Review Article

Insight on Krukatika Marma with Reference to the Injury of Cranio-Cervical Joints

*PhD scholar and Professor Post Graduate Department of Shareera Rachana, SDM College of Ayurveda, Hassan
**Formerly Professor, Post Graduate Department of Shareera Rachana, SDM College of Ayurveda, Udupi
***Professor, Post Graduate Department of Kayachikitsa SDM College of Ayurveda, Hassan

Corresponding Author: Mail ID – drbgkulkarni@gmail.com, Mobile No. +919480302935
II\textsuperscript{nd} Author: E-mail – girishakanthi@gmail.com Mob number -9448888378,
III\textsuperscript{rd} author E-Mail- girideepa@yahoo.co.in Mobile number-9448646855

Abstract:
Sushruta is first to explore the door of traumatology in the field of surgery by introducing the concept of marma i. e. vulnerable areas of body. There are 107 marma points over the body, injury of which leads to death of the victim or disruption in functions of that area or excruciating pain. Krukatika marma is one among them, constituted mainly by joints, located at cranio-cervical junction. The vulnerability is limited to approximately half Angula (1cm) circumference or in deep area. Injury of this marma exhibits the instability of cranio-cervical joint.

Actually, the joints of cranio-cervical joints (CCJ) have unique kinematic properties that contribute to the complex motions. When the elements like occipital condyles, lateral masses, alar ligament, odontoid process, anterior and posterior arches of atlas etc involve in the trauma, they disrupt the stability of CVJ. This is observed in various clinical and experimental studies. The systematic review of clinical data helps to substantiate/designate these joints as vulnerable. Sushruta’s ancient thought of traumatology is appreciated here.

Key Words: Krukatika marma, cranio-cervical joints, Chala-murdhata, Greeva, alar ligament, atlas vertebra, atlanto-occipital joint.

Introduction:
Now day’s trauma has become a part of the life. Such a trauma affects the homeostasis of the body because there are many vulnerable areas present in the body. These anatomical locations are vital in the sense that any injury to these parts shall be painful and can cripple local functions or even can lead to sudden death of the individual. Therefore those lethal areas are referred to as marma in Ayurveda. There are 107 vital spots in the body out of which krukatika marma is one which is situated on either side on the neck. It is sandhi marma i.e. mainly constituted by joints. Injury of these marma leads to instability of cranio-cervical joints. These joints are involved in various movements of neck. The joints of CVJ have unique kinematic properties that contribute to the complex motion. When the elements like occipital Condyles, lateral masses, alar ligament, odontoid process, anterior and posterior arches of atlas etc involve in the trauma, they disrupt the stability of CVJ. The clinical and experimental observations revealed in various studies help to substantiate the traumatic effect of krukatika marma.

Concept of Marma
The matrix of vital points (marma) is constituted by confluence of māmsa (muscular tissue), sirā (vascular tissue), snāyu (nervous or connective tissue), asthi (bone/cartilage), sandhi (joints) and prāṇa (vital energy). In each marma there is a dominancy of one of the above elements (māmsa, sirā etc). Depending up on the involvement of the structure, the clinical symptoms are manifested. Different marma exhibits different grades of severity. Further severity is depending upon the involvement of area of that marma because each marma is having its own dimension. If peripheral area of the marma is injured then different clinical feature are seen.

Classical Aspects of Krukatika
Fourteen marma are present in the neck region, krukatika are two among them, located at the junction of shiras (head) and greevā (neck) constituted by sandhi (joints) and measures only 1 cm (half angula) dimension. Injury to this give rise to chalamurdhata (loss of stability of head), therefore this is included under vaikalykara (deformity) category.1,2

Anatomical Features of Krukatika Region
Krukatika marma is located in the region of cranio-cervical junction therefore there is need to focus the anatomical features. The junction between the skull and the cervical vertebrae is stabilized by ligaments joining the axis and atlas to the clivus, occipital bone, and occipital condyle. The cranio cervical junction must accommodate a wide variety of motions, which require ligaments for stabilization.3 Atlanto-occipital joint is formed by the superior articular facet of the atlas and the occipital condyle, which are stabilized by an articular capsule. This joint allows for 25 degrees of flexion and extension and 5 degrees of axial rotation. The atlanto-axial segment consists of 3 joints, which together allow for 15 degrees of flexion and extension and 30 degrees of axial rotation. These include 2 lateral mass articulations and an atlanto-dental joint. The latter resists excessive
extension, allowing only 10 degrees of extension in the average person.\(^4,5\) The anterior atlanto-occipital membrane serves to prevent excessive neck extension.\(^4,5\) The alar ligaments limit contra lateral flexion and axial rotation at the atlanto-occipital joint.\(^4,5\) The apical ligament attaches from the tip of the odontoid process to the basion. The Barkow ligament connects the tip of the dens to the occipital condyle and it assists in preventing excessive neck extension. The transverse occipital ligament sometimes joins the alar ligaments and may help prevent excessive lateral bending, flexion, and axial rotation.\(^4,5\) The cruciform or cruciate ligament limits lateral motion of C1 relative to the dens and prevents posterior displacement of the dens, thus limiting anterior C1–2 subluxation to 3–5 mm. The tectorial membrane limits both excessive flexion and extension. A small group of deep muscles in the upper cervical region at the base of the occipital bone move the head, they are referred to as suboccipital muscles. These muscles are innervated by the posterior ramus of the first cervical nerve, which enters the area between the vertebral artery and the posterior arch of the atlas.\(^6,8\)

Clinical Review

**Atlanto-Occipital Fusion:** There is compression over the vertebral artery and first cervical i.e. suboccipital nerve root. Several predisposing conditions, including inflammatory, neoplastic, and congenital disorders, may increase the risk of Atlanto-occipital dislocation (AOD) in the face of relatively minor trauma. Rheumatoid arthritis may involve the spine, particularly the cranio-cervical junction and cause weakening of the transverse ligament, thus increasing the risk of C1 subluxation. Down syndrome is associated with laxity of cranio cervical ligaments in up to 30% of cases. Congenital cervical vertebra fusion syndromes may also predispose to AOD by creating a fulcrum-like effect.\(^5\) Vertebral artery is accessed in sub-occipital triangle in order to conduct angiography of circle of Willis.\(^5,9\)

**Occipital Condyles Fracture (OCF):** Although many occipital condyle fractures are asymptomatic, some have the potential to cause major CVJ destabilization. These fractures are classified as type I, type II, and type III fractures. Type I fractures occur from comminute of the occipital condyle without significant bone fragment displacement into the foramen magnum. Excessive axial loading is believed to be the biomechanical cause of these injuries. Tuli et al\(^8\) found 96 case reports of OCF, approximately 40% of which were from postmortem studies. The incidence, among that of severe cranio-cervical injuries, ranges from 4% to 19%.

**Hangman Fracture:** It is also known as traumatic spondylolysis of axis which involves the pars interarticularis of C2 on both sides, and is a result of hyperextension and distraction. Post-traumatic neck pain after hyperextension high velocity injury is the most common presentation. Neurological impairment is seen only in 25% of patients.\(^9\)

**Odontoid Process Fracture:** It is also known as the PEG or dens fracture, which occurs where there is a fracture through the odontoid process of C2. The mechanism of injury is variable, and can occur both during flexion or extension.\(^9\) Precise mechanism of odontoid fractures is unknown. However, the mechanism most likely includes a combination of flexion, extension and rotation. In addition to pain and inability to actively move the neck, most patients complain of a sensation of instability, described as a feeling of the head being unstable on the spine. Patients may present by holding their head with their hands to prevent any motion. Clinical findings range from quadriplegia with respiratory center involvement to minimal upper extremity motor and sensory deficits secondary to loss of 1 or more cervical nerve roots.\(^10\)

**Jefferson fracture** is the eponymous name given to a burst fracture of C1. It was originally described as a four-part fracture with double fractures through the anterior and posterior arches, but three-part and two-part fractures have also been described. It is Associated with 50% of other C-spine injuries, 33% are associated with a C2 fracture, 25–50% of young children have concurrent head injury, vertebral artery injury extra-cranial cranial nerve.\(^11\) There is a high prevalence of concomitant fractures of the axis, especially odontoid fractures.\(^12\) Most recent biomechanical studies of atlas fractures have concluded that these fractures are usually caused by axial loading through the occiput.\(^13\) An unstable burst fracture of the atlas may result in atlanto-axial instability, even if properly treated.\(^14\) C1 posterior osteosynthesis does expose the patient to the risks of vertebral artery and greater occipital nerve injury. The greater occipital nerve is at risk with a more cranial starting point for C1 lateral mass screws and the vertebral artery can be injured near the C1–2 joint.\(^15,16\)

**Discussion**

As per the classical description *Krukatika marm* is situated at cranio cervical junction (CCJ). This vital area is constituted by joint (sandhi), injury of which leads to instability of the head. In the review of the literature it is revealed that atlanto occipital joint is holding the head on cervical column with association of atlanto occipital and atlanto axial joint. By keeping the movements of the head in the view, the design of the joint is made. The CVJ plays an important role in the overall motion of the cervical spine, accounting for 25% of the flexion and extension and up to 50% of the axial rotation of the neck.\(^17\) Although the CVJ consists of two distinct joints (atlanto-occipital and atlanto-axial), it still functions
as a single mobile unit, with the atlas acting like a washer between the cervical spine and the occiput. Each of these joints, however, has unique kinematic properties that contribute to the complex motion of the CVJ. The place of exit of C1 Nerve root and entry of vertebral artery measures very small area. When there is injury to the components of CCJ it may create a compression on above mentioned structure which leads to neck muscles weakness. Consequently it develops the instability of head. This observation supports the Sushruta’s observation of chala-murdhata i.e. instability of CVJ.

The two components of AO joint and joint between Dens and atlas is also an important part. There are eight main ligaments like tectorial membrane, the alar ligament also support the CVJ. The right alar ligament limits rotation to the left, and the left alar ligament limits rotation to the right. Capsular joint ligaments also play an important role in limiting atlanto-axial rotation. More recent evidence suggests that the tectorial membrane prevents anterior spinal cord compression by the odontoid process.

Trauma to the cervical spine typically occurs through high energy events such as falls, sports injuries, motor vehicle crashes, and diving accidents. CVJ instability should be suspected if there is weakness in the arms, dislocation, subluxation, although many occipital condyles fractures are asymptomatic, some have the potential to cause major CVJ destabilization. These fractures are classified as type I, type II, and type III fractures. Type III fractures occur from condylar avulsion due to excess force form lateral bending or axial rotation.

The alar ligaments are often compromised in type III fracture, causing them to generally be considered unstable, and the condylar fragments can be displaced into the crowded foramen magnum, which can cause neurovascular injury. By considering the clinical fact sushruta might have included this marma as vaikalyakar (deformity) catagory. Damage to the occipital condyle has been modelled in cadaveric studies with progressive, unilateral condylectomies. Hypermobility was noted in all of the motions of the atlanto-occipital joint (flexion, extension, axial rotation, and lateral bending) with a fifty percent resection of the condyle. In the atlantoaxial joint, hypermobility was achieved with 25% resection for flexion and extension, 75% resection for axial rotation, and 100% resection for lateral bending. Taken together, these results indicate that condylar injuries have great potential to disrupt the stability of the atlantooccipital joint. In a cadaveric study of atlantal fractures, high-speed axial force produced fragmentation in the classical pattern described by Jefferson. These cervical segments also had significant destabilization, resulting in range of motion increases of 40% in flexion and extension, and 20% in lateral bending.

Most recent biomechanical studies of atlas fractures have concluded that these fractures are usually caused by axial loading through the occiput. An unstable burst fracture of the atlas may result in atlantoaxial instability, even if properly treated. Severe rheumatoid arthritis can cause erosion of the bony components of the CVJ. In particular, these degenerative changes can affect the insertions of the transverse ligament into the atlas, causing ligamentous laxity and atlanto-axial instability in 20-86% of patients with rheumatoid arthritis. These osteoarthropathies may contribute further instability as they progress to include disruption of the alar ligament, the occipital condyles and the odontoid process. This condition, known as basilar impression, is hallmarked by translation of the odontoid process in the cranial direction and subluxation or dislocation of the atlanto-occipital joint.

In a recent study of 300 patients with cervical spine trauma, 30% of injuries were located between the occiput and C2. Among these, acute spondylolysis of C2 (hangman’s fracture), C1 ring fractures odontoid fractures, and atlanto-occipital dislocation (AOD) were the most common. The above cadaveric and clinical reviews indicate the importance of bony components of AO joint in the manifestation of CCJ instability, because Asthi (bone) is the important component of marma sthaana (vital point)

AOD is more common among children and young adults. In fact, the injury is 3 times more common in children than in adults. This is thought to be secondary to a more horizontal plane of the articular surfaces and a relative laxity of the ligamentous structures, combined with the presence of a relatively large head and a higher effective fulcrum in the cervical spine. This observation reveals the greater vitality of Krukatika Marma in children than the adult.

The above discussion reveals that the ligaments structures around the AO (atlanto-occipital joint) and AA joint (Atlanto-axial joint) have very important role to maintain the stability of CVJ. There is limited space in the region of C1-C2 when surgical intervention is considered. Matthew B.et al have discussed a case who sustained fractures of C-1 and C-2 in conjunction with a unilateral non displaced Occipital condyle fractures (OCF), underwent surgery for the atlantoaxial fractures with extension of the fusion to include the occiput due to an inability to place screws in C-1. Occipital condyle fractures precipitating disruption of the occiput-C1 joint should be treated using occipitocervical fusion. This shows the vulnerability of this region. There are multiple ligaments attached in limited space. Injury of these ligaments disrupts the functions of both joints.

The axial loading that causes Jefferson fractures is also implicated in the genesis of transverse ligament
damage, and the identification of a coexisting ligament injury is of utmost clinical importance. These two pathologies often coexist, causing significantly increased cervical destabilization. Damage to the transverse ligament can occur in isolation, but it usually accompanies damage to other regions of the CVJ, especially fractures of the atlas. Likewise, associated damage to the alar and apical ligaments is also common. The transverse ligament is susceptible to mid substance tearing, or it can be disrupted by avulsion from the lateral mass of the atlas. In one study, axial loading was shown to cause damage to the transverse ligament, both with and without fractures of the atlas. Other reports suggest that neck flexion can also cause transverse ligament disruption. This explains why head-on collisions are more likely to result in transverse ligament injury than rear-end crashes.

Yong Hu, Todd J Albert et al. stated that treatment algorithms in determining surgical versus nonsurgical treatment of unstable Jefferson fractures have not reached a consensus, but treatment decisions are often based on the integrity of the transverse ligament. This indicates the vital role of ligaments in maintenance of functional concord of joints.

The above clinical observations stress the significance of ligaments (Snayu) in the constitution of vulnerability. It is revealed that CVJ comprising AO &AA joint are structurally and functionally very vulnerable, therefore this region is considered as marma.

This discussion substantiates the Sushrut’s clinical view about this Marma i.e. Chalamarudhata. This clinical observational data helps to determine the structure to be included under this Marma. They are atlanto-occipital joint, Atlanto-axial joint, the tectorial membrane, the alar ligament, the cruciate ligament, the apical ligament, capsular ligament, accessory atlanto-axial ligament, the anterior and posterior atlanto-occipital membranes, Posterior ramus of C1 vertebral artery. These all structures are arranged bilaterally in a very small area i.e.in half angula circumference. Depending on the involvement of side these are giving rise to the symptoms.

Conclusion

Based on the classical description, applied anatomy and clinical data following conclusion can be drawn. Krukati Marma is located on medial aspect of atlanto-occipital joint which is very crucial as there are attachments of various ligaments. As it is a sandhi marma therefore atlanto-occipital, atlanto-axial joint with its surrounding ligamentous structures attached to the same within 1cm (half angula) area on either side to be concluded. Ligamentous structures like the alar ligament, the cruciate ligament, the apical ligament, capsular ligaments etc around the AO (atlanto-occipital) joint and AA joint (Atlanto-axial joint) have very important role to maintain the stability of CVJ. Injury of these structures influencing the instability (Chalamarudhata) of cranio-cervical joint (shirogreeva sandhan). Depending upon the severity of involvement of structures grading of symptoms will be exhibited. This is one of reason to influence the quality of life in such injuries. This study proves the relevancy of Sushrut’s clinical view about sandhi marma.

References


11. Muratsu H, Doita M, Yanagi T et-al. Cerebellar infarction resulting from vertebral artery


Financial support: Not declared; Conflict of interest: Not declared