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PHYSIOLOGICAL AND PATHOLOGICAL ASPECTS OF *ASTHI DHATU*

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ABSTRACT

Ayurveda considers *Dosha*, *Dhatu* and *Mala* as basic constituents of *Sharir*. *Asthi* is a vital *Dhatu* of body. *Asthi* protects organs of body from external shock, maintain posture of the body, provides strength and stability, supports *Majja Dhatu*, imparts compactness of body. Each *Dhatu* has an *Upadhatu*, that works together to strengthen the body. The previous *Dhatu* nourishes the next *Dhatu*, and they act as the substratum for each. The constantly diminishing *Dhatus* are kept in a state of equilibrium by food. This means that the *Dhatus* are interdependent, with an increase or decrease in one causing an increase or decrease in the other. *Prithivi Mahabhuta* is dominant in *Asthi Dhatu* and *Vata* is the *Ashrayi Dosha* in *Asthi*. The abnormal state of *Asthi Dhatu* can be considered in terms of *Vriddhi* or *Kshay*. *Dhatu Kshaya* and *Vriddhi* are responsible for initiating various disease pathologies. Changes in life style, early aging have increased the incidence of bone related disorders. So, an attempt is made to review *Asthi Dhatu* and its disorders from Ayurvedic and Modern point of view. It can be concluded that most of the pathologies in *Asthi Dhatu* are due to *Vata Vitiation*. Genetic, hormonal, infectious, degenerative, tumorous and traumatic factors play an important role in the pathogenesis of bones.

KEYWORD: *Asthi Dhatu, Dhatu Kshaya, Dhatu Vriddhi*, Bones.

INTRODUCTION

According to Ayurveda, human body is made of *Dosha*, *Dhatu* and *Mala.*[1] The structural and functional integrity of body depends upon *Dhatu*. *Dhatu* means body constituents which build the basic structure and carry various physiological functions. They work as body tissues, stabilize and sustain body. Among the seven *Dhatus*, *Asthi Dhatu* is related to *Dharana* of *Sharira*.[2] Along with its joints and in association with muscles, tendons and ligaments it takes part in locomotion.

The *Purisha Dhara Kala* is the membrane that holds the *Asthi Agni* which exits in *Pakvashaya. Asthi Dhatu* shows predominance of *Prithvi Mahabhuta.Asthi Dhatu* is formed by *Poshaka* (unstable) *Meda Dhatu*, flows into the *Purisha Dhara Kala* and is digested by the *Asthiagni*.[3] In addition to the formation of the bones of the body, teeth are formed through this process and are thus the *Upadhatu* (secondary tissue) of *Asthi Dhatu*. The *Malas* (waste products) of this metabolic process are the hair and nails.

Ayurveda considers *Dosha* reside in *Dathu* or there is *Ashraya Ashrayi Bhava* in *Dosha* and *Dhatu*.[4] For example, *Rakta* and *Sweda* are the residing sites for *Pitta Dosha*. Like that *Vata Dosha* resides mainly in *Asthi Dhatu*. Considering this, *Vata Dosha* vitiation plays an important role in the pathogenesis of *Asthi Dathu Dushti*. *Pitta* and *Kapha Dosha* vitiation lead to inflammatory or obstructive pathologies respectively in the bone.

Upadhatu and *Mala Dushti* of *Asthi* includes *Kesha*, *Danta* and *Nakha Vikruti*. So pathology in *Asthi Dhatu* may also lead to deformities in these body organs.

Basic understanding of *Dhatu* is essential to understand the underlying pathology of disease. It is necessary to understand the normal *Asthi Dhatu* to get the knowledge of its abnormality. Nowadays, changes in life style, early aging have increased the incidence of bone related disorders. Due to high prevalence of *Asthi* related disorders it is very important to identify these disorders with proper pathogenesis from the Ayurvedic point of view and by integrating it from modern aspect also, So that proper treatment can be initiated.

So an attempt is made to review *Asthi Dhatu and* bone related disorders from Ayurvedic and modern point of view for the prevention and proper treatment of the disease.

AIM AND OBJECTIVE

1. To evaluate and elaborate the Ayurvedic concepts of *Asthi dhatu.*

2. To review bone disorders from Ayurvedic and modern perspective.

MATERIAL AND METHOD

1. Ayurvedic texts, mainly *Samhita like Charak Samhita, Sushrut Samhita, Ashtang Hridaya* and their commentaries.
2. Modern textbooks, websites and articles related to the topic were reviewed to collect the literary material.

REVIEW OF LITERATURE

Nirukti (Etymology and derivation)

The word *Asthi* is a combination of two Sanskrit words "*as*" and "*kthin*". They together give the meaning "stability".[5]

Paribhasha (Definition)

Asthi is a body component which stays for a longer time (*Asyate*) and which takes part in movements (*Kshipyate*) with muscles. It is also termed as the *Sara* (extract) of the body which remains even after the destruction of all other body components.[6]

Prayay (Synonyms)

1. *Kikasam*: Round structures.
2. *Kulyam*: Tubular or canal like structure.
3. *Svadayitam*: Animals like dogs like it.
4. *Medasteja:* Essence of Medadhatu.
5. *Sara:* Extract of body which remains even after death.
6. *Majjakrit:* Which produces *Majja Dhatu.*
7. *Dehadharakam:* This maintains body skeleton and bears body weight.
8. *Karkaram:* Rough.

Panchabhautika sanghatana, Guna (Fundamental constitution and properties)

Fundamental constitution of *Asthi Dhatu* shows predominance of *Prithvi Mahabhuta.*

The physical properties of "*Asthi Dhatu*" are *Guru* (heaviness), *Khara* (roughness), *Kathina* (hardness), *Sthula* (bulkiness), *Sthira* (static), with a definite physical form.[7]

Utpatti and Poshana of Asthi Dhatu (Metabolism and Development)

The *Asthi Dhatu* is formed from its precursor *Meda Dhatu.* The nourishing portion of *Meda Dhatu* and constituents of *Ahara Rasa* are transformed into *Asthi Dhatu* by action of *Asthi*

Dhatvagni. *Agni Mahabhuta* and *Vayu Mahabhuta* play a major role in the solidification and roughness of *Asthi* by acting upon *Prithvi Mahabhuta*.[8]

Porosity in bones is due to actions of *Vayu* and *Akasha Mahabhuta*.

***Upadhatu And Mala* (Metabolic by products and waste products)**

During the process of metabolism and development of *Asthi Dhatu*, *Nakha* (nails) are formed as the metabolic by products.[9]

Sharangadhara considered *Danta* (teeth) only as metabolic by product of *Asthi Dhatu*.[10]

Kesha (scalp hair) and *Loma* (body hair) are waste products of metabolism of *Asthi Dhatu*.[11]

***Sankhya* (Quantity)**

There are total 360 well-formed *Asthi* in human body.[12]

Sushruta opines the total number as 300.[13] Currently, most sources state that there are total 270 bones in human body at the time of birth. Many bones fuse together and form 206 separate bones.

Types of *Asthi*:-There are five types of bones in human body.[14]

Table No. 1: Types of Bones.

Sr. No.	Type	Site
1	*Kapala* (Flat bones)	*Janu* (knee), *Jaghana*(pelvic), *Amsa* (shoulder), *Ganda*(cheek), Talu (palate), Shankha (temples), Shira (skull)
2	*Ruchaka* (Teeth)	*Danta* (teeth)
3	*Taruna* (Cartilage)	*Ghrana* (nose), *Karna* (ear), *Griva* (neck), *Akshikosha* (orbit of the eye)
4	*Valaya* (Curved/Annular bones)	*Parshuka* (ribs), *Prushthakasheruka* (vertebrae)
5	*Nalaka* (Tubular bones)	All other long bones

The contemporary anatomical views also categorize bones under five categories like long bones, short bones, flat bones, sesamoid bones, and irregular bones.[15]

Time span

The *Asthi Dhatu* is formed on 6th day from the *Ahara Rasa* (nutrient fluid).[16]

However, Sushruta opines that the *Asthi Dhatu* is formed in a time span of twenty days. [17]

Karma (Functions)

The important function of *Asthi Dhatu* is providing structure and support to the body. It also nourishes the successor *Majja Dhatu*.[18]

In addition, contemporary physiology states that bone tissue carries out the following functions too.

Mechanical, protect internal organs, facilitate movement, Facilitate hearing, and it indirectly helps in the production of formed elements.

Asthisara (Characteristics of best quality or essence)

The persons with essence of *Asthi Dhatu* have prominent *Parshni* (heels), *Gulpha* (ankles), *Janu* (knee Joint), *Aratni* (elbows), *Jatru* (collarbones), *Chibuka* (chin), *Shira* (head), *Parshva* (flanks), joints, bones and teeth. Such persons are highly enthusiastic, active, enduring, having strong and firm body as well as longevity.[19]

Anatomical and physiological structures formed by *Asthi*

The *Asthi Dhatu* is present in various forms as below.

Asthivaha Srotas

The *Moola Sthana* of *Asthivaha Srotas* are *Meda Dhatu* and *Jaghana*.[20]

Asthidhara Kala (Layer of bone tissue)

Kala is the layer in outer coverings of body observed in sagittal section. The inner layer of large intestine is *Purishadhara Kala* that holds fecal matter, has relation with the layer *Asthidhara Kala*.[21]

Asthi Sanghata (Confluence of bones)

The places where many bones are present are called confluences. The confluences of bones are fourteen in number. They include *Gulpha* (ankle), *Janu* (knee), and *Vankshana* (groin) in lower limbs and their counter parts *Manibandha* (wrist), *Kurpara* (elbow) and *Kaksha* (axilla) in upper limbs on each side. One is in the *Trika* (lower back) and the other on the *Shira* (skull).[22]

***Asthi Marma*(Vital points)**

There are eight vital points formed from bones.[23] These are *Katikataruna* (vital spots on both sides of the vertebral column above and near the pelvic crest), *Nitamba* (vital points above the two pelvic bones meeting the flank), *Amsaphalaka* (vital points on scapula- one on each side of the vertebral column in the upper back region) and *Shankha*(vital spots on each side between the outer end of the brow and the ear).[24]

Main causative factors for the occurrence of *Asthyashrayavyadhis* are:[25]
Ati Vyayama, Ati Sankshobha, Ati Vighattana of *Asthi, Vatala Ahara* and *Vihara*

Diseases of *Asthi Dhatu*

Asthi Kshaya and *Asthivriddhi Lakshanas* are considered under *Asthyashraya Vyadhis.*

Asthi Kshaya Lakshana:- *Asthishool* (joint and bone pain), *Nakhabhang* (brittle and easily breakable nails), *Dantabhang* (weak, loose teeth which can easily fall off), *Kasha-Lomashmashru Patana* (loss of hairs of scalp, skin and beard), *Dwija Patana* (loss of teeth), *Shrama* (exertion) and *Sandhishaithilya* (subluxation of joint) are the symptoms of *Asthi Kshaya*.[26]

Asthivriddhi Lakshanas

Adhyasthi (extra pointed bone growth over bone or calcification) and *Adhidanta* (growth of extra teeth or hyperdontia) are the symptoms of *Asthi Vriddhi*.[27]

Asthi Pradoshaja Vikar[28] are *Adhyasthi, Adhi Danta, Danta Bheda, Asthibheda, Danta Shula, Asthishula, Asthi Toda, Vivarnata, Kesha Loma Dosha, Shamshru Doshaah* and *Kunakha.*

***Adhyasthi*:-** It can be understood as the unhealthy growth or remodeling of the Bone called as Osteophytes. Usually, these Osteophytes / Bony spurs are formed marginally in the joints of Bones. Bone spurs cause pain when rubbed or pressed against the surrounding tissues.

***Asthibheda*:-** Increased *Rukshata* and *Shushkata* due to *Vatavriddhi* causes breaks or cracks in Bones or Teeth.

***Asthishula*:-** Pain in the affected Bone is the *Pratyatmak Lakshana* often observed in *Asthyashraya Vyadhi*. *Asthishula* is the result of *Vatadosha* being lodged in *Asthi* or it may be

due to degenerated *Asthi*. *Asthishula* is often expressed in *Kati, Janu, Prishta, Greeva, Amsa, Asthi Sandhis.*

Asthitoda, the pricking pain in *Asthi* is also one of the *Rupa* of *Asthyashraya Vyadhi*, It represents the Severity of the *Vyadhi.*

Adhidanta (extra unusual growth of Teeth):- *Danta* is the *Upadhatu* of *Asthi Dhatu*, therefore abnormal growth is also seen in Denture.

Dantashula and *Dantabheda* because of the under nourished *Asthi Dhatu*, its *Upadhatu, Danta* also undergoes degeneration.

Vivarnata and *Sadana* of *Kesha, Loama, Nakha, Smashru* (Discoloration of Nails/ Hairs and fall of Hairs on Scalp/ body, Moustache and Nails) is observed.

MODERN REVIEW[29]

A bone is a rigid organ that constitutes part of the skeleton in most vertebrate animals. Bones protect the various other organs of the body, produce formed elements, store minerals, provide structure and support to the body, and enable mobility. Bones come in a variety of shapes and sizes and have a complex internal and external structure.

Bone tissue (osseous tissue), is hard tissue, a type of specialized connective tissue. It has a honeycomb-like matrix internally, which helps to give the bone rigidity. Bone tissue is made up of different types of bone cells. Osteoblasts and Osteocytes are involved in the formation and mineralization of bone. Osteoclasts are involved in the resorption of bone tissue. Modified (flattened) osteoblasts become the lining cells that form a protective layer on the bone surface. The mineralized matrix of bone tissue has an organic component of mainly collagen called ossein and an inorganic component of bone mineral made up of various salts. Bone tissue is mineralized tissue of two types, cortical bone and cancellous bone. Other types of tissue found in bones include bone marrow, endosteum, periosteum, nerves, blood vessels and cartilage.

The formation of bone is called ossification. During the fetal stage of development this occurs by two processes: Intramembranous ossification and Endochondral ossification. Intramembranous ossification involves the formation of bone from connective tissue whereas endochondral ossification involves the formation of bone from cartilage.

Intramembranous ossification mainly occurs during formation of the flat bones of the skull but also the mandible, maxilla, and clavicles; the bone is formed from connective tissue such as mesenchyme tissue rather than from cartilage. The process includes: the development of the ossification center, calcification, trabeculae formation and the development of the periosteum.

Endochondral ossification occurs in long bones and most other bones in the body; it involves the development of bone from cartilage. This process includes the development of a cartilage model, its growth and development, development of the primary and secondary ossification centers, and the formation of articular cartilage and the epiphyseal plates.

Disease of Bones[30]

1. Osteoporosis:- Osteoporosis is defined as low bone mineral density caused by altered bone microstructure, ultimately predisposing patients to low-impact, fragility fractures. Primary osteoporosis is a disease of the elderly and is related to the aging process in conjunction with decreasing sex hormones. Medications that can lead to secondary osteoporosis include glucocorticoids and anti-epileptics. Other medications such as chemotherapy agents, proton pump inhibitors contribute to osteoporosis.

Disease that can cause osteoporosis include hyperparathyroidism, anorexia, malabsorption, hyperthyroidism, or overtreatment of hypothyroidism, chronic renal failure, Cushing syndrome, and any disease that can lead to long-term immobilization. Secondary amenorrhea for more than one year from various causes, including non-estrogen hormonal therapy, low body weight, and excessive exercise, can also lead to rapid loss of bone mass.

2. Rickets and osteomalacia

Nutritional deficiencies, particularly of vitamin D, calcium, and phosphorus, can result in the formation of weak, poorly mineralized bone. In children, vitamin D deficiency produces rickets in which there is not only a marked weakness of bone and fractures but also bending of the long bones and a characteristic deformity due to overgrowth of cartilage at the ends of the bones. In adults, vitamin D deficiency leads to a softening of the bone (a condition known as osteomalacia) that can also lead to fractures and deformities.

Rickets is the clinical consequence of impaired mineralization of bone matrix throughout the growing skeleton, while osteomalacia is the result of this disturbance after the growth plates have fused in adults. A lack of vitamin D or calcium is the most common cause of rickets. The signs and symptoms of rickets can include: pain in the bones affected, skeletal deformities, dental problems, poor growth and development and fragile bones.

3. Osteomyelitis:- Bone infection is called osteomyelitis. It is an acute or chronic inflammatory process involving the bone and its structures secondary to infection with pyogenic organisms, including bacteria, fungi, and mycobacteria. Symptoms may include pain in a specific bone with overlying redness, fever, and weakness and inability to walk especially in children with acute bacterial osteomyelitis.

4. Paget disease:- Paget disease is a skeletal growth disorder in which abnormalities such as unusual bone growth can occur in several multifactoral ways. This is often manifested by diffuse pain throughout the musculoskeletal system.

The condition presents with excess osteoclastic activity followed by a compensatory increase in osteoblastic activity, leading to the formation of disorganized bone, which is less compact, mechanically weaker, highly vascular and more susceptible to fracture. It is the 2nd most common bone disorder in elderly individuals, after osteoporosis. The condition can affect one or multiple bones but the axial skeleton is most often involved (spine, pelvis, and skull).

Genetic abnormalities can produce weak, thin bones, or bones that are too dense. The disease osteogenesis imperfecta is caused by abnormalities in the collagen molecule that make the matrix weak and can lead to multiple fractures. In another congenital disorder, osteopetrosis, the bones are too dense because of failure of osteoclast formation or function. This failure of the remodeling process results in persistence of trabecular bone in the marrow space so that the marrow cavity may not be large enough to form red and white blood cells normally. These dense bones cannot remodel well in response to mechanical forces or micro damage and hence may be weaker and subject to fracture even though bone mass is increased.

Many hormonal disorders can also affect the skeleton. Hyperparathyroidism can cause excessive bone breakdown and increase the risk of fractures. In severe cases, large holes or cystic lesions appear in the bone, which makes them particularly fragile. A deficiency of the growth hormone can inhibit growth, leading to short stature. Loss of gonadal function or

hypogonadism in children and young adults can cause severe osteoporosis due to loss of the effects of testosterone and estrogen. In addition, too much cortisol production by the adrenal gland can occur in Cushing's syndrome.

Use of glucocorticoids as medication is a common cause of bone disease. Excess glucocorticoids will stop bone growth in children and cause marked thinning of the bone in adults, often leading to fracture.

5. Bone tumor:- A bone tumor is an abnormal growth of tissue in bone**.** Bone tumors are traditionally classified as noncancerous (benign) or cancerous (malignant).

Their classification was revised by the World Health Organization in 2020.[31] This newer classification categorises bone tumors into cartilage tumors, osteogenic tumors, fibrogenic tumors, vascular tumors of bone, osteoclastic giant cell-rich tumors, notochordal tumors, other mesenchymal tumors of bone, and hematopoietic neoplasms of bone.

Bone tumors may be classified as "Primary tumors", which originate in bone or from bone-derived cells and tissues, and "Secondary tumors" which originate in other sites and spread to the skeleton. Carcinomas of the prostate, breasts, lungs, thyroid, and kidneys are the carcinomas that most commonly metastasize to bone. Secondary malignant bone tumors are estimated to be 50 to 100 times as common as primary bone cancers.

6. Fractures:-In normal bone, fractures occur when there is significant force applied or repetitive trauma over a long time. Fractures can also occur when a bone is weakened, such as with osteoporosis, or when there is a structural problem, such as when the bone remodels excessively (such as Paget's disease) or is the site of the growth of cancer. Common fractures include wrist fractures and hip fractures, associated with osteoporosis, vertebral fractures associated with high-energy trauma and cancer, and fractures of long-bones.

DISCUSSION

Sharir is made up *of Dosha, Dhatu* and *Mala*. Among these three, *Dhatu* beholds strength and energy and gives sustenance to *Sharir (Dharanatdhaatavaha). Asthi* is the deep seated *Dhatu* proved to be the supporting pillar of the body. Physically, *Asthidhatu* is formed in an unstable form when *medodhatu* flows into the *Purishdharakala* and is digested by *Asthi-agni*. *Dhatvagni* and *Bhutagni* both bring heaviness and hardness to ground substance which constitutes the bone.

Asthyashrayavyadhis are those diseases which take shelter in the skeletal system, alter the natural structure and functioning of the bones leading to several disorders.

Due to *Nidanas* like *Ativyayama, Atisankshobha, Asthi Vighattana* and due to *Vatakara Ahara* and *Viharas, Asthivaha Srotodushti* takes place which is characterized by either *Vriddhi* or *Kshaya* of *Asthi Dhatu*. *Prakupita Doshas* get collected in the *Asthivaha Srotas* by means of *Srotodushti Prakaras* such as *Sanga, Atipravritti* or *Vimargamana*.

Dhatu kshaya and *Margavrodha* are the pathologies responsible for *Asthi Vikruti*. *Dhatu kshaya* is common in old age (*Vata* phase of the life) giving rise to degenerative arthritis.

The main cause of *Asthivikruti* is *Vata Prakopa.* According to the concept of *Ashraya Ashrayi Bhava, Asthi* is the seat of *Vata dosha*. There is an inversely proportional relationship between *Asthi* and *Vata*. If there is an increase in *Vata*, there is decrease of *Asthi*. In *Asthi kshaya*, there is decrease in *Asthi dhatu* content. Similar to *Asthi kshaya*, a disease condition called Osteoporosis, has been described in contemporary system of medicine. Decrease in the bone tissues causes brittle bones and increases the risk of fractures. *Upadhatu* of *Asthi* i.e. *Nakha, Danta* and *Mala Kasha* and *Loma* also become brittle in *Asthi Kshaya.*

Rickets and osteomalacia can also be taken in relation to *Asthikshaya*. In our classical text, *Asthi-kshaya* is not mentioned as a separate disease but is mentioned under *Dhatu Kshaya* .

Nutritional deficiencies (Vitamin D, C, and Phosphorus) can result in the formation of weak, poorly mineralized bone.

Tooth, nails, skin and bone have genetic connectivity they have paternal lineage. i.e. They come from the genes of the father.(*Pitruja Bhavas*)Thus bones are connected to the hard tissues like hairs, body hairs, nails and tooth genetically. Therefore pathology in one element will lead to the deformity and pathology in the other. *Vivarnata* and *Sadana* of *Kesha, Loama, Nakha, Smashru* is observed due to vitiation of *Pitta* and *Vata Dosha*. It is mostly due to local infection.

Many things interfere with the development of a strong and healthy skeleton. Genetic abnormalities can produce weak, thin bones, or bones that are too dense. Many hormonal disorders can also affect the skeleton. Lack of exercise, immobilization, and smoking can also have negative effects on bone mass and strength.

Inflammation can lead to bone loss, probably through the production of local resorbing factors by the inflammatory white cells. This process can occur around the affected joints in patients with arthritis.

Bone tumor can be produced due to abnormal growth of tissue in bone.

Asthi Vriddhi can be observed in various hormonal, genetic and tumorous pathologies.

Bone pathologies can be simple or complex. *Vata* vitiation leads to weak or fragile bones that become osteoporotic and fracture easily. *Pitta* vitiation leads to bone infections (osteomyelitis) and inflammation. *Kapha* vitiation leads to excessively thick, dense bones. Other diseases of the bones are more complicated. Fractures can be considered as *Aagantuja* pathology. Tumorous growth of bone can be considered under *Sannipatik Dosha Prakopa.*

CONCLUSION

Asthi is the most important *Dhatu* providing structural framework to the *Sharir*. It is made up of *Prithavi Mahabhuta*. *Vata Dosha* is *Ashrayi* in *Asthi Dhatu*. Most of the pathologies related to *Asthi Dhatu* are due to *Vata* vitiation. Genetic, hormonal, infectious, degenerative, tumourous and traumatic factors play an important role in the pathogenesis related to bones. So it is necessary to consider all these factors while treating the bone disorders.

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