61 Cartilaginous Lesions, Osteoarthritis, and Arthroplasty in Foot and Ankle

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Overview
Articular cartilage in foot and ankle experiences heavy wear and tear in daily activities and sports. This chapter focuses on these cartilaginous conditions, their orthopedic management, and the commonly performed arthroplasty procedures.

61.1 Introduction

Joints in the foot and ankle provide stability and flexibility that are required to support body weight and maintain mobility. While ankle, talonavicular, subtalar, metatarsophalangeal, and interphalangeal joints are notably mobile, the more stable articulations in the mid-foot provide force transmission through the arch and absorb shock stresses. Adapting to the diverse joint functions, articular cartilage in each locations has distinct morphological, biological, and mechanical features, which contribute to the natural history of diseases and injury and ultimately influence the treatment options and outcome of these foot and ankle conditions.

The ankle joint, the largest in the foot and ankle complex, consists of articulations among distal tibia, distal fibula, and talus. The main movement of the ankle is in the sagittal plane, performing dorsiflexion and plantar flexion. Although the ankle often bears a loading force several times greater than the body weight, due to its highly congruent geometry, stresses disperse relatively evenly across the articular cartilage within the ankle. This may explain thinner articular cartilage in the ankle than that in the knee. During physical activities, the articular cartilage on both distal tibia and talar dome experiences less compression strain than the cartilage on the tibial plateau in the knee does. Nevertheless, the peak strain in contact areas could be as much as 35% of the roughly 1.5 mm thick articular cartilage in the ankle. The biomechanics and functionality of ankle cartilage are backed by its biology. Histologically, there are fewer chondrocytes distributed in the superficial zone of ankle cartilage as compared with other articular cartilage. Moreover, the superficial layer of the ankle cartilage contains more type II collagen and aggrecan, the major structural molecules in cartilage matrix, which translates to sustained surface tensile stiffness over the course of aging. Cadaveric studies revealed consistently, across the gender and age groups, far less articular sur-

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face degradation in the ankle than in the knee. Chondrocytes and their immediate territory of matrix, which together form the functional unit of the cartilage, are comparable between the ankle and knee cartilage as assessed by morphometrical measurements. Metabolically, however, ankle cartilage differs from the cartilage in the knee, where osteoarthritis (OA) is more prevalent. For example, compared with knee cartilage, the ankle cartilage is less responsive to the catabolic cytokines, such as interleukin 1β, in degrading matrix molecules. In early OA, ankle cartilage has higher rates of type II collagen and aggrecan syntheses than knee cartilage. The metabolic trait inherited in ankle cartilage may, in part, contribute to a relatively low incidence of OA in the ankle and influence its progression. The biochemical features of ankle cartilage are recognizable by high Tesla magnetic resonance imaging (MRI): its T2 value is lower than the patella. Within the ankle joint, however, cartilages on both distal tibia and talus are not different on T2 mapping.

Articular cartilage in foot and ankle experiences heavy wear and tear in daily activities and sports.

61.2 Cartilaginous Lesions in the Foot and Ankle

The articular cartilage in the foot and ankle joints endures repetitive mechanical strain and is susceptible to physical injury (Fig. 61.1). An osteochondral lesion is an articular cartilage defect and extends into subchondral bone. When a focal defect is confined within articular cartilage or, precisely, its depth does not extend beyond the tidemark between cartilage and subchondral bone, it is a chondral defect. The two types of cartilage lesions have different natural healing capacities and outcomes. While a chondral defect is unable to heal by itself, osteochondral defect may be repaired without intervention, through the migration and differentiation of mesenchymal stem/progenitor cells which originate from bone marrow. Clinically, however, the decision-making of the treatment of a chondral or osteochondral lesion relies more on the length and severity of the symptoms, patient's age, professional demands, ankle stability, and size and location of the lesion. Osteochondral lesions in foot and ankle joints may occur on tibial plafond, talonavicular joint, and metatarsal heads but are most common on the talar dome.

Osteochondral lesion of the talus (OLT): An accurate estimate of the incidence of OLT is not available. It is known, however, that more than 70% of OLT cases have a history of ankle sprains or fracture, both of which are common ankle injuries. For those without a history of ankle injury, the OLT has been referred to as chondritis dissecans. The etiology of OLT is still unclear but generally believed to be in association with repetitive microtrauma to the cartilage resulted from ankle injury or heavy use. For example, injury of ankle lateral ligaments destabilizes the ankle and makes it excessively internally rotate when the ankle is in plantar flexion. This kinematic alteration could elevate the contact strain at the medial and anterior regions of the talar dome and cause cartilage damages. Anatomically, a slight deviation of bony morphology may make the ankle more susceptible to the development of OLT. For example, a wider distal opening angle of the medial malleolus or a larger anterior opening angle of the talus often presents in OLT patients.

The progression of OLT varies among cases. The pathology of OLT is divided into stages based on its imaging features. Although conventional ankle radiography could show signs of compression/depression of the subchondral bone of the talus in early OLT and, later, the detachment and displacement of the osteochondral fragments from the talus, it misses the early signs of cartilage damage during the development of OLT. Based on MRI, the progression of OLT is classified as stage I: cartilage damage only; stage II: cartilage injury with underlining fracture, with/without bony edema; stage III: detached but undisplaced cartilage fragment; stage IV: displaced fragment; and stage V: a cartilage lesion with subchondral cyst formation.

Clinically, OLT may be asymptomatic. For those with symptoms, the most common complaint is deep ankle pain during activities. The

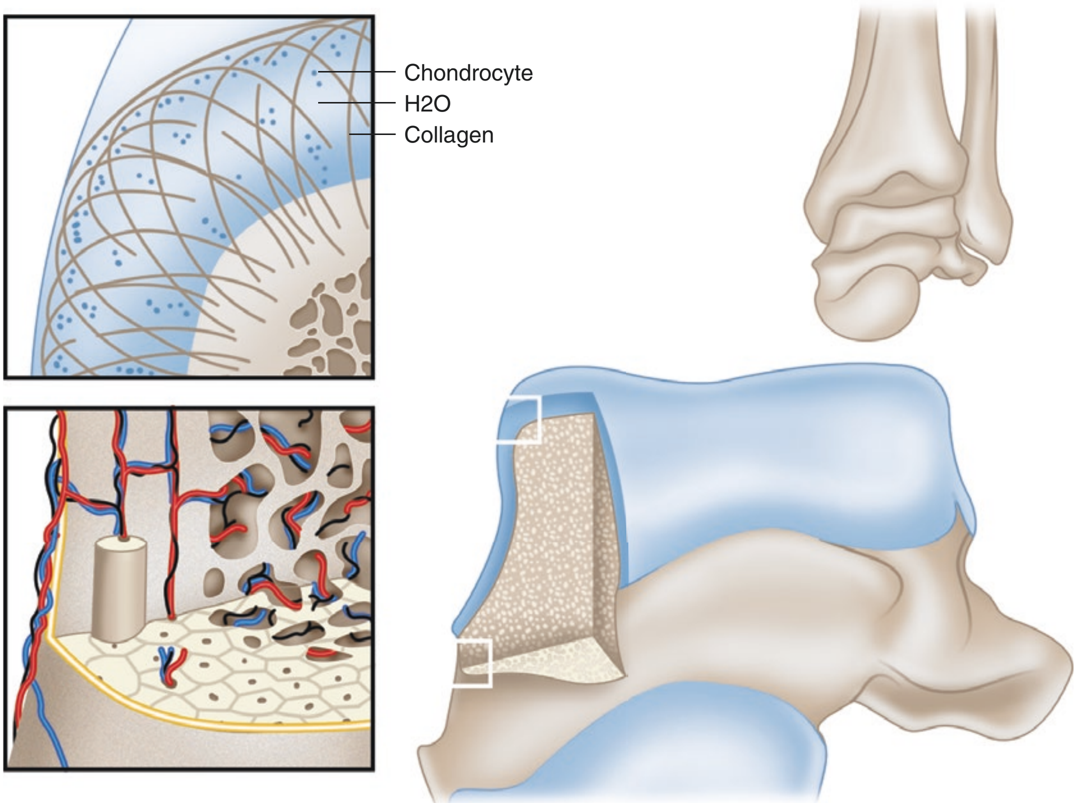

Fig. 61.1 Cartilaginous lesion of the ankle

ankle may be felt as stiff or unstable. There may be locking, catching, or giving way. Patients may have swelling and decreased endurance. On physical examination, there can be tenderness around the joint line and an effusion. The range of motion of the ankle is often limited. For severe and chronic OLT, radiographs may reveal a localized radiolucency on the talus and possibly a narrowing joint space. An ankle MRI is valuable for OLT diagnosis, particularly with either a delayed gadolinium-enhanced technique or T2 mapping techniques. MRI demonstrates the location and size of the OLT as well as associated pathologies, such as bone marrow edema and cysts in the talus, and synovitis in the ankle (Fig. 61.2). Additionally, MRI is useful for the evaluation of surrounding ligaments and tendons, which are critical for ankle stability and long-term outcome of the OLT treatment. Scans of computed tomography (CT) accurately show the bony defect of the OLT, and the size and location of cysts in the talus, which are important for surgical planning and approaches.

Early-stage OLT, with mild symptoms, is managed conservatively to mitigate the reactive pathologies around the lesion and in the ankle, such as synovitis and tendonitis. Conservative therapies include avoidance of the offending activity, reducing ankle loading from limited weight-bearing to total non-weight-bearing, using off-the-shelf cloth or boot ankle braces, custom ankle foot orthosis (AFO), and physical therapy.

The ultimate goal of surgical interventions of OLT is to repair the osteochondral defect, when it becomes a source of persistent ankle pain, inflammation, and instability. For surgical planning, the stage of an OLT is important, but its size and location are more relevant to the selection of procedures. Generally, debridement or microfracture

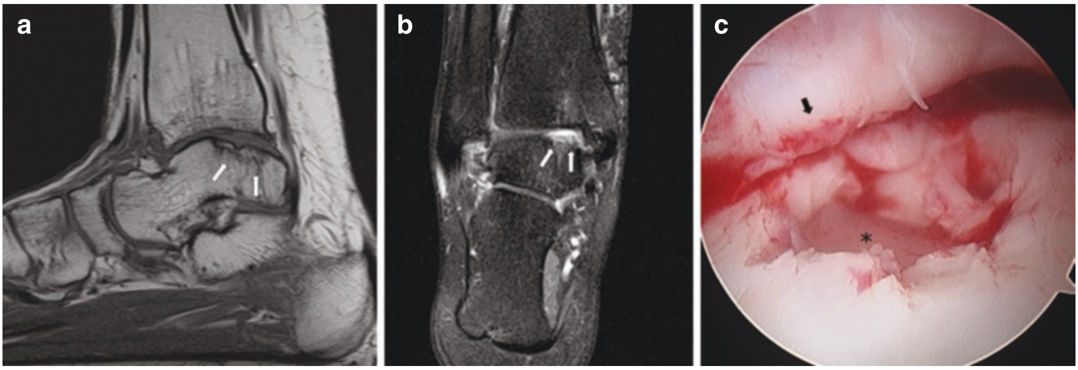

Fig. 61.2 Osteochondral lesion of the talus. (**a**) Sagittal MRI (T1 weighted) shows that an osteochondral lesion (indicated with arrows) occupies medial and posterior sections of the talar dome, including a defect on the surface and detached osteochondral fragments. (**b**) Coronal MRI (T2 weighted) locates an osteochondral lesion (indicated with arrows) on the medial side of the talar dome, with chondral fragments and local accumulation of joint fluid. Regional bone marrow edema extended into the talar body and in the opposite side of the tibia. (**c**) An arthroscopic view of an osteochondral lesion on the talar dome. Note the rough articular surface on the opposite tibial plafond (marked with an arrow). * indicates subchondral bone

is considered for an OLT smaller than 1.5–2.0 cm^2. To repair an OLT larger than 2.0 cm^2, transplantations of (auto/allo)osteochondral grafts, with or without the enhancement of other chondrogenic biologics, may be required.

- Debridement and/or microfracture: The procedure can be performed arthroscopically or through an open incision. The key point of the procedure is that by debriding or drilling through the subchondral bone at the bottom of the osteochondral defect, mesenchymal stromal/progenitor cells in bone marrow migrate into the OLT. In a favorable (biological and mechanical) joint environment, the stromal/progenitor cells differentiate and form fibrocartilage to fill the defect. Additionally, microfractures themselves trigger acute healing responses around the lesion in the talus. In most of the OLT cases, debridement and microfracture relieve ankle pain and improve its function. Because microfracture repairs OLT with fibrocartilage, which is inferior to hyaline articular cartilage mechanically, the repair may not be a long-lasting one.
- Osteochondral transplants: Transplantation of osteochondral graft (autograft or allograft) restores the surface contour of the talus and the congruity of ankle joint approximately. The autografts are osteochondral plugs harvested, with a separate procedure, from a non-weight-bearing area of a joint, such as the trochlear border of the femoral condyle. Allo-osteochondral grafts are cadaveric tissues prepared by a tissue bank. When a cadaveric talus is available, the allografts can be made to match the OLT shape and location for more precise restoration of the talar surfaces. The osteochondral autografts or allografts can be implanted as one piece to repair a defect or multiple plugs (also called mosaic arthroplasty) to cover a large OLT. Unlike microfracture, osteochondral grafts repair the OLT with hyaline cartilage, which better matches the talar cartilage biochemically and mechanically. However, the preparation of the graft, the size of the defect, and other ankle conditions also influence the outcome of osteochondral grafts.
- Transplantation of autologous chondrocytes or particulated juvenile cartilage allografts are other surgical options for repairing OLT. Chondrogenic biologics are increasingly available for OLT treatment, being used alone or in combination with other procedures, and diversify the treatment strategy of OLT. For most of the products, their effectiveness and cost-effectiveness remain to be validated by large, long-term clinical trials.

Currently, OLT is still a challenging condition with uncertain outcomes. When planning surgical interventions, it is important to thoroughly evaluate the entire ankle. Any ankle instability should be investigated and addressed at the time of repairing OLT. Cartilage regenerative therapies and biologics function well only in relatively normal joint conditions. Ankle inflammation, often in the form of synovitis, interferes with the molecular and cellular biology of chondrogenesis. A window of opportunity for repairing OLT exists only before secondary OA is evident in the ankle.

61.3 Osteoarthritis (OA) of Foot and Ankle Joints

The foot and ankle joints are common sites of OA. Of the population aged 50 and over, about one in six (or 15%) experiences osteoarthritic symptoms in the foot and ankle. In the foot, the most common site of OA is the first metatarsophalangeal joint (first MTP), followed by midfoot joints and the ankle.

1. Ankle OA: It is estimated that about 1% of the adult population suffers from ankle OA. Unlike most of the hip and knee OA associated with aging, the majority of ankle OA cases (>70%) are posttraumatic, having previous fracture or repeated ligament injuries in the foot and ankle. In average, the patients of ankle OA are younger than hip and knee OA patients. Consequently, ankle OA more profoundly impacts the patient's quality of life and social productivity.

Symptoms and diagnosis: Activity-aggravated ankle pain is the chief complaint of ankle OA. Another common symptom is ankle stiffness, swelling, and decreased endurance. Some patients complain of progressive deformity of the ankle. On physical examination, ankle is swollen, warm, and tender to palpation and has reduced range of motion. A history of ankle fracture or injury is an important lead of further examination.

Although MRI is advantageous for detection of cartilage lesion, radiography is essential and reliable for diagnosis of ankle OA. On radiographs, preferably taken while in weight-bearing positions, ankle OA presents narrowing joint space, osteophytes, and subchondral sclerosis as indirect signs of cartilage degeneration in the ankle (Fig. 61.3).

Treatment: The stage of pathology, symptoms, and patient's age and physical conditions are taken into consideration in the management of ankle OA. In its early stage, especially when the ankle symptoms are moderate, ankle OA is treated conservatively. To relieve ankle pain, nonoperative treatments shield the degenerative ankle from stresses. By guiding the patients to control body weight and modify daily activities, symptoms can be reduced. Additionally, modified shoes such as adding a soft heel, a rocker-bottom sole, foot orthosis inserts, an ankle brace, and walking aids help shift ankle stress and reduce pain during activities. A variety of physical therapies and rehabilitation programs are beneficial for reducing pain and stiffness. Nonsteroidal anti-inflammatory drugs (NSAIDs) inhibit joint inflammation and can be used to relieve ankle pain.

Intra-articular injection: Hyaluronic acid (or hyaluronate) in synovial fluid lubricates joint surfaces. In an OA joint, hyaluronate is depolymerized and loses the function of lubrication. After supplementation of hyaluronate via intra-articular injection, clinical studies have reported pain relief and function recovery of the OA joints. Many hyaluronate products vary in compositions and delivery vehicles, which complicate their indications, optimal dosages, and application scheme. The therapy's long-term efficacy and impact on OA pathology are still to be investigated by large, well-controlled clinical trials.

Intra-articular injection of corticosteroid reduces ankle pain for most of the ankle OA patients. The pain relief, however, generally lasts less than 6 months.

Surgery: Late-stage ankle OA is traditionally treated with arthrodesis, which includes removal of degenerative cartilage from the ankle and fusion of the tibiotalar articulation. The fused

Fig. 61.3 Osteoarthritis of the ankle. (**a**) A radiograph of the anterior-posterior view of the ankle shows the disappearance of a normal joint space, especially on the medial side. The talus is tilted. There is subchondral sclerosis on both sides of joints: the talus and tibia. Osteophytes are formed on the tips of both medial and lateral malleoli. (**b**) A lateral-view radiograph of the ankle shows that the ankle joint surfaces are incongruent. Additionally, there are osteophytes formed on the anterior and posterior lips of the tibia and talus

ankle joint no longer moves and has reduced pain at rest, walking, and standing. But walking up or down a slope can be problematic. Rising up from a seated position, squatting, or operating foot pedals can be challenging. The patient usually tolerates the restricted motion at the fused ankle through compensatory motion of the hindfoot joints (subtalar, talonavicular, and calcaneocuboid joints) and overall has improved physical activity. Unfortunately, the elevated stresses in the hindfoot joints can be the source of foot pain, degeneration, and dysfunction after ankle arthrodesis.

The ankle arthrodesis procedure has improved over the last several decades with the introduction of less invasive approaches, better options for internal fixation, and application of osteogenic biologics. Using ankle arthroscopy, the procedure can be performed with less associated surgical trauma. Optimally designed internal fixation and osteogenic biologics have reduced complications of ankle arthrodesis, such as nonunion, infection, and malalignment. The fusion rate of ankle arthrodesis is greater than 90% but can be compromised by smoking and diabetes.

Total ankle replacement (arthroplasty) has advanced in the last decades with better component design, advanced materials, more bone preservation, and more accurate implantation techniques to become for many the first choice of late-stage ankle OA. The procedure removes osteoarthritic cartilage from the ankle, restores alignment, and preserves/restores ankle motion by providing a synthetic (metal and plastic) surface. Ankle replacement for ankle OA improves ankle pain and swelling and preserves ankle motion.

Hindfoot and mid-foot OA: More than 10% of the population over age 50 have symptomatic OA in the hindfoot and mid-foot joints, which include first and second cuneometatarsal, navicular-first cuneiform, and talonavicular joints. OA in this location is more prevalent in females and significantly increased in the population aged 75 years and over. Its risk factors include obesity, previous foot injury, and pain in other weight-bearing joints.

Hindfoot and mid-foot OA tends to involve in both feet. Foot pain and stiffness, particularly at the push-off position of the foot, are the most common complaints. On physical examination, the foot longitudinal arch may collapse with weight-bearing. The stride length is shorter, and cadence is reduced. Bony prominences may be palpable over the affected joints. On radiographs, osteoarthritic changes, such as narrowing of the joint space, osteophytes, cysts, and erosions, often show in a cluster of the joints. Weight-bearing radiographs, including dorso-plantar, oblique, and lateral views, of the foot are required for the diagnosis.

The conservative treatment of hindfoot and mid-foot OA emphasizes modifying the load distribution by using foot orthoses, wearing thicker cushioned rocker-soled footwear, and at times using an AFO. NSAIDs are useful for pain relief. Intra-articular injection of corticosteroid, however, is not used as common as for OA in other major joints due to the difficulty performing the injections by nonspecialists. With persistent and debilitating symptoms, arthrodesis of the affected joints is indicated. As the osteoarthritic pathology is often clustered among several joints, arthrodesis of multiple hindfoot and mid-foot joints may be necessary. To determine which joints are to be fused, clinical examination correlated with X-rays is needed. At times, an MRI, CT, or SPECT-CT (single photon emission computed tomography combined with CT) offers more detail of the involvement. Alternatively, the symptomatic joints can be identified by injection of local anesthetics under fluoroscopic guidance. Arthrodesis for hindfoot and mid-foot OA has a high union rate and satisfactory outcome.

OA of the first metatarsophalangeal joint (1st MTP-OA): About 35–60% of adults aged 65 years and over have 1st MTP-OA of the great toe. Radiographic anomaly of 1st MTP has been reported in about 20–50% of the people aged 40 years and over. Indeed, 1st MTP-OA is the most common OA in the foot. Two types of skeletal anomaly are relevant to 1st MTP-OA: hallux valgus and hallux rigidus. By definition, hallux valgus is a deformity at the 1st MTP joint, but clinically it may present with joint degeneration. Hallux rigidus is the “primary” OA of the 1st MTP joint. Its pathology as well as clinical manifestation is progressive pain, stiffness, and dorsal bony prominence over the great toe joint. X-rays demonstrate narrowing of the joint space and osteophytes on the dorsal surface of the first metatarsal head and base of the proximal phalanx. On physical examination, the joint may have crepitus and a reduced range of motion.

In the early stage of 1st MTP-OA, activity modification and using a stiffer soled shoe can reduce foot pain. For advanced conditions (sometimes associated with hallux valgus), surgical procedures are performed to correct the deformity and address OA pathology. For hallux rigidus, according to the stages of the pathology, there are three options of surgeries. Cheilectomy includes removal of 1/3 to ½ of the dorsal articular cartilage and removing the dorsal osteophytes. This procedure can be successful if the remaining articular cartilage is healthy. Several other procedures using osteotomy or resection of the osteoarthritic articulation have been shown to improve the pain and mobility of the 1st MTP joint. The disadvantages of the resection procedures can be instability of the 1st MTP joint and weakened big toe power. Implant arthroplasty replaces the osteoarthritic 1st MTP joint with metallic or silicone prosthesis. There are several prostheses designed for the 1st MTP joint. In general, the procedure restores motion in the 1st MTP joint and can improve pain. With newer implant designs and improved techniques, the survivorship of the implanted prostheses has been extended. Nevertheless, implant failure remains an issue compromising the long-term outcome. Arthrodesis includes resecting the arthritic joint surfaces locking the 1st MTP joint in a neutral position with internal fixation. The procedure is reliable for pain relief and suitable for late-stage OA, by sacrificing the motion of the 1st MTP joint.

61.4 Arthroplasty of Foot and Ankle Joints

Arthroplasty is a collection of surgical procedures that preserve the mobility of a joint using biologic methods—with autogenous or allogenic or synthetic materials. One example of resectional arthroplasty is the Valenti arthroplasty: a V-shape resection of the 1st MTP joint for the treatment of severe hallux rigidus. An interpositional arthroplasty maintains articulation between bones by interposing tissues, such as periosteum, fat, tendon, joint capsule, or allografts.

In modern orthopedic surgery, total joint replacement/arthroplasty removes the diseased articular surfaces and replaces them with artificial prostheses. Total ankle replacement (TAR) is now performed on many ankle conditions that are traditionally treated by arthrodesis. Particularly for late-stage ankle OA, TAR reduces ankle pain and retains ankle mobility (Fig. 61.4). As a result, modern TARs can usually outperform ankle arthrodesis in improving patients' quality of life. Studies show that one year after TAR, the ankle functions measured by the American Orthopaedic Foot and Ankle Society hindfoot scores (normal = 100) are improved from 40 to 80, and this outcome can be sustained for about 10 years. After TAR, patients also improve in gait velocity cadence, stride length, and ankle power. About 90% of the TAR implants survive for at least 10 years.

TAR indications: The most common condition for TAR is late-stage ankle OA. For an optimal outcome, the OA ankle should be stable, with good-quality bone, minimal deformity, and good mobility. Another indication of TAR is nonunion or malunion of a previous arthrodesis. Currently, nearly half of TAR procedures are performed on the ankles with posttraumatic OA, followed by primary OA, rheumatoid arthritis, and postinfection arthrosis.

Contraindications: Charcot neuroarthropathy of the ankle is not suitable for TAR, because its progressive neuropathic pathology may destroy the local bone around the implant or trigger destruction of other foot joints. Ankle infection and compromised limb circulation are the other contraindications of TAR.

Surgical technique: The ankle is accessed through either an anterior approach or a lateral trans-fibular approach. Osteophytes around the joint surfaces are removed, and the anterior and posterior joint capsule is released, to free the ankle from any restriction of motion. Several total ankle designs and instrumentations have been developed, with different engineering principles and prosthesis fixations. For example, the Zimmer Trabecular Metal Total Ankle™ system takes a trans-fibular lateral approach and uses a frame to guide bone cutting, and the installation and alignment of total ankle components. If necessary, the length of the osteotomized fibula is adjusted to correct deformity and address ligamentous imbalance on the coronal plane of the hindfoot. The fibula is fixed with a plate and screw before closing the wound.

Postoperative care includes rehabilitation programs focusing on ankle motion and weight-bearing. According to several national registries (collected in later 1990s and 2000s), TAR revision rate increases significantly after 5 years. TAR complications include aseptic loosening of prosthesis, which is often caused by periprosthetic osteolysis. Wearing particles produced from total ankle components, plastic or metallic,

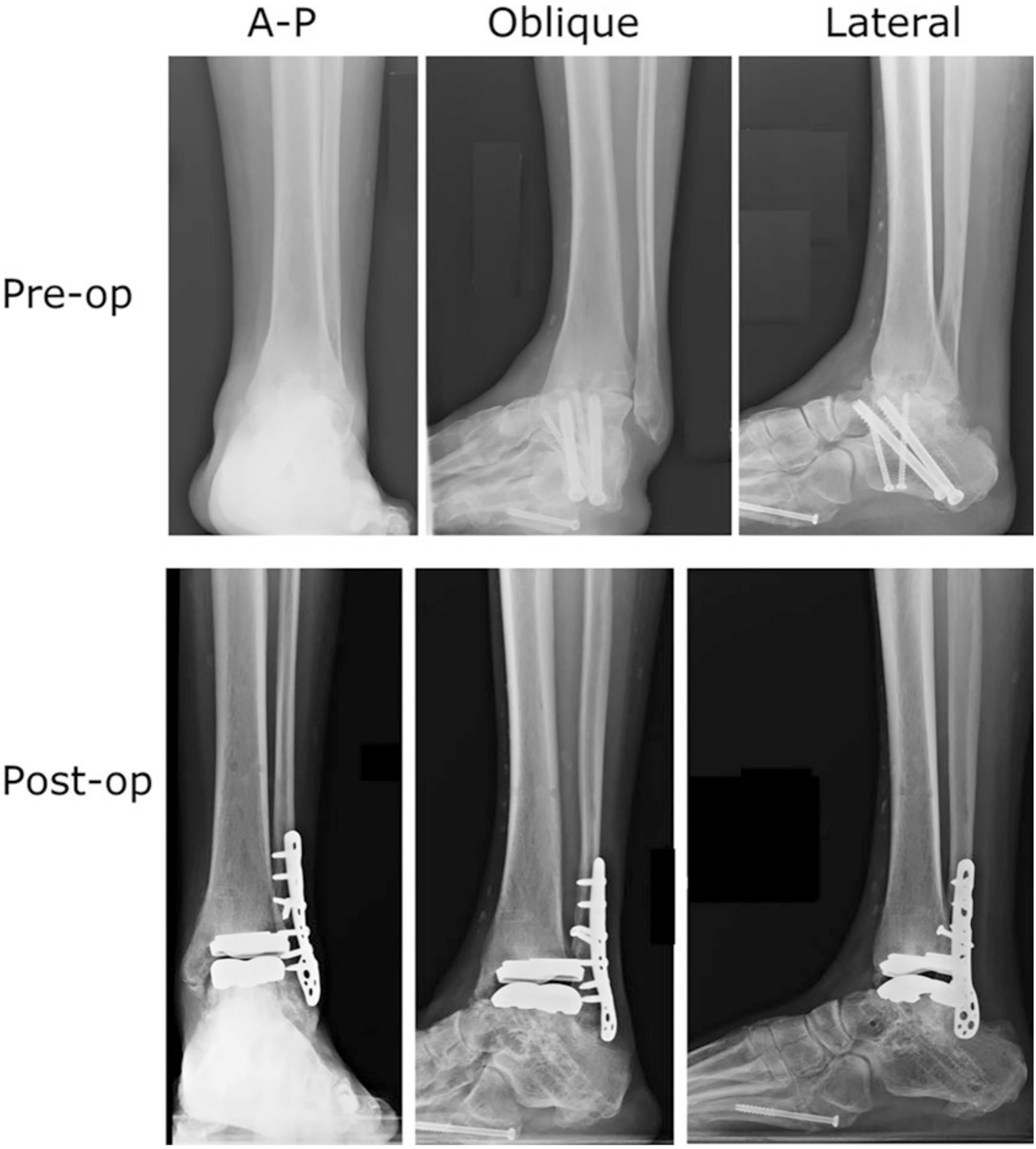

Fig. 61.4 Total ankle replacement for ankle osteoarthritis. The top row (pre-op) shows a posttraumatic ankle osteoarthritis in anterior-posterior (A-P), oblique, and lateral views. The bottom row (post-op) shows an ankle replaced with Zimmer Trabecular Metal Total Ankle™ (anterior-posterior, oblique, and lateral views). Some of the internal fixation hardware for previous foot injury are removed. Two metal components of the total ankle are implanted on the surfaces of the distal tibia and talar dome. This total ankle system includes a highly cross-linked polyethylene liner, which is radio-translucent, on the tibial component. The procedure was performed through a trans-fibular approach. The osteotomized distal fibula is fixed with a plate and screw

may induce inflammation and activate osteoclasts absorbing the bone surrounding the prostheses. Aseptic loosening of TAR is usually managed with surgical revision of the loosened components and grafting bone or its substitutes. If the surrounding bone no longer provides adequate support for the prostheses, an ankle arthrodesis is an option.

Take-Home Message

- The foot and ankle joints are prone to injuries from daily activities and sports.
- The foot and ankle are common sites of osteoarthritis in aging population.
- Ankle arthroplasty is increasingly performed for ankle conditions that are traditionally treated with arthrodesis.

Summary

The repetitive insults the foot and ankle joints endure during daily activities and sports are the main sources of cartilage lesions and joint degeneration. An osteochondral lesion of the talus, depending on its location and size, can be treated with debridement or microfracture procedures to introduce bone marrow stromal cells for cartilage repair, and transplantation of chondrocytes or cartilage grafts. The first metatarsophalangeal joint is a common site of osteoarthritis in aging population. The majority of ankle osteoarthritis cases are posttraumatic at a relatively younger age. It, therefore, has greater impact on social productivity and quality of life. With improved prosthesis design and surgical techniques, total ankle arthroplasty (replacement) has increasingly replaced the traditional arthrodesis for the treatment of late-stage ankle osteoarthritis and other ankle conditions.

Questions

Multiple correct answers are possible. Answers available in the book back matter.

1. Where is the most common site of osteochondral lesion in the ankle?
   (a) Talar dome
   (b) Talus
   (c) Navicular
   (d) Distal tibia

2. What type of cartilage does the microfracture procedure produce?
   (a) Fibrocartilage
   (b) Articular cartilage
   (c) Enchondral cartilage
   (d) Subchondral cartilage

3. Is it aging or injury more often associated with ankle osteoarthritis?
   (a) Injury
   (b) Aging
4. Which joint is the most common site of osteoarthritis in the foot?
   (a) First metatarsophalangeal joint
   (b) Second metatarsophalangeal joint
   (c) Third metatarsophalangeal joint
   (d) Fourth metatarsophalangeal joint
5. What is the most common ankle condition for ankle arthroplasty?
   (a) Posttraumatic ankle osteoarthritis
   (b) Joint degeneration due to aging
   (c) Degeneration due to ankle infection
   (d) Acute traumas

Further Reading

Maffulli N, Longo UG, Locher J, Romeo G, Salvatore G, Denaro V. Outcome of ankle arthrodesis and ankle prosthesis: a review of the current status. Br Med Bull. 2017;124(1):91–112. https://doi.org/10.1093/bmb/ldx042. PMID: 29186357.

Rothrauff BB, Murawski CD, Angthong C, Becher C, Nehrer S, Niemeyer P, Sullivan M, Valderrabano V, Walther M, Ferkel RD; International Consensus Group on Cartilage Repair of the Ankle. Scaffold-Based Therapies: Proceedings of the International Consensus Meeting on Cartilage Repair of the Ankle. Foot Ankle Int. 2018;39(1_suppl):41S–47S. https://doi.org/10.1177/1071100718781864.

van Dijk PAD, Murawski CD, Hunt KJ, Andrews CL, Longo UG, McCollum G, Simpson H, Sofka CM, Yoshimura I, Karlsson J; International Consensus Group on Cartilage Repair of the Ankle. Post-treatment Follow-up, Imaging, and Outcome Scores: Proceedings of the International Consensus Meeting on Cartilage Repair of the Ankle. Foot Ankle Int. 2018;39(1_suppl):68S–73S. https://doi.org/10.1177/1071100718781861. Erratum in: Foot Ankle Int. 2021;42(2):248. PMID: 30215316.