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Review Article

AYURVEDIC UNDERSTANDING OF BIOMECHANICAL DYSFUNCTION OF ANKLE JOINT WITH SPECIAL REFERENCE TO *GULPHA MARMA ABHIGHATHA*

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ABSTRACT

Marma sthana is the vital and most vulnerable point of the body. The *Prana* or the life resides in it. Among the detailed and broad classification of *Marma* by *Susruthacharya* in his *Sareerasthana*, the *Gulpha Marma* is one among 20 *Sandhi Marma* (vital point related to joints) and one of the 8 *Rujakara Marma* according to its traumatic effect of pain. The *Gulpha* viz. ankle joint is located at the junction of *Paada* (foot) and *Jankha* (leg), the trauma in this region will leads to pain, restriction of movement, and limping. The ankle (talo-crural) joint is a uni-axial synovial joint, with primary movements of dorsi and plantar flexions. Ankle joint is one of the most frequently injured areas of the body since being the connecting link between stable leg bone and the mobile foot and subjected to great varieties of forces in walking, running, standing etc. If there is any trauma or injury at *Gulpha Marma* region that directly affect the (*Gulpha Sandhi*) ankle joint. The ligaments, tendons and bones have an important role in maintaining the stability of ankle joint and some clinical and pathological aspects of these are reviewed. Various traumas on ankle joint or *Gulpha Marma* leads to the biomechanical dysfunction of the joint.

KEYWORDS: *Gulpha Marma*, Ankle joint, Biomechanical dysfunction.

INTRODUCTION

Marma ie the vital spots is a very important and unique concept of Ayurveda. The development of science of *Marma* took place from *Saraswathi* culture to the time period of *Charaka, Sushrutha, Vagbhata* and later on Buddhism was responsible for its spread in the neighboring countries like China and Japan.[1] According to *Sushrutha*, *Marma* point is an anatomical site where *Mamsa* (muscles), *Sira* (blood vessels), *Snayu* (tendons), *Asthi* (bones), *Sandhi* (joints) confluence. *Marma*s are classified as *Sadhyapranahara* (causing death immediately), *Kalanthara pranahara* (causing death in time), *Rujakara* (causing pain), *Vaikalyakara* (causing deformity) and *Vishalyaghna* (one with foreign body) according to the traumatic effect. *Gulpha Marma* which is located at the junction between *Paada* (foot) and *Jankha* (leg) is classified under *Rujakara Marma*.

The primary motions allowed at the ankle joint are dorsiflexion and plantar flexion. The talocrural joint has greater stability than other diarthrodial joints (such as the knee and shoulder) due to its structural anatomical features and the combination of weight-bearing and axial loading at the joint.[2] Failure of the foot to control and absorb forces during dynamic and functional activity can result in injuries like various sprains and fractures of the joint.[3] Ankle joint is one of the most frequently injured sites after knee joint, since being the connecting link between stable leg bone and the mobile foot. Injury to the joint will cause swelling with impairment of the biomechanics.

Gulpha marma

As the *Marma* are the site of *Prana* (Life), the sense of distress or pain will be more over here compared to other parts of the body[4]. *Marma* is an anatomical site where *Mamsa* (muscles), *Sira* (blood vessels), *Snayu* (tendons), *Asthi* (bones), *Sandhi* (joints) agglomerate, these sites are the adobe of *Prana*.[5] If any injury to the *Marma* points that leads to deformity of the structures produces the severe pain, loss of movements, and even some times it may lead to death.

The word *Gulpha* is derived from '*Gal*' dhatu (root) '*Fuk*' prateya (affix) . *Gulpha Marma* is situated at the junction of *Paada* (foot) and *Jankha* (leg) [6]. So the location of *Gulpha Marma* can be considered between leg and the foot.

Gulpha Marma is *Shakaghatha Marma* (related to extremities) and it is two in numbers, one in each lower limb. *Acharya* explained its dimension as 2 *Angula* specifically. According to the location it is classified under one among the 20 *Sandhi Marma*. According to the traumatic effect it is classified under *Rujakara Marma* which causes pain on injury. Trauma to this *Gulpha Marma* causes pain, restricted movements and limping.

Ankle joint

The term Ankle refers specifically to the talocrural joint that is the articulation between the distal tibia and fibula proximally and the body of talus distally[7]. The ankle is a uni-axial synovial joint. Since the axis of movement is basically transverse with a slight downward inclination on the lateral side, it is a modified hinge joint. The ankle joint is supported by capsular ligament with synovial membrane, medially deltoid ligament, laterally anterior and posterior talo-fibular and calcaneo-fibular ligaments[8]. The ankle joint is supplied by branches from the anterior

tibial and peroneal arteries and from the deep peroneal and tibial nerves. The movements that take place at the ankle joint are those of plantar flexion and dorsiflexion. Dorsi flexion is produced by muscles of the anterior compartment of the leg viz., tibialis anterior, extensor digitorum longus, extensor hallucis longus and peroneus tertius. Plantar flexion is mainly by the gastrocnemius and soleus muscles. It is assisted by the plantaris, the tibialis posterior, the flexor hallucis longus and flexor digitorum longus[9]. Ankle centre is located in the L_4, L_5, S_1 and S_2 segments of spinal cord. L_4 and L_5 segments control dorsiflexion, and S_1 and S_2 segments regulate plantar flexion.[10]

Biomechanics

The study of mechanical laws and their application to living organisms, especially the human body and its loco motor system is known as biomechanics. The primary motions allowed at the ankle joint are dorsiflexion and plantar flexion. Normal ankle joint ranges of motion are reported to be 10^0 to 20^0 for dorsiflexion and 20^0 to 50^0 for plantar flexion. Ten degrees of ankle dorsiflexion often is considered the minimal amount needed to ambulate without deviation or injury. In neutral position of the ankle joint, the joint axis passes approximately through the fibular malleolus and the body of the talus and through or just below the tibial malleolus.[11]

The dorsiflexion diminishes the angle between the leg and foot where as in plantar flexion increases the angle between them. During dorsi flexion, the wider anterior part of the trochlear surface of talus comes in contact with the tibiofibular mortise. Dorsiflexion of foot takes place at the ankle joint with the assistance of inferior and superior tibiofibular joints. The ankle joint becomes close packed in dorsiflexion, which provides maximum stability to joints. In plantar flexion ankle joint becomes loose packed, because some joint space is available between the tibiofibular mortise and the narrower posterior part of the trochlear surface of the talus.[12]

The ankle joint is also capable of some rotation of the talus within the mortise in both the transverse plane around a vertical axis (talar rotation or abduction/ adduction) and the frontal plane around an antero-posterior axis (talar tilt or inversion/eversion)[13].

Effect of trauma

The injury of ankle joint can be studied under three headings namely tendon ligament and bones. Ankle joint is one of the most frequently injured areas since being the connecting link between stable leg bone and the mobile foot. It is subjected to great variety of forces in walking running, and standing. Abnormal or excessive forces produce injury to the bones and ligaments, usually by indirect violence.[14] *Ruja* (pain) is the first sign of morbidity of any tissue this phenomenon has already been observed in Indian classic by father of surgeon *Susrutha*. The symptoms of injury on *Gulpha* are *Ruja* (pain), *Sthabdha Paadatha* (restricted movement), and *Khanjatha* (limping). Common symptoms present in ankle injuries are swelling, tenderness, bruising, and pain, inability to put weight on the affected ankle, skin discoloration and stiffness.

DISCUSSION

Marma is a place of vital importance in the body which, if injured, results in serious consequences, or death sooner or later. *Gulpha Marma* is a *Sandhi*gatha *Marma* which is classified under *Rujakara Marma* according to effect on injury. *Gulpha Marma* is located between the *Paada* (foot) and *Jangha*. According to *Acharya Susrutha* any trauma to this region will leads to *Ruja* (pain), *Sthabda Paadatha* (restricted movement) and *Khanjatha* (limping). Actually *Gulpha* viz. ankle joint is a synovial hinge joint that connects the distal ends of tibia and fibula in the lower limb with the proximal end of the talus. The ankle joint is bound by capsular ligament with synovial membrane, medially deltoid ligament, laterally anterior and posterior talo-fibular and calcaneo-fibular ligaments. *Snayu* which is the *Upadhathu* of *Meda Dhatu*, is a thin white fibrous band which acts as a binding material in joints[15]

Four types of sensory endings can be located in the capsule and ligaments of synovial joints. Three of these endings are encapsulated and resemble pacinian, Ruffini, and tendon stretch receptors. They provide the central nervous system with information regarding the position and movements of the joint. A fourth type of ending is nonencapsulated and is thought to be sensitive to excessive movements and to transmit pain.[16] Freeman and others have postulated that the nerve fibres to mechanoreceptors, which are the specialized nerve endings thought to play a role in proprioception, are torn at the time of an ankle sprain.[17] The body features present in the ankle region mainly allows larger range of inversion than eversion, thus, inversion sprains are more common than eversion ones.[18] Generally, the lateral collateral ligaments are weaker and more prone to injury than medial collateral ligaments. The anterior talofibular ligament is the most frequently damaged lateral collateral ligament followed by calcaneofibular ligament and then Posterior talo-fibular ligament which is rarely injured.[19]

The tendons of ankle joint can be damaged if sudden force is applied to it, normally happens in a vigorous push off or it could occur in a sudden reflex contraction to stabilize the ankle or sub-talar joints.

An Achilles tendon injury is one of the most common causes of pain felt behind the heel and up the back of the ankle when walking and running[20]. In the normal calf, the feet will plantar flex on compression of the muscle, whereas no movement occurs when the Achilles tendon divided. Because of the inability to maintain tiptoe position the patient adopts a flat footed, plodding type of gait, and completely loose the active plantar flexion.[21]

A dislocated ankle is a condition characterized by damage and tearing of the connective tissue surrounding the ankle joint with subsequent displacement of the bones forming the joints so they are no longer situated next to each other. A dislocated ankle typically occurs traumatically due to forces pushing the ankle bones apart. The usual mechanism of injury is an extreme combination of pointing the foot and ankle downwards (plantar flexion) whilst turning the foot either inwards (inversion) or outwards (eversion) excessively during weight bearing. Patients with a dislocated ankle usually experience sudden

severe pain at the time of injury. The pain is usually so intense that the patient cannot continue activity and will limp or be unable to weight bear at all. A sensation of the 'moving out' at the ankle, loss of ankle movement, swelling, visible deformity and bruising of the ankle etc may be detected[22].

A fracture subluxation of the ankle involves great forces onto the ankle that results in both a fracture and a partial dislocation of the ankle. If the foot is forcefully rotated externally, there is fracture of the bone with disruption of the ligaments so that the ankle has one or more bones fractures with subluxation of the joint. Hearing a snap or crack in your ankle when you are initially injured. It shows the signs and symptoms like having extreme pain, especially with movement of the ankle, swelling, severe ankle deformity, bruising, and inability to move and bear weight on ankle[23]. Occasionally the peroneal retinaculum can be torn. As a result, the peroneal tendons are no longer held in place by the retinaculum and therefore may slip out of position and flick over the bony prominence on the outside of the ankle. This condition is known as peroneal tendon subluxation or dislocation. The usual mechanism of injury for this condition is an excessive turning of the foot inwards (inversion) sometimes in combination with the knee moving forward over the toes (dorsiflexion) during weight bearing. [24]

The estimated incidence of all ankle fracture is 187 per 100,000 people each year in the Western world and happens twice more often in men (2:1). The energy creating a fracture can compromise both joint configuration and ligamentous stability. In theory, more energy leads to more damage, which results in more instability.[25]

Pott's fracture is an archaic term loosely applied to a variety of malleolar ankle fractures. The injury is caused by a combined abduction external rotation from an eversion force. This action strains the sturdy medial ligament of the ankle, often tearing off the medial malleolus due to its strong attachment. The talus then moves laterally, shearing off the lateral malleolus or more commonly, breaking the fibula superior to the tibiofibular syndesmosis. If the tibia is carried anteriorly, the posterior margin of the distal end of the tibia is also sheared off by the talus. A fractured fibula in addition to detaching the medial malleolus will tear the tibiofibular syndesmosis.

The fractures of body of talus, malleolus of tibia and fibula will hamper the stability and thus it will affect the biomechanics of the joint. Since the malleoli are attached to the talus by the joint capsule and collateral ligaments, the fragments follow the displacement of the foot on the leg bones and subsequently it leads to the biomechanical dysfunction of the ankle joint.

Sports injuries can be broadly classified as either traumatic or overuse injuries. Traumatic injuries account for most injuries in contact sports because of the dynamic and high collision nature of these sports. Signs and symptoms are inflammation is characterized by pain, localized swelling, heat, redness and a loss of function.[26] Ankle injury accounted for more than 10% of all sports injuries[27], in which 80% or more were ligamentous sprain injuries[28]. Among sports, a survey in Hong Kong reported that most ankle sprains were sustained while pursuing running and jogging activities (25%), racquet sports (20%) and ball games (19%) [29].

In above description it is observed that the elements of ankle joint namely tendon, ligament, and bones have together role in the maintenance of stability and integrity. And it is revealed that fracture of bone and tear of ligaments and tendons are extreme painful conditions. In addition to this body weight is also contributing to enhance the severity of pain. And edema around it is a result of improper venous drainage against the gravity. By considering the vitality of this region *Susrutha* might have included this *Sandhi*gatha *Marma* under *rujakara Marma*. All the Injuries around ankle joint are very painful this may be the reason to designate it *Marma* as *Rujakara*. The above discussion reveals that the trauma of *Gulpha Marma* impairing the biomechanics and resulting into *Ruja* (pain), *Sthabda Paadatha* (restricted movement), *Khanjatha* (limping gait). Thus in today's era also the *Susrutha*'s clinical observations on the orthopedic injury stand relevant.

CONCLUSION

Marma are considered as the vital points of the body. *Gulpha Marma* is one among them which is located at the junction of *Paada* and *Jangha* (ankle joint). The main functions of the ankle joint are weight bearing and locomotion and a trauma to this leads to the impairment of its functions. Biomechanical dysfunctions are caused by injury to ligament tendon and bones of the joints. The *Gulpha Marma abhighatha lakshanan* of *Ruja* (pain), *Sthabda padatha* (restricted movement) and *Khanjatha* (limping) enumerated by *Acharya Susrutha* represents the biomechanical dysfunction of ankle joint. Therefore classification of the *Gulpha Marma* under *Sandhi*gatha *Marma* and *Rujakara* is relevant. This throws light to the clinical and scientific excellence of *Acharyas* who explained these centuries ago, before the contemporary science could discover it.

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