteochondritis dissecans of the ankle. Osteochondritis dissecans of the talus was described as an osteochondral fracture and is related to trauma^{2,3,4}. Lateral osteochondritis dissecans involves the superolateral aspect of the anterior half of the talar dome, while a medial lesion involves the superomedial aspect. Prevalence of the lateral lesion is higher than that of the medial lesion. Moreover, a crater of lateral lesion is shallower than that of the medial^{2,3,4}. This study was therefore carried out to determine the local compressive strength of the superolateral and superomedial aspect of the anterior half of the talar dome by applying a maximal compressive load. A histological study of the compressive lesion was also carried out.

MATERIALS AND METHODS

Twenty-fresh cadaveric tali (ten pairs) with no history of metabolic bone diseases, tumor, or previous fracture were obtained from 5 males and 5 females between 20-45 years of age. Soft tissues around the talus were removed. The test was performed at room temperature and the talus was moistened with normal saline. A universal testing machine with 6-mm diameter round-tipped metal indenter was used. The talus' position was adjusted such that the superomedial aspect of the anterior half of the talar dome was under the indenter's tip and 1 mm from the lateral edge. After the position of the talus was adjusted, it was fixed on the metal base of the universal testing machine using acrylic cement (Figure 1). A uniaxial compressive load was applied at the speed of 2 mm/min until the maximal load was obtained as

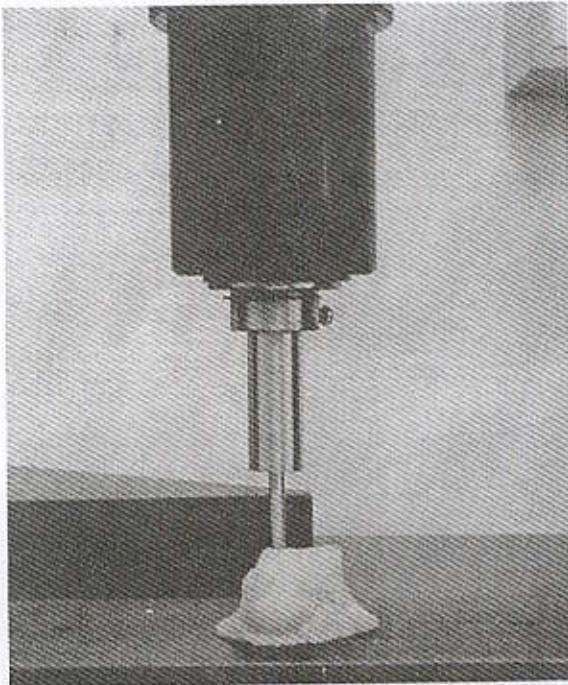


Figure 1. A uniaxial compressive load was applied at the superomedial aspect of the anterior half of the talar dome until the maximal compressive load was obtained.

shown in the load and deformation curve. At that time, the load applied was stopped. The superolateral aspect of the anterior half of the talar dome was tested in the same manner as the superolateral aspect. Maximal load and depth of depression at maximal load were recorded by the universal testing machine's computer. Stiffness was calculated. The compressive lesion of the talar dome was histologically studied using decalcified hematoxylin and eosin stain. The data were analyzed using the Mann-Whitney U Test.

RESULTS

The superolateral aspect of the anterior half of the talar dome could withstand an average compression load of 1,131.1 N (SD 325.49). Its stiffness was 1,330.72 N/mm (SD 461.22) and depth of depression was 1.07 mm (SD 0.38). The corresponding figures for the superomedial aspect were 1,435.90 N (SD 226.67), 1,354.63 N/mm (SD 149.03), and

1.45 mm (SD 0.52) respectively (Table 1). Statistical analysis showed that the local compressive strength of the superolateral aspect of the anterior half of the talar dome was 1.27 times less than that of the superomedial aspect ($P = 0.0013$) without a significant difference in stiffness ($P = 0.4330$). Moreover, the depth of the superolateral compressive lesion was shallower than that of the superomedial aspect ($P = 0.0030$). Histological studies of the superomedial and superolateral compressive lesions showed that there was a depression osteochondral fracture as a free fragment surrounded by normal osteochondral tissue. The free fragment included articular cartilage, subchondral plate, and subchondral cancellous bone (Figure 2).

DISCUSSION

This study revealed that the superolateral aspect of the anterior half of the talar dome is weaker than the superomedial aspect. However, there is no significant difference in stiffnesses. This may be because the quality of the osteochondral tissue of the superomedial and superolateral aspect of the talar dome is not significantly different. The shapes of superomedial and superolateral talar aspects of the talar dome however, are different. The superomedial aspect of the talar dome has a wide-angled edge at the top and the medial surface is convex with a broad base, while the superolateral aspect has a narrow-angled edge at the top and the lateral surface is concave with a narrow base⁵. This is why the superolateral aspect of the talar dome withstands less compressive load than the superomedial aspect^{5,6}. Described in the literature, the lesion of osteochondritis dissecans of the talar dome is a free fragment of osteochondral tissue. Lateral osteochondritis dissecans is related to trauma and is more common than the medial lesion; the lateral lesion also has a shallower crater^{2,3,4}. According to the results of the study, the superolateral aspect of the anterior half of the talar dome withstands less compressive load than does the superomedial aspect, so a traumatic osteochondral lesion at the superolateral aspect of the anterior half of the talar dome should be found more often than at the superomedial aspect. Moreover, the lateral lesion found in this experiment is a free fragment of osteochondral tissue with shallower depth than the

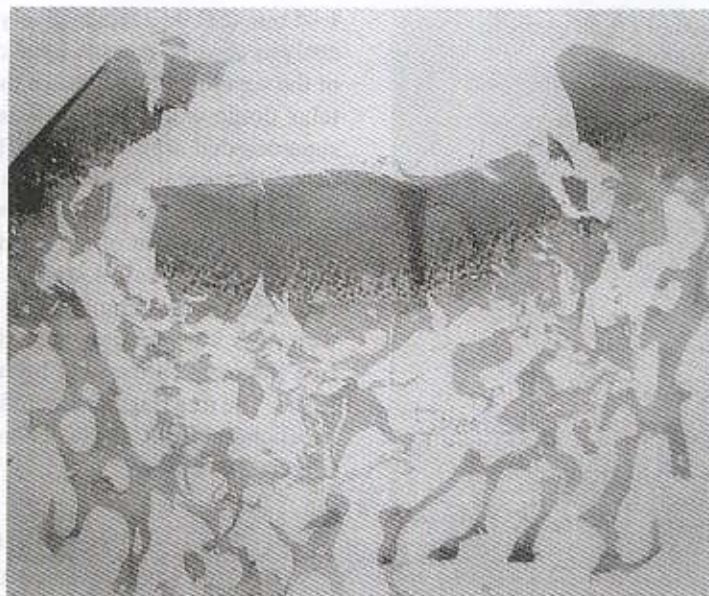


Figure 2. A compressive lesion is a depressive osteochondral fracture that occurs as a free fragment surrounded by normal osteochondral tissue. The free fragment includes articular cartilage, subchondral plate, and subchondral cancellous bone (magnified x 10).

Table 1. Data on maximal load, stiffness, and depth of depression at maximal load of the compressive lesions of the talar dome.

No.	Maximum Load (N)		Stiffness (N/mm)		Depth (mm)	
	Medial	Lateral	Medial	Lateral	Medial	Lateral
1	1574.27	805.95	872.89	1066.24	2.33	1.32
2	1536.64	1113.28	1254.40	1400.71	1.66	1.18
3	1712.26	2013.31	1280.57	2331.13	1.43	1.12
4	1141.50	1194.82	977.35	1437.37	1.35	1.12
5	1712.26	1611.90	1536.64	1975.68	2.33	1.01
6	1527.23	1458.24	1829.37	1813.69	0.78	0.90
7	1404.93	906.30	1688.25	956.48	1.19	0.93
8	1549.18	1075.65	1724.80	1217.85	1.27	1.06
9	921.98	831.04	1055.75	919.93	1.70	0.77
10	1041.15	1072.51	1092.41	1249.21	1.33	1.07
11	1655.81	818.50	1332.80	810.17	2.49	0.76
12	1254.40	900.03	1123.77	679.43	1.94	2.56
13	1756.16	994.11	1651.59	1149.83	1.68	1.00
14	1379.84	978.43	1416.39	1646.40	0.91	0.63
15	1335.94	1448.83	1724.80	1813.69	0.89	0.93
16	1665.22	1401.79	1897.28	1803.20	1.10	1.00
17	1370.43	639.74	1489.60	533.12	1.01	0.87
18	1329.66	984.70	2132.48	1113.28	0.73	0.95
19	1420.61	1154.05	1442.56	1280.57	1.36	1.14
20	1428.45	1223.04	1212.55	1416.39	1.55	1.16
Mean	1435.90	1131.31	1351.63	1330.72	1.45	1.07
SD	226.67	325.49	149.03	462.22	0.52	0.38

medial lesion. All of these facts correspond with lateral osteochondritis dissecans of the talar dome. To conclude, the result of this study may explain the

prevalence and pathomechanics of traumatic lateral osteochondritis dissecans of the talar dome.

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