Journal of ISAKOS: Joint Disorders & Orthopaedic Sports Medicine Publish Ahead of Print, published on May 6, 2016 as doi:10.1136/jisakos-2015-000020

Good clinical outcome after osteochondral autologous transplantation surgery for osteochondral lesions of the talus but at the cost of a high rate of complications: a systematic review

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Received 25 January 2016
Revised 12 April 2016
Accepted 18 April 2016

To cite: Ferreira C, Vuurberg G, Oliveira JM, *et al*. *JISAKOS* Published Online First: [*please include* Day Month Year] doi:10.1136/jisakos-2015-000020

ABSTRACT

Importance Osteochondral autologous transplantation surgery (OATS) is one of many treatment modalities for osteochondral lesions of the talus (OLT). OATS uses bone-cartilage cylinder grafts from a non-weight bearing portion of another joint and transplants these on the site of the defect. This may cause complications of the donor site and the ankle. Overall, there is scarce knowledge concerning the clinical outcome and complication rate after OATS.

Objective To determine the clinical outcome and complications of OATS for the treatment of OLT.

Evidence review The data sources are PubMed and EMBASE. Studies were included if they were written in English and were level I–IV clinical studies. Excluded were level V publications, systematic reviews and the use of osteoperiosteal grafts. All participants of included studies were treated for their OLT using OATS. An electronic search was performed to find clinical studies published on OATS from 2005 until March 2016. All titles and abstracts were independently evaluated by 2 researchers. Full texts that met the inclusion criteria were subsequently assessed for quality using the Coleman Methodology score as modified by Kon. To analyse clinical outcome, from each article, demographic information, patient history, study design, clinical variables, patient-reported outcomes and complications were extracted.

Findings The initial search identified 578 studies. A total of 24 articles were selected for the final analysis. Of 24 included articles, 1 was classified as level I, 3 as level III and 20 as level IV studies. The mean modified Coleman Methodology score for all trials was 40.9 (SD 11.0). The 24 studies included a total of 643 patients with a mean age ranging from 22 to 48 years. 11 studies, including a total of 310 patients, evaluated surgery outcome using the American Orthopaedic Foot and Ankle Society (AOFAS) both preoperatively and postoperatively, showing a mean improvement of 51.9–85.4 points. A total of 278 complications were reported including 173 ankle joint complications, 35 donor site-related complications and 70 general complications.

Conclusions and relevance OATS provides good clinical outcome in patients with OLT as both primary and secondary surgical treatment. It is, however, associated with complications related to the ankle joint and donor site.

Level of evidence Level IV, systematic review of level I–IV studies.

What is already known

- There was limited knowledge concerning the clinical outcome and complication rate of osteochondral autologous transplantation surgery (OATS) for treatment of osteochondral lesions of the talus (OLT).
- OATS has been mainly used as secondary treatment.

What are the new findings

- Despite providing good clinical results overall, the global complication rate was 43.2% (278/643 patients) including ankle site, donor site and general complications.
- There was a low methodology score and high heterogeneity between study populations. Different assessment scores and 13 different classification systems for OLT were used, which hamper the analysis.

INTRODUCTION

Symptomatic osteochondral lesions of the talus (OLT) are not uncommon. In up to 50% of ankle sprains, a secondary OLT has been described.[1 2] In about 24% of cases, non-traumatic causes are reported.[3] Causes of non-traumatic OLT may be vascular, genetic, morphological, endocrine or idiopathic.[4 5]

A variety of symptoms are associated with OLT, including deep ankle pain, swelling and limited range of motion (ROM), ultimately leading to degenerative changes and osteoarthritis. OLT may lead to a considerable functional impairment affecting people during daily activities, sports and even during regular walking.[6–8]

Several treatment strategies for OLT have been described. It is stated that asymptomatic lesions should not be treated, but kept under observation.[5] In case of mild symptoms and in early phases of OLT, conservative treatment is advised.[9–11] Conservative treatment may include injections (eg, platelet-rich plasma, hyaluronic acid), physiotherapy, use of non-steroidal anti-inflammatory drugs, an orthosis in case of giving way and avoidance of high-intensity activities.[4 12 13] Surgical treatment can exist of reparative techniques, that is, bone marrow stimulation (BMS) or autologous chondrocyte implantation (ACI) and replacement techniques, that is, osteochondral autologous transplantation system (OATS) or osteochondral allograft transplantation.[4 14–16] Until now, no technique has been proven to be superior based on measured outcome.[8]

BMS, consisting of microfracturing, drilling or abrasion arthroplasty, is one of the most popular approaches.[14] It is the treatment of choice in lesions $<150\,mm^2$. However, in large lesions ($>150\,mm^2$), BMS has a significantly higher rate to failure.[17 18]

ACI or matrix-associated tissue engineering is the implantation of in vitro cultured autologous chondrocytes with a periosteal tissue cover after expansion of isolated chondrocytes. This technique is applied in lesions $>150\,mm^2$. Until now, it has not yet shown superior results compared with other techniques in clinical practice.[8] Additionally, disadvantages of these techniques include two-staged surgery, high costs and donor site morbidity.[8 19–21] Recently, the option for one-stage cell-based procedures has also been described but further investigation is required before more definitive conclusions can be drawn.[22] Tissue engineering, however, may provide new treatment options for the future, but is still under research.[4]

The OATS procedure has been proposed for lesions $>150\,mm^2$, cystic lesions or as an alternative after failure of the primary procedure (eg, in most cases BMS).[3 23] It addresses both the cartilage and bony defect at the same time, and additionally applies a hyaline cartilage coverage to the lesion. OATS is a one-step procedure, transplanting bone-cartilage cylinder grafts from a non-weight bearing portion of another joint to the site of the defect (figure 1). Grafts are typically harvested from the ipsilateral knee joint, although grafts from other joints have also been used with success.[17 18 24–27] There is, however, a lack of knowledge concerning the outcome and the effects related to the graft donor site.[28]

This study therefore aims to determine the clinical outcome and complications after surgical treatment of patients with OLT using the OATS procedure as reported in the literature.

METHODS

To determine the clinical results and complications after OATS in patients with OLT, a systematic review was performed following the PRISMA guidelines.[29] The following search strategy was developed by two researchers: '(OATS OR osteochondral autologous transplantation OR autologous transplantation OR osteochondral autografting OR mosaicplasty OR osteochondral autograft OR osteoarticular transfer system) AND (ankle OR talus OR talar)'. The search was performed for all articles published from 1 January 2005 until 6 March 2016 using PubMed and EMBASE as search engines.

According to predefined criteria, articles were eligible for inclusion if they were written in English, to avoid any translation bias, and if they were level I–IV clinical studies performed in adults. Level V publications, systematic reviews, animal studies and studies that included osteoperiosteal grafts were excluded.

First, all titles and abstracts of the search results were identified and screened by two individual researchers. Articles that did not meet the inclusion criteria were excluded. In case of doubt or disagreement, articles passed onto the next round of

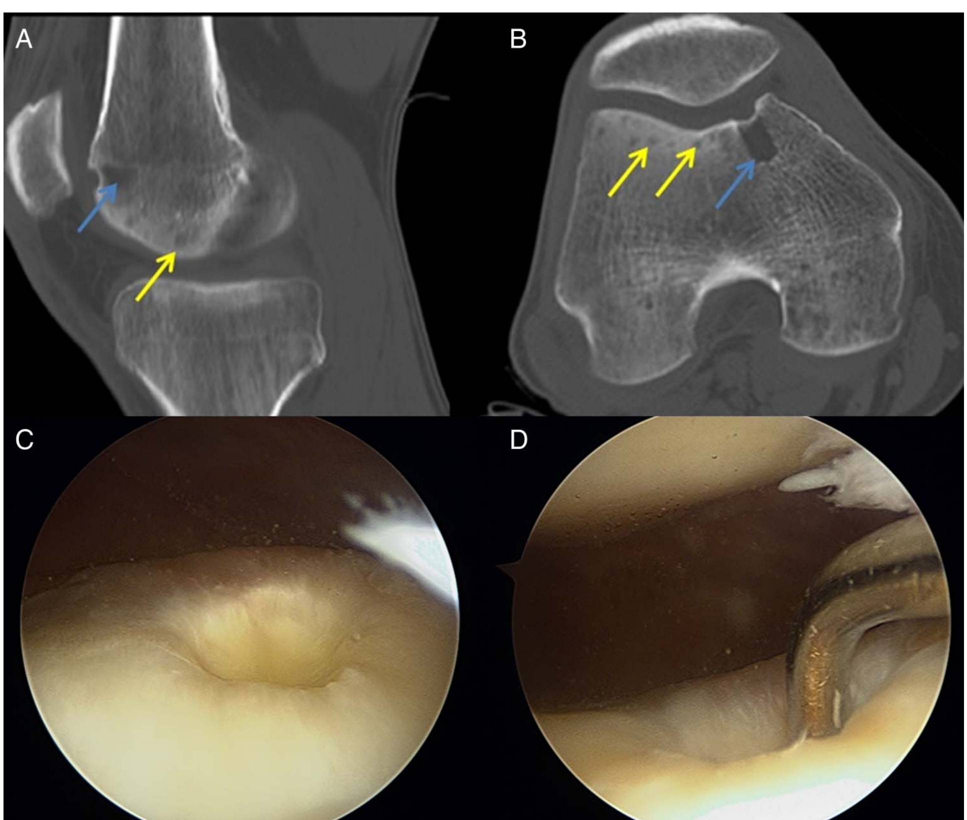

Figure 1 Imaging of the ipsilateral (donor zone). Lateral view (A) and axial view (B). Focal osteoporosis (yellow arrow) and place from where the graft was harvested (blue arrow). Arthroscopic view of the defect created by donor zone (C) and (D).

full-text assessment. Subsequently, full texts were again assessed on meeting the inclusion criteria. All included articles identified by this search were discussed among the authors, and a final decision was made regarding inclusion or exclusion. In the absence of agreement, the final decision was made by the senior corresponding author (HP). To ensure that no articles were missed, cross-checks were performed with the references of finally included articles.

All articles were classified by levels of evidence, according to the five-level system.[30] Quality of clinical studies was analysed using the Coleman Methodology score, as modified by Kon *et al*,[31] designed to assess the quality of cartilage repair studies.

To analyse the baseline, study design, demographic information and patient history were extracted from included articles. Subsequently, to conclude on the generalisability of our results, we analysed the homogeneity between included articles by extracting classifications and clinical variables used. Finally, to come to any conclusions on results and complications after OATS, patient-reported outcomes and patient-reported complications were extracted. Absence of data was reported using the notation NR (not reported). In patient history, duration of symptoms was defined as the time between the onset of symptoms and the first surgery.

RESULTS

Within the defined period, 578 articles resulted from our search. Duplicates and articles not published in English were excluded (n=50). From the remaining 528 articles, all titles and abstracts were evaluated and the articles that were not specifically related to the topic, level V publications, systematic reviews, animal studies, studies including children (<18 years) and including osteoperiosteal grafts were excluded (n=490). The remaining 24 articles were included in this systematic review (figure 2). Of the clinical studies, we identified 1 as level I, 3 as level III and 20 as level IV. The mean modified Coleman Methodology score, with a maximum of 90 points for all studies, was 40.9 (SD 11.0) and it ranged from 17 to 58, showing that the included studies were of average quality.

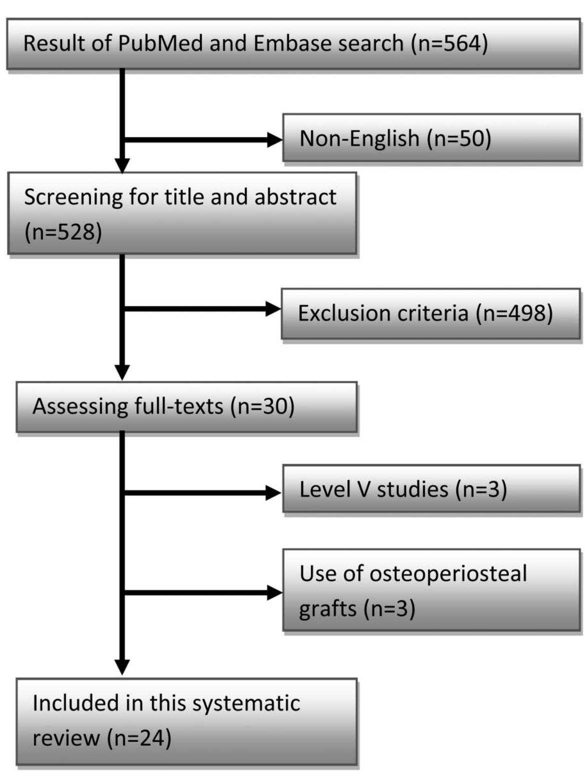

Figure 2 Flow chart of study selection.

Demographic information and patient history

In all studies, a total of 673 patients were included. Apart from studies that did not report on gender, a total of 371 men and 209 women were enrolled (table 1). Mean reported age ranged from 22 to 48 years.

The duration of symptoms was mentioned in 15 trials, showing a mean duration of 16–88 months. Association of symptoms with a traumatic event was assessed by 17 studies (table 1). Of 449 patients, 70.6% reported a history of trauma (n=317). The description of patient's activity level, including activities of daily living, before diagnosis of OLT was reported in 10 (41.7%) articles.

Only 8.3% (n=2) did not report any treatment prior to OATS. Conservative treatment was mentioned as previous treatment in 45.8% (n=11) and surgical treatment was mentioned in 75% (n=18) of included articles (table 1). Of a total of 496 patients, 54.0% (n=268) had undergone some form of surgery prior to OATS.

Study design

Of the 24 included studies, 58.3% (n=14) were retrospective and 41.7% (n=10) were prospective. The follow-up period ranged from 16.8 to 87.9 months (table 1).

Thirteen different classification systems for OLT were used. Some articles used more than one classification system (table 2). Details of the performed OATS technique were explained by all studies, except by Hangody *et al*.[42]

Clinical variables influencing outcome

A wide variety of variables that may have influenced surgery outcome were reported. Area of lesion is described in 50% of articles (n=12). The mean area of lesion was described by 45.8% (n=11) and extended from 68.9 to 370 mm^2 (table 3). Twelve articles reported the absence or presence of preoperative cystic lesions. Of 325 patients, 38.3% had a preoperative cystic lesion (n=125). The use of procedures associated with the performed OATS technique, like arthrotomy, osteotomies or other procedures needed to access the defect, was described in 83.3% of studies (n=20). Four articles (16.7%) additionally reported on concomitant procedures performed, such as the Bröstrom-Gould (table 4). In total, 455 additional procedures were reported. Even though 91.7% (n=22) reported the number of grafts used, only 75% (n=18) reported on graft size. The graft size ranged from 3.5 to 30 mm and the maximum number of grafts per patient reported was 8.

In total, two donor site locations were reported: the ipsilateral knee in 85.2% of cases (n=548) and the ipsilateral articular talar facet in 14.8% of cases (n=95). In the knee, the intercondylar notch, the lateral, medial and posterior femoral condyles and the lateral wedge of the lateral trochlea were reported as donor sites.

Patient-reported outcomes

In 66.7% (n=16) of the included articles, pain, function and activity were evaluated preoperatively using 12 different scores. Postoperatively, 100% (n=24) reported using scores for measuring pain, function and activity (table 5). Only six scores were used to assess donor site morbidity.

The two most frequently used scores were the American Orthopaedic Foot and Ankle Society (AOFAS) score and visual

Table 1 Demographic and patient history information in the included studies

	Study design		Demographic information			Patient history		
	Design	Mean follow-up time (months)	N	Gender	Mean age (years)	Mean duration of symptoms (weeks)	History of trauma	Previous ankle treatment
Reddy *et al*[25]	Retrospective	47	15	M=7; F=8	31	NR	n=8	CT and PAS (n=15)
Haleem *et al*[18]	Retrospective	87.9	42	M=24; F=18	43.6	31.8	n=29	CT; BMS (n=5)
Yoon *et al*[24]	Prospective	45	22	M=15; F=7	37.1	59.9	n=12	BMS (n=22)
Kim *et al*[32]	Retrospective	34.1	48	M=34; F=18	48.2	20.4	NR	CT (n=48); MF (n=10)
Georgiannos *et al*[33]	Prospective	66	46	M=37; F=9	36.2	24	n=39	PAS (n=46)
Valderrabano *et al*[34]	Retrospective	72	21	M=14; F=7	42	NR	n=15	PAS (n=9)
Kokkinakis *et al*[6]	Retrospective	26	13	M=8; F=5	38.4	28	n=6	CT (n=13); PAS (n=1)
Kreuz *et al*[7]	Prospective	48.9	35	M=18; F=17	30.9	95.2	n=30	CT (n=21); PAS (n=35); AD (n=17); MF (n=5); LBR (n=7); MP (n=6)
Emre *et al*[35]	Prospective	16.8	32	M=29; F=3	27.5	NR	NR	CT
Gobbi *et al*[36]	RCT	Inconclusive data	12	M=8; F=4	27.8	NR	NR	CT (n=12)
Liu *et al*[37]	Retrospective	36.3	16	M=10; F=6	33.9	NR	NR	NR
Petersen *et al*[38]	Prospective	25.14	20	M=12; F=8	25.4	68	NR	PAS (n=20)
Woelfle *et al*[39]	Retrospective	29	36	M=17; F=15	24.5	116	n=19	PAS (n=15); MF (n=11); refixation (n=2); cancellous filling (n=3)
Woelfle *et al*[40]	Retrospective	29	36	M=17; F=15	24.5	116	n=19	PAS (n=15); MF (n=11); refixation (n=2); cancellous filling (n=3)
Imhoff *et al*[41]	Retrospective	84	25	M=13; F=12	33	81.6	n=20	DB (n=9)
Hangody *et al*[42]	Prospective	NR	39	NR	NR as mean	NR	NR	NR
Haasper *et al*[43]	Retrospective	24	14	M=6; F=8	22	NR	n=3	PAS (n=6)
Scranton *et al*[44]	Retrospective	36	50	NR	36	NR as mean	n=42	CT (n=50); PAS (n=32)
Baltzer *et al*[45]	Prospective	NR as mean	43	M=30; F=13	31.2	>36	n=16	CT
Largey *et al*[46]	Retrospective	30	5	M=2; F=3	33.8	>36	n=4	CT (n=5)
Kreuz *et al*[47]	Prospective	60	16	M=8; F=8	32	116	n=12	CT (n=16); PAS (n=1)
L'Escalopier *et al*[48]	Retrospective	76	37	M=29; F=8	33	348	n=31	DB±PF/MF (n=8)
Hintermann *et al*[49]	Prospective	49	14	M=9; F=5	34.8	NR	NR	DB+MF (n=9); MP (n=3); CB (n=3); OATS (n=3); AMIC (n=5)
Fraser *et al*[50]	Retrospective	71	36	M=24; F=12	31	NR	N=31	MF (n=6)

AD, arthroscopic drilling; AMIC, autologous matrix induced chondrogenesis; BMS, bone marrow stimulation; CB, cancellous bone; CT, conservative treatment; DB, debridement; F, female; LBR, loose body removal; M, male; MF, microfracture; MP, mosaicplasty; N, number of patients in the study; NR, not reported; OATS, osteochondral autologous transplantation surgery; PAS, previous ankle surgery (not specified); PF, perforation.

analogue scale (VAS) on pain. The VAS was used for preoperative and postoperative evaluation in nine studies with a total of 241 patients. Overall improvement was demonstrated by a score decrease from 6.6 to 2.3 points. One additional study reported significant improvement in the VAS score in their study population, but did not report a mean.

In 11 studies, including a total of 310 patients, the AOFAS score was evaluated both preoperatively and postoperatively. Score improvement was shown from 57.5 to 87.1 points.

Complications

Three studies did not report any complications. All other articles reported a wide variety of complications. In total, 278 complications were registered including 173 complications related to the ankle joint, 35 related to the donor site joint and 70 general complications (table 6).

Of the complications related to the ankle (figure 3), subchondral oedema and incongruity of the ankle joint were not correlated with clinical symptoms and did not affect the clinical outcome.[6 39 40] Soft tissue impingement, surface incongruity of transplants and the uncovered area between plugs, however, did affect clinical outcome.[36 41 51] Of the total of 578 OATS procedures with the ipsilateral knee as the donor site, 34.8%

Table 2 Classifications used for osteochondral lesions of the talus

Classification	Classification used
Berndt and Harty without Loomer modification	20.8% (n=5)
ICRS	20.8% (n=5)
Berndt and Harty with Loomer modification	12.5% (n=3)
Taranow classification	4.2% (n=1)
Ferkel and Cheng classification	4.2% (n=1)
Ferkel and Sgaglione classification	4.2% (n=1)
Hepple classification	4.2% (n=1)
Bristol classification	4.2% (n=1)
Lauge-Hansen classification	4.2% (n=1)
Danis-Weber classification	4.2% (n=1)
Herde classification	4.2% (n=1)
Outerbridge classification	4.2% (n=1)
FOC system	4.2% (n=1)
Van Dijk osteoarthritis scale	4.2% (n=1)
Takakura	4.2% (n=1)
Used more than 1 classification	25% (n=6)
Unknown which classification used	20.8% (n=5)

FOC, fracture, osteonecrosis, cyst; ICRS, International Cartilage Repair Society.

Table 3 Clinical variables of the included studies

			Clinical variables				
	Mean area of lesion (mm^2)	Patients with cystic lesion	Surgical approach	Associated procedures	Graft size used (mm)	Mean number of grafts per patient	Donor site
Reddy *et al*[25]	130	NR	Anterior and medial arthrotomy	AA (n=15); MMO (n=11)	3.5 or 4.5 or 6.5	2.9	Ipsilateral knee
Haleem *et al*[18]	111.6	NR	Anterior, medial and lateral arthrotomy	AA; MMO; LMO	6 or 8 or 10	1.7	Ipsilateral knee
Yoon *et al*[24]	152.9	n=13	Anterior and medial arthrotomy	MMO (n=19)	6 or 8	2.1	Ipsilateral knee
Kim *et al*[32]	150.4	n=30	Medial arthrotomy	MMO (n=48)	8 or10	1.36	Ipsilateral knee
Georgiannos *et al*[33]	NR	n=6	Anterior and medial arthrotomy	MMO (n=6); TBO (n=40); ATFL and CFL release (n=1)	4.75 or 6 or 8	1	Ipsilateral talar articular facet
Valderrabano *et al*[34]	135	n=8	NR	NR	NR	3	Ipsilateral knee
Kokkinakis *et al*[6]	Diameter only	NR	Medial arthrotomy	MMO (n=13)	10 or 20	3.3	Ipsilateral knee
Kreuz *et al*[7]	Diameter only	n=0	Anterior and medial arthrotomy	TBO (n=13); MMO (n=7)	6.29 or 6.4 or 8.0	1.1	Ipsilateral talar articular facet and ipsilateral knee (n=1)
Emre *et al*[35]	113	n=7	Medial arthrotomy	MMO (n=32)	6 or 8	1.7	Ipsilateral knee
Gobbi *et al*[36]	370	n=0	Anterior arthroscopy	NR	NR	NR as mean	Ipsilateral knee
Liu *et al*[37]	84.1	n=0	Anterior arthrotomy	Without osteotomy	NR	NR as mean	Ipsilateral knee
Petersen *et al*[38]	Diameter only	NR	Medial and lateral	MMO (n=19); LMO (n=1)	9.45 to 14	1.75	Ipsilateral knee
Woelfle *et al*[39]	NR	NR	Medial and lateral arthrotomy	MMO (n=25); LMO (n=1); AMA/ALA (n=6)	6 or 8 or 10	1.5	Ipsilateral knee
Woelfle *et al*[40]	NR	NR	Medial and lateral arthrotomy	MMO (n=25); LMO (n=1); AMA/ALA (n=6)	6 or 8 or 10	1.5	Ipsilateral knee
Imhoff *et al*[41]	NR as mean	NR	Anterior and medial arthrotomy	MMO (n=17); osseous detachment of the anterior syndesmosis (5)	10	1.5	Ipsilateral knee
Hangody *et al*[42]	NR as mean	NR	NR	NR	6.5 or 8.5	NR	NR
Haasper *et al*[43]	68,9	NR	Anterior, medial and lateral arthrotomy	MMO (n=10); LMO (n=1)	NR	1.8	Ipsilateral knee
Scranton *et al*[44]	Diameter only	n=53	Medial and lateral	MMO (n=26)	7 or 8	NR as mean	Ipsilateral knee
Baltzer *et al*[45]	170	NR	Anteromedial and lateral arthrotomy	AMA/ALA (n=23); MMO (n=20)	NR	1.8	Ipsilateral knee
Largey *et al*[46]	50	n=1	Anterior arthroscopy	Transmalleolar drilling (n=5)	4.5	NR as mean	Ipsilateral knee
Kreuz *et al*[47]	Diameter only	n=0	Anterior arthrotomy	TBO (n=16)	4 or 6 or 8 or 10	1	Ipsilateral talar articular facet (n=15) and ipsilateral knee (n=1)
l'Escalopier *et al*[48]	85	NR	Medial and lateral arthrotomy	MMO (n=26); LMO (n=11)	NR	2.3	Ipsilateral knee
Hintermann *et al*[49]	NR	n=7	Medial and lateral arthrotomy	MMO (n=13); ALA (n=1)	10–30	NR	Ipsilateral knee
Fraser *et al*[50]	133	NR	Anterior, medial and lateral arthrotomy	MMO/LMO (NR); BG (n=6)	6 or 8 or 10	NR as mean	Ipsilateral knee

AA, ankle arthrotomy; AMA/ALA, anteromedial or anterolateral arthrotomy; ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; LMO, lateral malleolar osteotomy; MMO, medial malleolar osteotomy; n, number of patients; NR, not reported; TBO, tibial block osteotomy.

(n=201) of patients experienced complications. Only 4.1% (n=24) complications were specifically related to the knee joint being the donor site in a total of 578 OATS procedures. Of patients with the ipsilateral articular talar facet as the donor site (n=95), 17.9% (n=17) experienced complications.

Of all articles, 62.5% (n=15) addressed donor site morbidity (table 5). The Lysholm knee score was most commonly used, but methods of clinical assessment like the VAS and ROM were also used. Some articles only reported the presence or absence of pain and/or complications but no numbers.

DISCUSSION

OATS as a treatment option for OLT, including cystic lesions, provides overall good results, showing improvement in VAS and AOFAS scores.[7 24 38 41 43 45 47 49 51] The technique is fit as both primary and secondary treatment for OLT in a relatively young population, showing general improvement in patient-reported outcome measures, but is mainly performed as secondary treatment (table 1). However, a considerable number of complications related to the donor and lesion sites have been reported. There is a great variety of OLT classification systems and clinical outcome measures used. This was considered an obstacle for pooling data. An effort should be made to standardise the classifications and patient-reported outcomes in future trials.

The majority of the patients included in the clinical studies were aged between 20 and 50 years and almost everyone had a minimum duration of symptoms of 24 weeks before the first

Table 4 Associated and concomitant procedures performed

Procedure	Incidence (%) (n_{total}=455)
Medial malleolar osteotomy	64.2 (n=292)
Tibial block osteotomy	15.2 (n=69)
Anteromedial and anterolateral osteotomy	6.4 (n=29)
Modified Bröstrom	4.4 (n=20)
Ankle arthrotomy	3.5 (n=16)
Lateral malleolar osteotomy	3.1 (n=14)
Osseous detachment of the anterior syndesmosis	1.1 (n=5)
Transmalleolar drilling	1.1 (n=5)
Anterior impingement resection	0.4 (n=2)
ATFL and CFL release	0.2 (n=1)
Stieda process removal	0.2 (n=1)
Cuboid-navicular coalition	0.2 (n=1)

ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament.

surgical procedure was performed. This confirms previous statements that OLT can have a great economic and social impact due to long periods of physical impairment with lost days at work in an active population.[52 53]

Traumatic cause is documented as an important and frequent aetiological factor of OLT.[1 2 14] This was confirmed by our results, with 67.8% of the patients with a traumatic cause for the OLT. This may in turn be related to the young age at which OLTs mainly occur, as this subpopulation is more active. However, most studies do not report the level of activity of their patients. This can be seen as a relevant limitation for subsequent analysis. Physicians should be aware of possibly present OLTs in this population, especially after a trauma.

Additionally, more than half of the patients had surgery prior to the OATS procedure. This should be taken into account when assessing the outcomes. Imhoff *et al*[41] concluded that patients submitted to OATS after arthroscopic drilling had worse outcomes than those submitted to OATS as primary treatment. In the majority of included articles, this was argued against by patients, stating that they did not feel like prior treatment influenced outcomes. Therefore, OATS was concluded to be an efficient treatment after failing primary surgical treatment.[7 18 24 32 39 43]

Another factor that may have influenced surgery outcome is the size of the lesion. Al-Shaikh *et al*[9] suspected that patients with larger lesions who underwent OATS had poorer outcomes, but this was not statistically proven. Yoon *et al*[24] showed that defect size was not a predictor for poor outcome in OATS. This was confirmed by Haleem *et al*[18] and Kim *et al*.[32] BMS, however, is associated with poor outcome in large OLTs.[17 24]

What stood out, concerning size, was that the mean lesion area overlaps with the lesion size for which BMS is indicated. Additionally, the mean lesion area was smaller than indicated for OATS, namely >150 mm^2. This may be explained by the fact that OATS is often used as a secondary procedure. Moreover, cell-based techniques have also been proposed for lesions >150 mm^2. This variation of techniques and possibilities and the different approach dictated by secondary surgeries contributes to the difficulty in comparing the results of all these techniques.

The technique used to perform OATS varied per author, consisting of several associated procedures. The main associated procedure used was a medial malleolar osteotomy (65%) to enable better vision and increase access of the lesion. These subprocedures, however, must be performed with care as they influence outcome. According to Kim *et al*,[32] a precise reduction of the malleolus is important because if the articular surface of the tibial plafond at the malleolar osteotomy site is uneven, patients present with significantly worse pain and lower functional outcomes. Kreuz *et al*[7] reported better results in patients without an osteotomy or in patients with a tibial block osteotomy compared with those with medial malleolar osteotomy. Woelfle *et al*[39] did not find a statistically significant difference between patients with or without an osteotomy.

Articles show contradictory results regarding the influence of number and size of grafts on surgery outcome.[18 25 28 36 39 45 54] To come to any conclusions, further research on this subject and on donor site morbidity is required. Despite some exceptions, donor site morbidity was only superficially evaluated or not at all. Donor site morbidity can lead to functional impairment and potentiate the reduction in sport activities.[1 28] The ipsilateral knee was the most frequent donor site location. Several reports confirm success of this donor site option and show short-term to mid-term follow-up. There are, however, some concerns related to the long-term morbidity of the knee, especially in younger people.[25 41] Alternative donor site locations have been used with good functional outcomes.[7 26 27 33 47] A crucial concern of OATS was long-term morbidity that might occur in donor and lesion locations. The follow-up time ranged from 16 to 88 months. Seven studies reported on results at a minimum of 5 years follow-up, concluding that our results concern long-term results.

Our major limitation consists of the narrow search using only PubMed and EMBASE articles published in English between 2005 and March 2016. Therefore, we may have missed some articles on OATS. However, since the great majority of articles are published in English, this was deemed acceptable.

The conclusions are limited by discrepancies of inclusion and exclusion criteria of the included studies. A wide variation of

Table 5 Patient-reported outcome measures

Scores for evaluation of pain, function and activity	Preoperatively		Postoperatively		Used to assess donor site morbidity	
VAS	4.4–8.5	41.7% (n=10)	1.1–4.8	50% (n=12)	1.7–3.4	4.2% (n=1)
AOFAS	31.1–77	50% (n=12)	78–95.4	66.7% (n=16)	NR	NR
Tegner Activity Scale	3–3.1	12.5% (n=3)	3.7–3.9	12.5% (n=3)	NR	NR
ROM	No exact values reported	8.3% (n=2)	Return to full ROM	8.3% (n=2)	5 patients experienced persisting ROM restriction	4.2% (n=1)
Lysholm Knee Score	NR	NR	NR	NR	81–88	16.7% (n=4)
NR	28.6%	(n=6)	0%	(n=0)	28.6%	(n=6)

AOFAS, American Orthopaedic Foot and Ankle Society; NR, not reported; ROM, range of motion; VAS, visual analogue scale.

Table 6 Complications

	Lesion site		Donor site ipsilateral knee joint		Donor site ipsilateral talar articular facet		General complications		
	Tenderness	12.2% (n=34)	Pain	5.7% (n=16)	Tibial or malleolar osteophytes	1.8% (n=5)	Symptomatic hardware	12.2% (n=34)	
	Synovitis	11.1% (n=31)	Crepitation	0.7% (n=2)	Incomplete osseous healing	1.1% (n=3)	Wound infection	1.8% (n=5)	
	Subchondral oedema on plug area	7.2% (n=20)	Stiffness	0.7% (n=2)	Pain	0.7% (n=2)	Deep venous thrombosis	1.1% (n=3)	
	Soft-tissue impingement	6.5% (n=18)	Dysaesthesia	0.7% (n=2)	Dysaesthesia	3.6% (n=1)	Septic arthritis	0.7% (n=2)	
	Adhesions	5.4% (n=15)	Donor site morbidity unspecified	3.6% (n=1)			Delayed wound healing	3.6% (n=1)	
	Pain	3.6% (n=10)	Symptomatic scar tissue	3.6% (n=1)			Suture reaction	3.6% (n=1)	
	Incongruent grafts margins	3.6% (n=10)							
	Swelling	2.5% (n=7)							
	Giving way	1.8% (n=5)							
	Decreased ROM	1.8% (n=5)							
	Degenerative arthritis	1.4% (n=4)							
	Dissociation of subchondral bone and cartilage	1.1% (n=3)							
	Paraesthesia or dysaesthesia	1.1% (n=3)							
	Stiffness	0.7% (n=2)							
	Incomplete graft integration	0.7% (n=2)							
	Delayed union osteotomy	3.6% (n=1)							
	Non-union osteotomy	3.6% (n=1)							
	Necrotic graft	3.6% (n=1)							
Total	62.2%	(n=173)	8.6%	(n=24)	3.9%	(n=11)	25.2%	(n=70)	278

ROM, range of motion.

specific pathologies, localisations and severity of lesions were intentionally included or excluded differently among the studies, causing heterogeneity between study populations. There was a large heterogeneity of classification systems, clinical scores and patient-reported outcome measures used. In case treatment strategy is based on the classification used, this may have caused selection bias. Several studies only represented postoperative AOFAS and/or VAS scores.

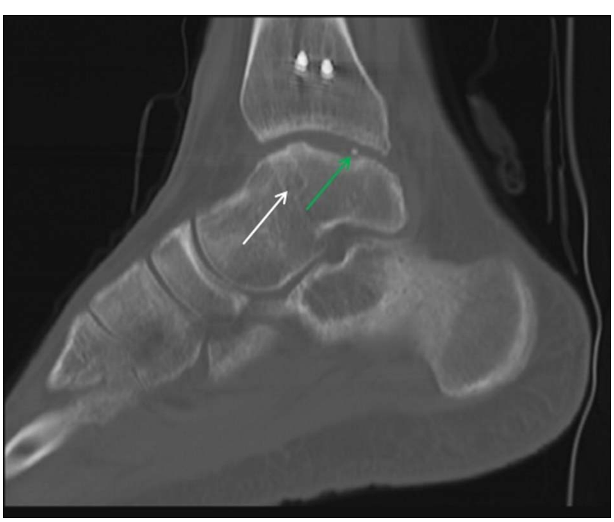

Figure 3 Imaging demonstrating malposition of the graft which has been implanted out of the site of the lesion (white arrow) during open surgery. The original osteochondral lesions of the talus (green arrow) are visible more posterior with some loose fragments (original image from senior author (HP)).

Homogenisation on clinical assessment is needed in order to permit a more definitive analysis in future.

CONCLUSION

OATS provides good postoperative results, both as primary and secondary treatment of OLT. However, a significant number of complications in the ankle joint and related to the donor site were reported. Homogenisation of clinical assessment is needed in order to permit a more definitive analysis in future.

Competing interests None declared.

Provenance and peer review Commissioned; externally peer reviewed.

Data sharing statement All available data are shown in the tables. If readers wish to, they can obtain all the data by contacting the corresponding author.

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Good clinical outcome after osteochondral autologous transplantation surgery for osteochondral lesions of the talus but at the cost of a high rate of complications: a systematic review

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J ISAKOS published online May 6, 2016