Osteochondral Lesions of the Tibial Plafond

A Systematic Review

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Background: There is a paucity of data regarding osteochondral lesions of the tibial plafond (OLTPs), in part because they are far less common than osteochondral lesions of the talus.

Purpose: To evaluate the topographical characteristics of OLTPs and outcomes after surgical intervention, while analyzing the level of evidence (LOE) and quality of evidence (QOE) of the included studies.

Study Design: Systematic review; Level of evidence, 4.

Methods: A systematic review of the MEDLINE, EMBASE, and Cochrane Library databases was performed in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Studies reporting clinical data for OLTPs were included. The LOE and QOE of the included studies were evaluated using a 5-level grading system and the modified Coleman Methodology Score, respectively.

Results: Included were 20 studies with 426 OLTPs; 4 studies were LOE 2 and 16 studies were LOE 4. Overall, 86.7% of OLTPs were associated with a traumatic history and/or previous ankle sprain. OLTPs were most commonly located in the centromedial region of the tibial plafond (30.4%), with the fewest number of OLTPs found in the anteromedial region of the tibial plafond (3.9%). In 17 of the studies, a total of 46.9% of OLTPs were associated with coexisting osteochondral lesions of the talus. The most frequently used surgical technique to treat OLTPs was microfracture, which resulted in good clinical outcomes at midterm follow-up.

Conclusion: The results of this systematic review indicated that OLTPs are frequently preceded by ankle trauma and are often associated with coexisting osteochondral lesions of the talus. Clinical outcomes after arthroscopic intervention appear to produce good results in the midterm, but the low LOE, poor QOE, marked heterogeneity, and underreporting of the data confound any recommendation based on this systematic review.

Keywords: osteochondral lesion; tibial plafond; ankle

Osteochondral lesions of the ankle represent a defect in the articular cartilage and the subchondral bone of the talus or tibia.[14,39] These lesions are a common cause of chronic ankle pain and are often associated with a traumatic origin, including ankle fractures or ankle sprains.[26,27,39] Osteochondral lesions of the talus (OLTs) account for most osteochondral lesions of the tibiotalar joint, and the literature reports ratios of 1 osteochondral lesion of the tibial plafond (OLTP) for every 14 to 20 OLTs.[5,9,10] OLTs have been widely investigated, with several classification systems described, pathophysiological factors theorized, and treatment paradigms developed.[23,25,32,34,41] Conversely, there is a paucity of data regarding OLTPs, in part because they are far less common than OLTs, with a frequently cited incidence of just 5% of all ankle osteochondral abnormalities.[5,9,10,31] Although the exact pathophysiological mechanisms of injury in OLTPs have not been determined, the stiffer articular cartilage lining the surface of the tibial plafond together with the concave

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TABLE 1
Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Clinical studies related to osteochondral lesions of the tibial plafond	Fewer than 10 patients
Published in a peer-reviewed journal	Case reports
Written in English	Cadaveric studies
	Animal studies

shape of the tibial plafond may account for the lower relative incidence of OLTPs.[1,10,17]

Despite the relatively lower incidence of OLTPs, they are a significant source of pain and disability, often requiring surgical intervention. Surgeons have used various arthroscopic interventions to treat OLTPs, including debridement, curettage, and microfracture, which have yielded good clinical outcomes at midterm follow-up.[9,13,20,31] However, despite a recent increase in reporting of OLTPs in the literature, no consensus has been reached regarding the cause of OLTPs, their topographical distribution, or optimal treatments.

The purpose of this systematic review was to evaluate the topographical characteristics of OLTPs and outcomes after surgical intervention and to analyze the level of evidence (LOE) and quality of evidence (QOE) of the included studies.

METHODS

Search Strategy

During July 2019, a systematic review of the MEDLINE, EMBASE, and Cochrane Library databases was performed based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The following search terms were used: ((osteochondral lesion OR OCL OR osteochondral defect OR OCD OR osteochondritis dissecans OR chondral OR cartilage) AND (tibia OR tibial or ankle OR tibiotalar)). The inclusion and exclusion criteria are shown in Table 1. After retrieval of the data, 2 independent reviewers screened the titles, abstracts, and full-text articles of all searched studies by applying the aforementioned criteria. A senior author (J.G.K.) was consulted to arbitrate any disagreements that arose.

Assessment of LOE and Methodological Quality

The LOE was assessed using previously published criteria.[40] The methodological QOE[19] was assessed by 2 independent reviewers using the modified Coleman Methodology Score (MCMS).[8] If any discrepancy existed, the senior author (J.G.K.) evaluated the available data and a consensus was reached. The QOE was considered excellent if the MCMS was between 85 and 100 (highest possible score), good if between 70 and 84, fair if between 55 and 69, and poor if <55.

Data Extraction and Evaluation

Two independent reviewers (J.J.B., N.P.M.) independently extracted and assessed the data from each study. Data on patient and lesion characteristics, including lesion location, lesion size, and the presence of coexisting OLT, were extracted. To illustrate the location of OLTPs, the surface of the tibial plafond was divided into 9 zones using a 3×3 grid, as has been previously described.[10] Data on the characteristics of the surgical procedure were also collected. Subjective outcomes, postoperative imaging, complications, failures, and reoperations were evaluated.

Statistical Analysis

Statistical analyses were performed using SAS software Version 9.3 (SAS Institute). Descriptive statistics were calculated for all continuous and categorical variables. Continuous variables were reported as weighted mean and estimated standard deviation, whereas categorical variables were reported as frequencies with percentages. $P < .05$ was considered statistically significant.

RESULTS

The initial search generated 29,561 studies. Of these, 20 met the inclusion and exclusion criteria (Figure 1).

Study Characteristics and Patient Data

In the 20 studies, 426 patients were diagnosed with an OLTP. Data for patients with an OLTP were obtained from only 8 studies.[2,3,9,10,13,16,20,31] The weighted mean age was 38.8 ± 5.7 years (range, 24.0-44.1 years). From these 8 studies, 81 patients (48.2%) were male. All but 5 of the 20 studies[2,3,24,30,37] recorded the cause of the lesion and concomitant injuries. Further, 86.7% of patients had a history of trauma and/or associated ankle sprain.

A total of 4 studies[10,17,30,37] were LOE 2 and 16 studies[‖] were LOE 4. The mean MCMS of all included studies was 44.1 ± 13.6. No studies were classified as having excellent quality per the MCMS. There were 2 studies[6,9] of good quality, 8 studies[2,3,7,13,16,25,30,31] of fair quality, and 10 studies[¶] of poor quality. Study characteristics and patient data are listed in Table 2.

Lesion Characteristics

In 17 studies (337 OLTPs), 179 (53.1%) lesions were described as isolated tibial plafond lesions, and 158 (46.9%) lesions entailed coexisting tibial plafond and talar osteochondral lesions.[#] Of the patients who had coexisting osteochondral lesions, 27 (17.1%) of the lesions were described as "kissing lesions." Ross et al[31] and Irwin et al[13] both assessed patients from a similar database at

[‖]References 2, 3, 6, 7, 9, 13-16, 20, 24, 25, 29, 31, 36, 42.
[¶]References 10, 14, 15, 17, 20, 24, 29, 36, 37, 42.
[#]References 2, 3, 6, 7, 9, 10, 13, 15, 16, 20, 24, 29-31, 36, 37, 42.

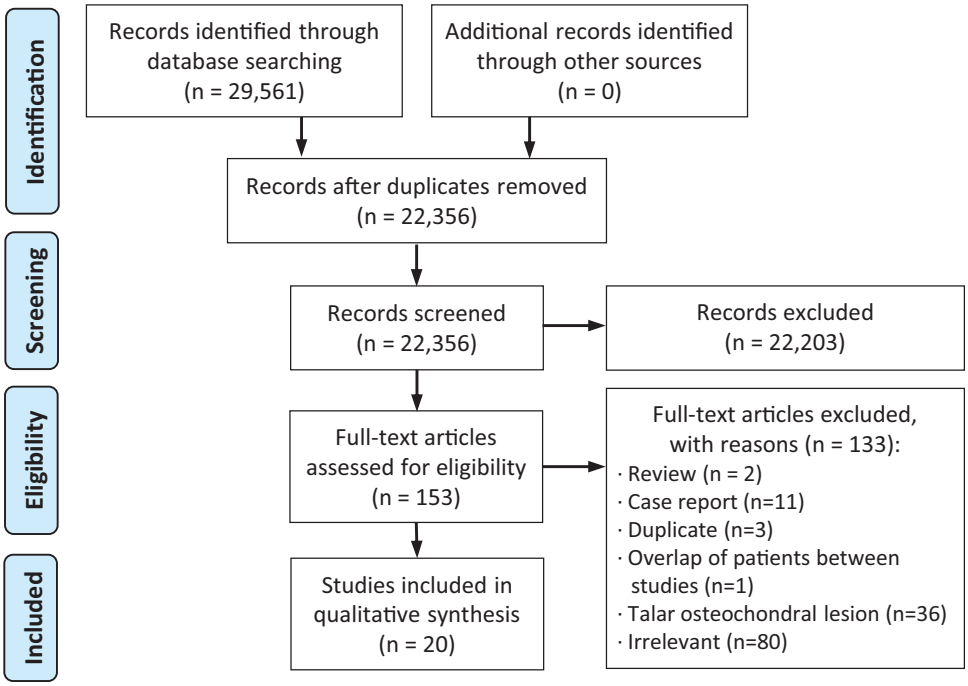

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

TABLE 2
Study Characteristics and Patient Data[a]

Lead Author (Year)	LOE	Patients With OLTP, n	Age, y	Sex, M/F, n	BMI	Follow-up, mo	MCMS[b]
Aurich[2] (2010)	4	3	24.0	—	—	24.3	58
Baldassari[3] (2018)	4	27	39.2	15/12	—	72.0	58
Chuckpaiwong[6] (2008)	4	19	—	—	—	—	72
Clanton[7] (2014)	4	7	—	—	—	—	58
Cuttica[9] (2012)	4	13	32.9	9/4	—	38.8	77
Elias[10] (2009)	2	38	38.7	12/26	—	—	37
Irwin[13] (2018)	4	26	43.5	16/10	—	—	58
Kirschke[14] (2016)	4	38	—	—	—	—	31
Körner[15] (2018)	4	13	—	—	—	—	54
Lee[16] (2019)	4	16	42.1	5/11	34.2	29.8	59
Leontaritis[17] (2009)	2	5	—	—	—	—	41
Mologne[20] (2007)	4	17	38.0	9/8	—	44.0	42
Ogul[24] (2019)	4	12	—	—	—	—	35
Okuda[25] (2005)	4	15	—	—	—	—	58
Regier[29] (2016)	4	27	—	—	—	—	45
Richter[30] (2020)	2	37	—	—	—	—	68
Ross[31] (2014)	4	31	37.0	15/16	—	44.0	58
Sijbrandij[36] (2000)	4	19	—	—	—	—	32
Takao[37] (2005)	2	2	—	—	—	—	39
You[42] (2016)	4	61	—	—	—	—	32

[a]Dashes indicate data not reported. BMI, body mass index; LOE, level of evidence; MCMS, modified Coleman Methodology Score; M/F, male/female; OLTP, osteochondral lesion of the tibial plafond.

[b]Grades the quality of evidence as excellent (85-100), good (70-84), fair (55-69), or poor (<55).

TABLE 3
Lesion Characteristics[a]

Lead Author (Year)	OLTPs, n	Isolated OLTPs, n	Coexisting OCLs, n	Kissing OCLs, n	OLTs, n	Isolated OLTs, n	Size of OLTP, mm^2	Depth of OLTP, mm	Cystic OLTPs, n
Aurich[2] (2010)	3	3	0	0	15	15	127.0	2.3	—
Baldassari[3] (2018)	27	27	0	0	0	0	180.0	4.4	2
Chuckpaiwong[6] (2008)	19	0	19	0	105	86	—	—	—
Clanton[7] (2014)	7	3	4	0	37	33	31.0	—	—
Cuttica[9] (2012)	13	9	4	1	4	0	—	—	3
Elias[10] (2009)	38	32	6	1	6	0	—	—	—
Irwin[13] (2018)	26	0	26	9	83	57	63.6	—	—
Kirschke[14] (2016)	38	—	—	—	51	—	—	—	—
Körner[15] (2018)	13	8	5	0	143	138	—	—	—
Lee[16] (2019)	16	12	4	0	4	0	65.2	—	—
Leontaritis[17] (2009)	5	—	—	—	51	—	—	—	—
Mologne[20] (2007)	17	11	6	0	6	0	—	—	1
Ogul[24] (2019)	12	12	0	0	54	0	—	—	—
Okuda[25] (2005)	15	—	—	—	12	—	—	—	—
Regier[29] (2016)	27	20	7	0	20	13	—	—	—
Richter[30] (2020)	37	37	0	0	221	221	—	—	—
Ross[31] (2014)	31	19	12	12	12	0	38.0	—	—
Sijbrandij[36] (2000)	19	3	16	16	23	7	—	—	—
Takao[37] (2005)	2	2	0	0	27	27	—	—	—
You[42] (2016)	61	0	61	0	297	236	—	—	—

[a]Dashes indicate data not reported. OCL, osteochondral lesion; OLT, osteochondral lesion of the talus; OLTP, osteochondral lesion of the tibial plafond.

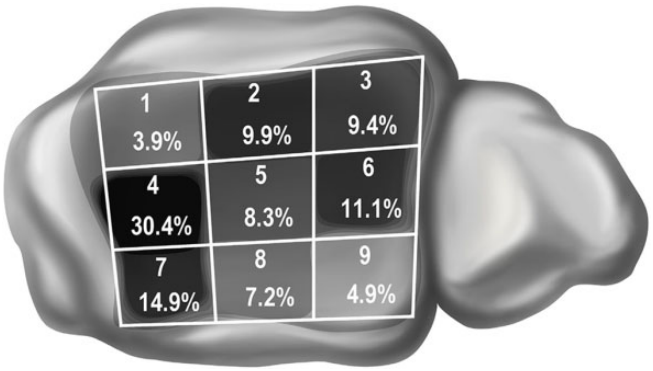

Figure 2. Zone locations shown in a grid format superimposed onto the distal tibial plafond with corresponding heat maps demonstrating the distribution of all osteochondral lesions of the tibial plafond (n = 181 reported in 6 studies that recorded location of osteochondral lesions of the tibial plafond). Heat map shading corresponds to the percentage of lesions found in each zone, with darker coloration indicating higher percentages.

the same institution between the years of 2006-2014, thus due to potential overlap of patient cohorts, lesion characteristic data from the Ross et al study were excluded from the analysis. The lesion characteristics are shown in Table 3.

A total of 6 studies recorded the location of OLTPs using a 9-zone mapping system.[3,9,10,13,16,41] Overall, 30.4% of OLTPs were found in zone 4 (centromedial). The region that contained the fewest OLTPs was zone 1 (anteromedial), with 3.9% of all OLTPs. The location of kissing lesions was reported in 2 studies.[10,13] Kissing lesions occurred most frequently in zone 4 (30.8%). The location of the OLTP was not significantly correlated with clinical outcomes in 2 studies.[20,31] Figure 2 shows the distribution of the OLTPs.

Lesion size was reported in 6 studies.[2,3,7,13,16,31] The weighted mean OLTP size was 103.2 ± 53.3 mm^2. Two studies recorded the depth of the osteochondral lesions.[2,3] The weighted mean depth of OLTPs was 4.2 ± 1.1 mm. A total of 6 cystic lesions (1.5%) were recorded in 3 studies.[3,9,20] One study demonstrated that increasing lesion size was significantly correlated with worse clinical outcomes.[3]

Surgical Characteristics

A total of 11 studies reported surgical techniques used to treat OLTPs.[**] A variety of surgical techniques were used, the most common of which was bone marrow stimulation (BMS) in the form of microfracture (8 studies).[6,7,9,13,15,16,20,31] A total of 6 studies reported concomitant surgical procedures, including lateral ankle ligament stabilization,[9,16,31] microfracture for OLT,[6,7,13,31] autologous osteochondral transplant (AOT) for OLT,[13] peroneal tendon repair,[16] peroneal retinaculum repair,[16] distal tibial exostectomy,[16] and Kidner procedure.[16]

**References 2, 3, 6, 7, 9, 13, 15, 16, 20, 30, 31.

Clinical Outcomes

A total of 11 studies examined clinical outcomes after the treatment of OLTPs.[††] The weighted mean time from onset of injury to surgical intervention was 17.8 ± 12.3 months (range, 2.7-40.0 months). Only 6 of these studies reported adequate data from which outcomes after treatment of OLTPs could be extracted.[2,9,13,16,20,31] The weighted mean postoperative follow-up time was 42.6 ± 15.2 months (range, 38.8-72.0 months). Two studies used the American Orthopaedic Foot and Ankle Society (AOFAS) score.[3,20] The weighted mean preoperative AOFAS score was 52.6 ± 0.5 (range, 52.0-53.0) and the postoperative score was 84.0 ± 3.0 (range, 81.0-87.0). One study found no significant correlations between body mass index and clinical outcomes, sex and clinical outcomes, and age and clinical outcomes.[3]

A total of 3 studies reported return to sporting activities.[2,9,16] Lee et al[16] demonstrated that 16 patients (100%) returned to their sporting activities after synovectomy, curettage, and microfracture of the OLTP. Cuttica et al[9] reported that 9 patients (69.2%) returned to their sporting activities after synovectomy, curettage, and microfracture of the OLTP. Aurich et al[2] reported that 2 patients (66.7%) returned to their previous sporting activity after matrix-associated chondrocyte implantation.

In 4 studies, postoperative magnetic resonance imaging (MRI) was conducted at final follow-up.[2,3,9,31] A total of 3 studies used the MOCART (magnetic resonance observation of cartilage repair tissue) scoring system, according to which 30 patients (56.6%) displayed complete filling of the defect, 15 patients (28.3%) had incomplete filling of the defect, 5 patients (9.4%) had subchondral bone exposure, and 3 patients (5.7%) had hypertrophic infill of the defect.[2,3,31] MOCART scores were negatively correlated with increasing age and lesion area in 2 studies.[3,31] In 1 study, reactive bone marrow edema was found in 4 patients who had poor outcomes after surgical intervention of the OLTP.[9]

In total, 6 complications were observed in 209 patients (2.9%). Complications included chronic ankle pain, subchondral cyst formation, superficial peroneal nerve dysesthesia, deep vein thrombosis, and sciatic and saphenous nerve neurapraxia. Further surgical intervention was recorded in 3 studies.[9,20,31] Cuttica et al[9] reported that 3 patients (23.0%) required further surgical intervention after microfracture, including 1 repeated microfracture, 1 removal of an osteochondral plug with a repeated microfracture, and 1 AOT procedure. Mologne and Ferkel[20] reported that 1 patient (5.9%) required iliac crest bone grafting after arthroscopic excision of a cystic lesion and transmalleolar drilling. Ross et al[31] reported that 1 patient underwent AOT for an OLT. The clinical outcomes and complications are listed in Table 4.

[††]References 2, 3, 6, 7, 9, 13, 15, 16, 20, 30, 31.

DISCUSSION

The most important finding of this systematic review was that OLTPs are frequently preceded by ankle trauma and are often associated with coexisting osteochondral lesions of the talus.

The cause of OLTPs may be considered in light of external and internal factors. The external factors implicated in OLTP development may be related to the mechanism of injury producing the OLTP. In an ankle inversion injury, the medial back shoulder of the talus may come into contact with the medial aspect of the tibial plafond. Over time, recurrent ankle sprains may lead to degradation of the cartilage that lines the medial articular surface of the distal tibia.[3] The current review found that almost half of all OLTPs were located in the medial region of the tibial plafond and were strongly associated with a history of ankle sprains, suggesting that OLTPs may be associated with a chronic cause. The low rate of kissing lesions (17.1%) further suggests that repetitive trauma from recurrent ankle sprains may play a more significant role in the development of osteochondral lesions of the tibiotalar joint, rather than high-energy impact injuries, which would lead to direct impaction of the tibia and the talus and subsequent juxtaposed or kissing lesions.

Internal factors influencing the cause of OLTPs include variations in cartilage morphology lining the tibial plafond. The cartilage at the centromedial region is considered to be the least rigid and least stiff compared with cartilage at other regions of the tibial plafond.[1] This was the most common site of OLTPs, and this mechanical property of regional cartilage variation may predispose it to greater risk of injury and subsequent development of OLTP. In contrast, the most rigid region of the cartilage at the surface of the distal tibia is the anteromedial region,[1] where the lowest number of OLTPs occurred, possibly reflecting its ability to resist cartilage damage. Other local topographical factors have been described to explain why OLTPs appear to be less frequent than OLTs, despite both having a traumatic origin. The talar dome has a convex shape in comparison with the concave shape of the tibial plafond. The axial forces acting on the convex talar dome exert compressive shear forces on the articular surface, placing the articular cartilage and the subchondral surface at high risk of injury.[10] Conversely, the axial forces acting on the concave tibial plafond create tensile shear forces. This allows for more efficient force distribution across the articular surface, thus reducing the likelihood of disruption of the articular cartilage and subchondral surface.[10] Furthermore, the cartilage that lines the surface of the tibial plafond is stiffer than the cartilage lining the talar dome.[1] Therefore, both the morphological and biomechanical differences between the tibia and talus may contribute to the lower incidence of OLTPs.

BMS in the form of microfracture was the most commonly used surgical procedure to treat OLTP, with improvement in clinical scores reported in all studies at final follow-up. Follow-up was typically <4 years, and these data should be interpreted in light of the relatively

TABLE 4
Summary of Clinical Outcomes and Complications[a]

Lead Author (Year)	No. of OLTPs	Follow-up for OLTP, mo	Surgery Performed	OLTP Score, Preoperative/ Postoperative	Postoperative Imaging	Complications After OLTP	Reoperations After OLTP	Concomitant Operations
Aurich[2] (2010)	3	24.3	Matrix-associated chondrocyte implantation		3 incomplete filling on MRI (MOCART)			
Baldassari[3] (2018)	27	72.0	Bone marrow–derived cell transplant	AOFAS: 52.4/80.6	18 complete filling, 3	hypertrophy, 6 incomplete filling on MRI (MOCART)		
Chuckpaiwong[6] (2008)	19		Microfracture					19 microfracture for OLT
Clanton[7] (2014)	7		Microfracture					4 microfracture for OLT
Cuttica[9] (2012)	13	38.8	9 microfracture, 2 drilling with back fill, 1 osteochondral plug	Modified AOFAS: 35.2/50.4	4 bone marrow edema on MRI	1 chronic ankle pain	2 repeat microfracture, 1 AOT	3 lateral ankle ligament stabilization
Irwin[13] (2018)	26		26 microfracture and concentrated bone marrow aspirate	FAOS: 49.4/83.8				26 microfracture or AOT for OLT
Körner[15] (2018)	13		13 bone marrow stimulation					
Lee[16] (2019)	16	29.8	Microfracture	VAS: 8.3/1.8 FAAM: 57.6/84.3, 34.5/65.2 SF-12 PCS: 36.3/ 46.0 SF-12 MCS: 41.3/ 52.6				9 Broström-Gould, 3 peroneal tendon repair, 4 peroneal retinaculum repair, 4 distal tibial exostectomy, 1 Kidner procedure
Mologne[20] (2007)	17	44.0	17 arthroscopic debridement and excision, 5 transmalleolar drilling, 2 microfracture, 2 iliac bone grafting	AOFAS: 52.0/87.0		1 sciatic nerve neurapraxia, 1 saphenous nerve neurapraxia	1 iliac crest bone grafting	
Richter[30] (2020)	37		19 matrix-associated stem cell transplant, 18 autologous matrix-induced chondrogenesis and peripheral blood concentrate					
Ross[31] (2014)	31	44.0	Microfracture	FAOS: 50.5/74.3 SF-12: 38.7/59.5	12 complete filling, 7 incomplete filling on MRI (MOCART)	1 subchondral cyst, 1 superficial peroneal nerve dysesthesia, 1 deep vein thrombosis	1 AOT for OLT	4 lateral ligament repair, 12 microfracture for OLT

[a]AOFAS, American Orthopaedic Foot and Ankle Society; AOT, autologous osteochondral transplant; FAAM, Foot and Ankle Ability Measure; FAOS, Foot and Ankle Outcome Score; MCS, Mental Component Score; MOCART, magnetic resonance observation of cartilage repair tissue; MRI, magnetic resonance imaging; OLT, osteochondral lesion of the talus; OLTP, osteochondral lesion of the tibial plafond; PCS, Physical Component Score; SF-12, 12-Item Short Form Health Survey; VAS, visual analog scale.

short follow-up. It is known that BMS produces a physiological grout that can fill the defect with type 2 collagen early in the reparative process. Over time, owing to mechanical and biological factors, this dedifferentiates to type 1 collagen with a reduction in proteoglycans and diminution of mechanical characteristics.[11,22] The fibrocartilage infill produced by microfracture in patients with OLTs struggles to withstand the high pressures in the tibiotalar joint over time, leading to degradation and long-term failure.[4,38] It is unknown whether the repair cartilage at the tibial plafond can maintain long-term integrity; thus, further studies with longer follow-up should be conducted.

Various biological adjuvants were used by surgeons in the included studies. Baldassari et al[3] used bone marrow–derived cell transplant (BMDCT) to treat OLTPs and reported improvement in AOFAS scores at final follow-up. BMDCT is a scaffold-based biological reconstructive technique that has shown promising results in patients with OLTs.[35] Follow-up MRI scans demonstrated a lower incidence of subchondral edema in this patient cohort compared with other groups of patients treated with microfracture,[9,31] suggesting that BMDCT may be less traumatic to the subchondral bone. The use of concentrated bone marrow aspirate (CBMA) as a biological adjunct to BMS for OLTP was observed in 1 study.[13] CBMA contains a rich source of mesenchymal stem cells and growth factors and has been shown to promote the development of cartilage repair tissue containing primarily type 2 collagen, reflecting "hyaline-like" repair tissue formation.[21] CBMA has been demonstrated to improve border repair tissue integration after BMS for OLT[12] and could possibly enhance the longevity of the repair tissue in OLTPs. Irwin et al[13] reported improved functional outcomes in their patient cohort at final follow-up; however, follow-up MOCART scores were not reported. Both Baldassari et al[3] and Irwin et al[13] reported no complications or reoperations in their patient cohorts, unlike other groups of patients who were not treated with any biological adjuvants.[9,20] The current study did not have the power required to establish that these biological adjuncts should be considered over BMS alone, and further long-term studies will be required to find the optimal treatment.

Lesion size of OLTs has been used to predict clinical outcomes and is often used to guide further management.[28] The current review has demonstrated that lesion size may be an important prognostic factor after surgical intervention for OLTPs. Increasing lesion size was negatively correlated with clinical outcome scores and MOCART scores at final follow-up.[3,31] Notably, MRI scans at midterm follow-up showed that subchondral bone marrow edema was more prevalent in larger tibial lesions compared with smaller tibial lesions.[3] The subchondral bone plays a mechanically protective role and is involved in maintaining the integrity of the cartilage that lines its surface via the regulation of signaling pathways by intercellular cross-talk.[18,33] Although transient reactive subchondral edema may be a normal physiological process after surgical intervention for OLTs, the presence of subchondral edema at midterm follow-up has been shown to be a harbinger of poor clinical outcomes after BMS for OLTs.[33] The damage to the subchondral bone observed postoperatively in larger tibial lesions at midterm follow-up suggests that larger OLTPs may have impaired regenerative capacity and thus may have poor long-term cartilage survival. Further studies must be carried out to develop prognostic size guidelines so as to achieve optimal outcomes after intervention for OLTPs.

Limitations

This systematic review has several inherent limitations and/or potential biases. The search was limited to MEDLINE, EMBASE, and Cochrane Library Database articles published exclusively in English. There was inconsistency in the reporting of data between studies, limiting any meaningful cross-sectional analysis. The LOE of the included studies was graded as low with poor methodological quality. Finally, the data extraction was not performed blindly but was carried out by 2 independent reviewers and later confirmed by the lead author.

CONCLUSION

This systematic review has found that OLTPs are frequently preceded by ankle trauma and are often associated with coexisting OLTs. Clinical outcomes after arthroscopic intervention appear to produce good results in the midterm, but the low LOE, poor QOE, marked heterogeneity, and underreporting of the data confound any recommendation based on this systematic review.

REFERENCES

1. Athanasiou KA, Niederauer GG, Schenck RC. Biomechanical topography of human ankle cartilage. *Ann Biomed Eng*. 1995;23(5):697-704.
2. Aurich M, Bedi HS, Smith PJ, et al. Arthroscopic treatment of osteochondral lesions of the ankle with matrix-associated chondrocyte implantation: early clinical and magnetic resonance imaging results. *Am J Sports Med*. 2010;39(2):311-319.
3. Baldassarri M, Perazzo L, Ricciarelli M, Natali S, Vannini F, Buda R. Regenerative treatment of osteochondral lesions of distal tibial plafond. *Eur J Orthop Surg Traumatol*. 2018;28(6):1199-1207.
4. Becher C, Driessen A, Hess T, Longo UG, Maffulli N, Thermann H. Microfracture for chondral defects of the talus: maintenance of early results at midterm follow-up. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(5):656-663.
5. Bui-Mansfield LT, Kline M, Chew FS, Rogers LF, Lenchik L. Osteochondritis dissecans of the tibial plafond: imaging characteristics and a review of the literature. *AJR Am J Roentgenol*. 2000;175(5):1305-1308.
6. Chuckpaiwong B, Berkson EM, Theodore GH. Microfracture for osteochondral lesions of the ankle: outcome analysis and outcome predictors of 105 cases. *Arthroscopy*. 2008;24(1):106-112.
7. Clanton TO, Johnson NS, Matheny LM. Outcomes following microfracture in grade 3 and 4 articular cartilage lesions of the ankle. *Foot Ankle Int*. 2014;(8):764-770.
8. Coleman B, Khan K, Maffulli N, Cook J, Wark J. Studies of surgical outcome after patellar tendinopathy: clinical significance of

methodological deficiencies and guidelines for future studies. *Scand J Med Sci Sports*. 2000;10(1):2-11.
9. Cuttica DJ, Smith WB, Hyer CF, Philbin TM, Berlet GC. Arthroscopic treatment of osteochondral lesions of the tibial plafond. *Foot Ankle Int*. 2012;33(8):662-668.
10. Elias I, Raikin SM, Schweitzer ME, Besser MP, Morrison WB, Zoga AC. Osteochondral lesions of the distal tibial plafond: localization and morphologic characteristics with an anatomical grid. *Foot Ankle Int*. 2009;30(6):524-529.
11. Ferkel RD, Zanotti RM, Komenda GA, et al. Arthroscopic treatment of chronic osteochondral lesions of the talus: long-term results. *Am J Sports Med*. 2008;36(9):1750-1762.
12. Hannon CP, Ross KA, Murawski CD, et al. Arthroscopic bone marrow stimulation and concentrated bone marrow aspirate for osteochondral lesions of the talus: a case-control study of functional and magnetic resonance observation of cartilage repair tissue outcomes. *Arthroscopy*. 2016;32(2):339-347.
13. Irwin R, Shimozono Y, Yasui Y, Megill R, Deyer T, Kennedy JG. Incidence of coexisting talar and tibial osteochondral lesions correlates with patient age and lesion location. *Orthop J Sports Med*. 2018;6(8): 232596711879096.
14. Kirschke JS, Braun S, Baum T, et al. Diagnostic value of CT arthrography for evaluation of osteochondral lesions at the ankle. *Biomed Res Int*. 2016;2016:3594253.
15. Körner D, Kohler P, Schröter S, et al. Pain in osteochondral lesions of the ankle—an investigation based on data from the German cartilage registry (KnorpelRegister DGOU). *Z Orthop Unfall*. 2018;156(2):160-167.
16. Lee W, Tran S, Cooper MT, Park JS, Perumal V. Clinical outcomes of osteochondral lesions of the tibial plafond following arthroscopic microfracture. *Foot Ankle Int*. 2019;40(9):1018-1024.
17. Leontaritis N, Hinojosa L, Panchbhavi VK. Arthroscopically detected intra-articular lesions associated with acute ankle fractures. *J Bone Joint Surg Am*. 2009;91(2):333-339.
18. Madry H, van Dijk CN, Mueller-Gerbi M. The basic science of the subchondral bone. *Knee Surg Sports Traumatol Arthrosc*. 2010; 18(4):419-433.
19. Marx RG, Wilson SM, Swiontkowski MF. Updating the assignment of levels of evidence. *J Bone Joint Surg Am*. 2015;97(1):1-2.
20. Mologne TS, Ferkel RD. Arthroscopic treatment of osteochondral lesions of the distal tibia. *Foot Ankle Int*. 2007;28(8):865-872.
21. Murawski CD, Duke GL, Deyer TW, Kennedy JG. Bone marrow aspirate concentrate (BMAC) as a biological adjunct to the surgical treatment of osteochondral lesions of the talus. *Techn Foot Ankle Surg*. 2011;10(1):18-27.
22. Murawski CD, Foo LF, Kennedy JG. A review of arthroscopic bone marrow stimulation techniques of the talus: the good, the bad, and the causes for concern. *Cartilage*. 2010;1(2):137-144.
23 . Murawksi CD, Hogan MV, Thordarson DB, Stone JW, Ferkel RD, Kennedy JG. Editorial. *Foot Ankle Int*. 2018;39(1 suppl):1S-2S.
24. Ogul H, Taydas O, Tuncer K, Polat G, Pirimoglu B, Kantarci M. MR arthrographic evaluation of the association between anterolateral soft tissue impingement and osteochondral lesion of the tibiotalar joint. *Radiol Med*. 2019;124(7):653-661.
25. Okuda R, Kinoshita M, Morikawa J, Yasuda T, Abe M. Arthroscopic findings in chronic lateral ankle instability: do focal chondral lesions influence the results of ligament reconstruction? *Am J Sports Med*. 2005;33(1):35-42.
26. O'Loughlin PF, Heyworth BE, Kennedy JG. Current concepts in the diagnosis and treatment of osteochondral lesions of the ankle. *Am J Sports Med*. 2010;38(2):392-404.
27. Orr JD, Dawson LK, Garcia EJ, Kirk KL. Incidence of osteochondral lesions of the talus in the United States military. *Foot Ankle Int*. 2011; 32(10):948-954.
28. Ramponi L, Yasui Y, Murawski CD, et al. Lesion size is a predictor of clinical outcomes after bone marrow stimulation for osteochondral lesions of the talus: a systematic review. *Am J Sports Med*. 2017; 45(7):1698-1705.
29. Regier M, Petersen JP, Hamurcu A, et al. High incidence of osteochondral lesions after open reduction and internal fixation of displaced ankle fractures: medium-term follow-up of 100 cases. *Injury*. 2016;47(3):757-761.
30. Richter M, Zech S, Meissner S, Naef I. Comparison matrix-associated stem cell transplantation (MAST) with autologous matrix induced chondrogenesis plus peripheral blood concentrate (AMIC + PBC) in chondral lesions at the ankle—a clinical matched-patient analysis. *Foot Ankle Surg*. 2020;26(6):669-675.
31. Ross KA, Hannon CP, Deyer TW, et al. Functional and MRI outcomes after arthroscopic microfracture for treatment of osteochondral lesions of the distal tibial plafond. *J Bone Joint Surg Am*. 2014; 96(20):1708-1715.
32. Savage-Elliott I, Ross KA, Smyth NA, Murawski CD, Kennedy JG. Osteochondral lesions of the talus: a current concepts review and evidence-based treatment paradigm. *Foot Ankle Spec*. 2014;7(5): 414-422.
33. Shimozono Y, Hurley ET, Yasui Y, Deyer TW, Kennedy JG. The presence and degree of bone marrow edema influence midterm clinical outcomes after microfracture for osteochondral lesions of the talus. *Am J Sports Med*. 2018;46(10):2503-2508.
34. Shimozono Y, Yasui Y, Hurley ET, Paugh RA, Deyer TW, Kennedy JG. Concentrated bone marrow aspirate may decrease postoperative cyst occurrence rate in autologous osteochondral transplantation for osteochondral lesions of the talus. *Arthroscopy*. 2019;35(1): 99-105.
35. Shimozono Y, Yasui Y, Ross AW, Miyamoto W, Kennedy JG. Scaffolds based therapy for osteochondral lesions of the talus: a systematic review. *World J Orthop*. 2017;8(10):798-808.
36. Sijbrandij ES, van Gils AP, Louwerens JW, de Lange EE. Posttraumatic subchondral bone contusions and fractures of the talotibial joint: occurrence of "kissing" lesions. *AJR Am J Roentgenol*. 2000; 175(6):1707-1710.
37. Takao M, Uchio Y, Naito K, Fukazawa I, Ochi M. Arthroscopic assessment for intra-articular disorders in residual ankle disability after sprain. *Am J Sports Med*. 2005;33(5):686-692.
38. van Bergen CJ, Kox LS, Maas M, Sierevelt IN, Kerkhoffs GM, van Dijk CN. Arthroscopic treatment of osteochondral defects of the talus: outcomes at eight to twenty years of follow up. *J Bone Joint Surg Am*. 2013;95(6):519-525.
39. Van Dijk CN, Reilingh ML, Zengerink M, van Bergen CJ. The natural history of osteochondral lesions in the ankle. *Instr Course Lect*. 2010; 59:375-386.
40. Wright JG, Swiontkowski MF, Heckman JD. Introducing levels of evidence to the journal. *J Bone Joint Surg Am*. 2003;85(1):1-3.
41. Yasui Y, Hannon C, Fraser E, et al. Lesion size measured on MRI does not accurately reflect arthroscopic measurement in talar osteochondral lesions. *Orthop J Sports Med*. 2019;7(2):2325967118825261.
42. You J, Lee G, Lee J, Lee E, Kang H. An osteochondral lesion of the distal tibia and fibula in patients with an osteochondral lesion of the talus on MRI: prevalence, location, and concomitant ligament and tendon injuries. *AJR Am J Roentgenol*. 2016;206(2):366-372.