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Ankle Arthritis: Classification, Diagnosis and Treatment Strategies

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Abstract This narrative review provides information regarding ankle arthritis with a description of its types, etiologies, pathogenesis and different treatment options. Despite ankle arthritis being less frequent than arthritis in other joints, it significantly impacts mobility and the quality of one's life. Categorization of arthritis based on etiology and degree is an important step in determining adequate treatment, which could include conservative options as well as more complex surgical techniques. This review provides the comparison of radiographic, deformity and end-stage classification of surgery.

Key Words Ankle Osteoarthritis, Post-Traumatic Arthritis, Radiographic Classification, Ankle Arthrodesis, Total Ankle Arthroplasty

INTRODUCTION

Ankle arthritis can result in pain, swelling, stiffness and functional impairment of the joint progressively [1]. Post-traumatic osteoarthritis can occur as a consequence of an ankle injury. Primary osteoarthritis and inflammatory arthritis are different etiologies of the condition [2]. Even though its prevalence is relatively low compared to other kinds of arthritis, the condition can cause disabilities due to the ankle's load-bearing properties and mobility in the human body [2,3]. The ankle osteoarthritis is among the sources of disabilities caused by foot arthritis [4]. Besides the aging population, younger people can suffer from the disorder too, especially when it comes to injured and fractured ankle joints.

The ankle joint is formed by the distal ends of the tibia and fibula, which surround the proximal part of the talus with a mortise-and-tenon structure, reinforced by the deltoid ligament on the medial side and lateral ligaments (ATFL, PTFL, CFL) on the lateral side of the ankle joint. Due to the specific biomechanics of the ankle joint, the treatment requires a special approach. It can consist of conservative management (e.g., physical therapy) or surgical procedures (e.g., ankle arthrodesis, total ankle replacement). This narrative review will compare the purposes of classifications of the disorder and discuss the diagnosis process and staging-specific treatments based on the selected literature. The article represents the results of narrative review of selected sources. No systematic search and evidence grading are described in the article.

Classification of Ankle Arthritis

Types of Ankle Arthritis

- **Osteoarthritis (OA):** Primary ankle osteoarthritis is rather unusual condition but the secondary one is possible as a result of mechanical deformities [5]. It usually evolves slowly and is accompanied by joint space narrowing, osteophyte formation and subchondral sclerosis [6]. Secondary OA can be a consequence of injury or deformity of the joint [2,5]
- **Post-Traumatic Arthritis (PTA):** This type of ankle arthritis is rather common and usually happens after fracture and major ligament injury [7-9]. The reasons of PTA can be fracture, cartilage injury and chronic ligament instability that change the joint load and lead to the secondary OA [2,7,8]. This type accounts for the vast majority of the cases reported in specialist series of ankle osteoarthritis [5,9]. What is characteristic for the type of the disease is that PTA often requires surgeries to improve the joint's congruence and function. Unfortunately, the mentioned operations are rather risky due to the complexity of biomechanical abnormalities,

which arise as a result of injury. PTA is important to distinguish since it usually requires special operations aimed at joint reorientation

- **Inflammatory arthritis:** This group of disorders consists of the inflammatory arthritis that is a complication of systemic autoimmune diseases (rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis) [10-12]. Inflammatory arthritis leads to the constant inflammation in the joint, which results in the wear off of the joint surfaces and adjacent structures [13,14]. When it comes to rheumatoid arthritis, local and specialist treatment of the disease is performed [10,15]

Classification Systems

Osteoarthritis (OA) is distinguished as varus and valgus depending on the direction of deformity and etiology. Varus deformity can be related to the joint space narrowing and vice versa. The osseous deformity, ligament imbalance and previous injury might lead to both deformities [16,17]. Special varus and valgus ankle osteoarthritis (OA) can take into account stage, extent and consequences of deformity. Also, congruency and soft tissue involvement are evaluated. This classification is important in order to select a special management strategy.

Kellgren-Lawrence Grading Scale is one of the well-known grading systems, which is used for osteoarthritis (OA) severity grading according to the radiographic features. The system has been created for generalized grading and later modified for the ankle osteoarthritis (OA). It consists of five grades (from 0 to 4). Each of them corresponds to increasing severity of structural damages in the joint. The criteria mainly concern the presence or absence of osteophytes (bony outgrowth), joint space narrowing, subchondral sclerosis (thinning of the bones adjacent to the joint) and bony deformities [18,19].

The Grade 0 corresponds to normal joint on radiographic images without any signs of OA. Grade 1 represents minimal osteophyte formation without joint space narrowing as a sign of possible early OA. Grade 2 characterizes definite osteophytes with possible narrowing of the joint space as mild OA. Grade 3 means multiple osteophytes with definite joint space narrowing, sclerotic features and sometimes bony deformity. Grade 4 implies large osteophytes, marked joint space narrowing, severe sclerosis and bony deformity. This grade causes pain, stiffness and joint function impairment [19].

Kellgren-Lawrence grade characterizes radiographic severity of OA. The decision about the treatment depends on the symptoms, joint function, alignment, stability and response to conservative treatment. However, the limitations of the method include lack of specificity for the ankle joint and subjective interpretation of the features at the early stages. Some modifications for particular populations are recommended.

Modified Kellgren-Lawrence Classification System is an adaptation of the original scale for particular needs. The modification adds measurements of the talar tilt to describe the tibiotalar alignment in the post-traumatic ankle OA. The talar tilt measures the angle of misalignment between talus and tibia on the weight-bearing ankle radiograph [20].

The modification maintains the evaluation of the joint structure in terms of osteophyte formation and joint space narrowing but adds subgroups based on talar tilt. Holzer *et al.* [20] have studied grade 3 subdividing at the talar tilt of 2° in the group of post-fracture patients. The angle of tibiotalar alignment is evaluated using talar tilt.

The Takakura-Tanaka Classification characterizes medial-predominant ankle osteoarthritis (OA). It divides the OA into four stages and additionally subdivides stage 3 in 3a and 3b depending on joint space narrowing, osteophyte formation and subchondral bone contact. Stage 1 demonstrates signs of sclerosis and osteophyte formation without joint space narrowing. Stage 2 corresponds to the visible narrowing of the medial joint space, indicating cartilage wear in the medial region of the ankle. Stage 3a represents full loss of medial joint space with bone contact on the medial malleolus and stage 3b shows advanced degeneration with bone contact extended on the talus' dome. Stage 4 is considered to be end-stage and is characterized by full loss of the joint space and bone-to-bone contact around the entire joint [21,22].

Van Dijk Classification describes radiographic degeneration in the case of post-traumatic ankle osteoarthritis (OA). The system divides OA in four groups depending on radiographic criteria such as osteophyte formation and joint space narrowing. The Grade 0 represents normal joint or minimal sclerosis. Grade I is characterized with osteophyte formation, while grade II corresponds to joint space narrowing with or without osteophyte formation, indicating moderate degeneration. Grade III is the most advanced and implies near-total or total joint space destruction [23].

The Canadian Orthopaedic Foot and Ankle Society (COFAS) Classification System characterizes end-stage ankle OA with regard to procedure complexity in the surgical environment. There is a preoperative COFAS Classification system that categorizes end-stage OA into four categories based on deformity and complexity. Category I includes isolated ankle OA and no additional surgery should be required. Category II includes intra-articular deformity or tight heel cord. Category III consists of extra-articular deformity. Category IV includes arthritis of the adjacent hindfoot joints [24].

The Postoperative COFAS Classification System characterizes extent of surgery conducted during procedure. This system also tracks additional procedures conducted along with index operation [25,26].

There are different ways of assessing ankle osteoarthritis (OA) using various classifications and grading scales: Kellgren-Lawrence Grading Scale, Modified Kellgren-Lawrence Classification System, Takakura-Tanaka Classification, Van Dijk Classification System and Canadian Orthopaedic Foot and Ankle Society (COFAS) Classification System.

They have several similar features like usage of radiographic imaging; however, these systems are also different in their aims, criteria of analysis and clinical application.

Radiographic grades are meant to characterize structural severity and location of joint space loss. Deformity assessment is used to describe alignment. COFAS characterizes complexity of end-stage disease and related procedures.

Nevertheless, these classification systems are distinguished from each other by their focus, scope of analysis and joint of interest.

Kellgren-Lawrence Grading Scale is initially aimed at evaluating knee, hip and hand OA and thus cannot reflect the features and progression of the ankle OA due to its unique biomechanics and peculiarities of degeneration. Modification of Kellgren-Lawrence Classification includes talar tilt measurement to describe ankle alignment. The Takakura-Tanaka Classification was specially designed to reflect the unique development of medial ankle OA, as ankle OA usually occurs in the medial ankle. The Van Dijk Classification System is meant to assess post-traumatic ankle OA and thus gives a simple way of staging due to structure changes caused by trauma. COFAS Classification System is dedicated to end-stage ankle OA which require joint-sacrifice surgeries like arthrodesis or replacement.

Grading criteria also are different for the given systems. Kellgren-Lawrence Grading Scale and its modification use general osteophyte presence, joint space narrowing, joint sclerosis with additional talar tilt measurement in the modified version to describe the ankle alignment. Takakura-Tanaka Classification System takes into account medial degeneration and subchondral bone contact as the features of OA development within ankle. Van Dijk Classification is based on structural post-traumatic changes and thus reflects the OA developed after injuries. COFAS Classification System describes clinical deformities such as valgus or varus joint alignment and joint instability, giving special pre- and post-operative classification.

In case of advanced or end-stage OA COFAS Classification System is specifically developed for end-stage ankle OA cases and helps to use common terminology to characterize surgical complexity and support postoperative documentation. All of other systems do not focus heavily on the issue of postoperative analysis and documentation.

Joint-specific features are taken into account only in Takakura-Tanaka, Van Dijk and COFAS Classification Systems. Modified Kellgren-Lawrence Classification gives general OA grading system with the inclusion of talar tilt.

To sum up, the discussed classification systems serve specific needs of the clinician and can be recommended in particular types and stages of ankle OA. Thus, Modified Kellgren-Lawrence is good for OA cases generally and with the need of talar tilt consideration. Takakura-Tanaka Classification is aimed at medial ankle OA. Van Dijk Classification is designed to reflect post-traumatic OA. And COFAS Classification System is needed to characterize the surgical complexity in end-stage OA.

Imaging and Diagnosis

Radiologic evaluation still remains the main tool of diagnosis and classification of ankle arthritis [18,27,28].

Weight bearing radiographs play an important role in evaluation of joint space narrowing, alignment and osteophyte [18,28]. Hindfoot alignment radiographs are especially useful in detecting coronal plane deformities, which might characterize the contribution of hindfoot to the overall alignment [18]. Weight bearing CT scans may be necessary for characterization of three-dimensional joint congruence and deformity in the cases when these information affect treatment decisions [20,30]. SPECT/CT may be helpful for localization of metabolically active anomalies in some patients with an uncertain pain generator [27]. MRI evaluation may be used to detect cartilage degeneration, osteochondral lesions, marrow edema, synovial changes and soft tissues changes, when this data is needed for diagnosis and treatment planning [27,28]. The usage of additional imaging techniques depends on the patient's problem and the necessity of surgical planning.

Treatment Approaches

Non-Surgical Management

Medication: NSAIDs may relieve symptomatic treatment of OA and inflammatory arthritis. The risk factors for GI, renal and cardiovascular damage should be considered [29]. Injection with intra-articular corticosteroid may relieve symptoms temporarily. Cartilage damage may be caused by repeated injections of corticosteroid based on the data of knee OA; however, this data is indirect in the case of ankle [30]. DMARDs (methotrexate and biologics like TNF inhibitors) may be used as the part of treatment for the inflammatory arthritis aiming to decrease systemic disease activity. They should be prescribed by specialists in arthritis [31-33].

Physical Therapy

Physical therapy is an essential component of conservative treatment, aiming at improvement of the strength and range of movement of muscles around joint, improvement of the body balance [34,35]. Exercising may be individualized regarding the patient's pain, restriction of movement, weakness and imbalance. Specific comparison evidence for ankle OA exercises is still limited [36].

Orthotic Devices

AFOs, UCBL orthotics, foot orthotics and cushioned shoes have an important role in relieving strain on joint and treatment of arthritis symptoms [32,37,38]. The usage of brace and shoe may be individualized regarding alignment, stability, symptoms and fit [37,38]. Rocker soles may influence gait load. The clinical data regarding specific design for ankle OA is still limited [36,37]. There is evidence that foot length varies by gender and correlates with height in the case of 18-25 years old medical students in Majmaah region [39]. It means direct measuring of the foot can be used for assessment of device fit.

Viscosupplementation

Hyaluronic acid injections are used for the treatment of knee OA rarely; however, they may be sometimes used for ankle OA treatment [40-42]. The specificity of the evidence for ankle OA is lacking. The magnitude and duration of the effect as well as the type of patients who may obtain maximum benefit are unknown [40-42].

Minimally Invasive Procedures

Arthroscopy: The procedure allows debridement of loose cartilage, removal of synovial tissues that become inflamed and joint lavage if the impingement is focal, loose bodies are present or focal lesions contribute to symptoms. Symptomatic improvement may not be predictable in the setting of diffuse joint space loss [36].

Evidence supports favorable outcomes with ankle arthroscopy in early stage arthritis management. In a report, former professional soccer players had a favorable score following arthroscopic debridement in mild to moderate osteoarthrosis [43]. In addition, arthroscopic synovectomy, which is designed to address synovitis, is effective in selected rheumatoid arthritis patients [44]. These reports document different procedures and patient cohorts.

PRP and Stem Cell Therapy

Both Platelet-Rich Plasma (PRP) and stem-cell based treatment methods are experimental and different in nature. In placebo-controlled ankle OA trial, PRP was not found to lead to symptom or functional improvements compared with saline over 52 weeks [45]. Limited data on stem-cell-based interventions exist; and there is a lack of evidence supporting cartilage restoration [46-48].

Surgical Management

Joint-preserving Surgeries: A wide variety of surgeries involving osteotomy of the tibia (supramalleolar osteotomy-SMO) can address malalignment issues by redistributing load among other indications, especially in those having ankle osteoarthritis (OA) [16,17,49,50]. SMO is defined as the surgical intervention involving reorientation of the ankle joint achieved by changing the alignment of the tibia and aiming at unloading the diseased compartment of the ankle. [19,18,49,50] Indications involve symptomatic patients, who have adequate amount of normal cartilage in the compartment to be loaded. Evaluation of ligaments imbalance and deformity distribution is critical. Persistent symptoms and even additional operations, fusion or replacement in particular, are also expected [16,17,50].

Ankle Arthrodesis (Fusion)

An operation of choice for advanced stages of ankle arthritis is arthrodesis, which provides pain relief via bone fusion; and limits the tibiotalar motion. Adjacent joint degeneration can be seen as the consequence of abnormal load and preexisting disease [51]. Although it is a serious limitation, arthrodesis is the highly reliable method providing pain relief and joint stability. Therefore, it is the widely accepted procedure in treating advanced stages of ankle arthritis [51-55]. Combination with subtalar joint fusion is recommended if two affected joints occur. The decision about open or arthroscopic fusion should be done based on the presence and degree of deformity [51-55]. The complications include nonunion, infection, malalignment and hardware-related symptoms [51-55].

Total Ankle Arthroplasty (TAA)

TAA is currently gaining popularity as an alternative to ankle fusion for those who have higher priority for preservation of joint movement. Selection of patients includes consideration of the status of their bone structure, alignment, soft tissue and vasculature condition, peripheral neuropathy, physical activity and treatment goal. Implant complications and possibility of further revisions are relevant [5,56].

Ankle Distraction Arthroplasty

A new treatment strategy involves Ankle Distraction Arthroplasty (ADA), which uses an external fixator in stretching the joint in order to preserve the joint structure and delay its fusion or Total Ankle Arthroplasty (TAA) in selected patients. Available scientific publications mention the selected indications to a joint-preserving procedure, different degrees of success and external fixator related complications. Some patients continue with fusion or replacement [57-60].

Comparative Effectiveness of Treatment Options

- **Fusion vs. Arthroplasty:** Both operations are able to provide pain and functional improvement in selected patients. As seen in TARVA, in the age group of 50-85 with end-stage ankle OA, the patients showed equal improvement after each procedure, with no statistical differences between groups in the primary walking and standing ability after 52 weeks [61]. Fusion eliminates the tibiotalar motion and nonunion remains the possible complication. Motion retention and implant-related complications are characteristic of TAA. The choice is affected by patient anatomical characteristics, comorbidities, physical activity and preferences [56,62,63]
- **Patient-Specific Factors:** Age, physical activity level and severity of the disease are important when choosing treatment options [36]. Joint preservation might be recommended if symptoms, deformity and remaining cartilage allow long-term correction. In diffuse end-stage arthritis, both fusion and TAA could be considered after analysis of stability, adjacent joints, comorbidities and functional requirements [5,36,64]

Rehabilitation and Postoperative Care

- **Physical Therapy:** Postoperative rehabilitation is vital and should focus on strengthening, flexibility and mobility. Rehabilitation program should be individualized depending on the performed surgery

- **Weight-Bearing Protocol:** Weight bearing program depends on surgery performed, type of fixation used, bone healing process, soft tissue status and on surgeon's protocol
- **Follow-Up and Monitoring for Complications:** Follow-up includes monitoring for wound problems, infection, persistence of pain, implant loosening after arthroplasty and nonunion after fusion

Future Directions in Ankle Arthritis Treatment

Gene therapy is one of the areas, which might become useful in treatment of cartilage damage. New prosthetic design is being developed for improving the lifespan and stability of ankle replacement prosthesis. Patient-specific planning and recent surgical advancements call for comparative effectiveness evaluation, using standardized patient-centered outcomes and extended follow-up.

This narrative literature review is limited by partial coverage of literature and variability of the patients, interventions and outcomes reported in scientific reports.

CONCLUSIONS

Ankle arthritis requires a thorough approach because of the particular features of ankle joint anatomy and biomechanics. Treatment of this condition is represented by a wide spectrum ranging from conservative treatment to surgery. Ankle arthrodesis and arthroplasty are the leading options for treatment of advanced cases. The etiology, radiographic features, deformity and difficulty of surgery influence different aspects of examination. Treatment plan includes the patient's symptoms, deformity, stability and goals. Experimental injections require further research.

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