



REVIEW ARTICLE

Review on the role of indigenous plants and plant derivatives of Ayurveda in bone healing

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Abstract

Ayurveda is an ancient medical science, that fundamentally manages the various disease by using plants and their derivatives. Bone healing is a complex process that needs restoration anatomically and physiologically. Ayurveda holds a rich knowledge of plant and their derivatives which possess certain bioactive compounds which act differently. Due to severe side effects by using synthetically derived compounds which have adverse effects like gastrointestinal bleeding, delayed blood clotting, and treatment lengthening, the use of synthetic compounds and minerals with NSAID on fractured bones also leads to low compliance among patients, alternate medicine is much needed. Earlier due to a lack of scientific studies and standardization of compounds, acceptance was not as per mark for the traditional system of medicine. However, with the rise in traditional practices their usage is also rising along with their reporting of their clinical efficacy creating a new hope to the world however due to lack of scientific support, they are not widely accepted. The article aims to review the available data to support the evaluation of plants described in Ayurveda. Textual literature, online resources, and electronic media are used to collect data. The review concluded that yet more research work has to be carried out with a modern approach to validate with more clarity.

Keywords

Asthisandhan; bone healers; herbal healers; *Bhagna*

Introduction

All ages of people can sustain fractures. However, the type of fracture depends upon the underlined cause which also varies with the type of body and part of the body in which it occurs (1). Fractures are a significant burden on individuals, families, societies, and healthcare systems because they can result in lost productivity, incapacity, diminished quality of life, health decline, and high healthcare expenditures. The prevalence of various fractures in each population is interesting from a sociological perspective. As per recent reports globally, there were 178 million new fractures in 2019, 455 million cases of prevalent acute or chronic fracture symptoms, and 25.8 million (17.8-35.8) YLDs since 1990 (2). Inflammatory, repair, and remodeling stages are the three main phases of bone healing, which is the process by which the shattered bone is reformed (3). Due to severe side effects like swelling, reduced blood flow, color changes in skin and nails, discomfort, pain, nephrotoxicity, gastrointestinal bleeding, delayed blood clotting, and

treatment lengthening, the use of synthetic compounds and minerals with NSAID on fractured bones is leading to low compliance among patients (4). In Ayurveda, most used medications are either plant-derived or metal or animal-derived (5). Plant-originated medicines are termed as *Kashtha Aushadha* (6). These medicines have with least side effects and are economical. In the Current era interest in traditional systems of medicine is rising. Biodynamic compounds of medicinal and therapeutic value are being obtained from plants (7). Ayurveda is a traditional system in India that possesses a holistic approach to managing any entity. Fractures and joint dislocation have the same approach, initially, the concept of *Bhagna Sandhana* (fracture) was mentioned by *Acharya Sushruta* (500BC) (8). In *Susruta Samhita* 12 types of *Kanda Bhagna* (fractures) and 6 types of *Sandhi Moksha* (joint dislocation) have been mentioned (9). The word "*Kanda*" refers to the long shaft of a bone, and any damage to the bone falls under the category of "*Kanda Bhagna*." Dislocation of the joints or articulating surfaces is known as *Sandhi Bhagna* (10). Each entity is mentioned in *Samhita* with its signs and symptoms, prognosis, and treatment, indicating the developed phase of bone healing a thousand years ago (11). [Table 1] Treatment includes the use of oral medicines, *Lepas* (poultice), *Bandha* (bandage), *Taila Dhara* (oil pouring), *Dhroni* (basin), and Slings to support affected areas [Table 2]. As per Ayurveda bone is the constituent structure of the body which is considered as the root of *Vata Dosha*, any deformity in bone or joints majorly affects *Vata Dosha* (12). Most medicines used in managing fractures involve *Vata pacifying* medication along with *Sandhanakar Dravya* (Binding medication)

application. Apart from *Dosha* pacification, the re-establishment of dislocated joints and fractured bones was also achieved through plant derivatives, and application as poultices and splints, anesthesia may or may not be used during the process. *Acharya Sushruta* mentioned the following principles to manage fracture or joint dislocation as follows (13)

1. *Anchana* (Traction)
2. *Peedana* (Compression)
3. *Sanskhepa* (Reduction)
4. *Bandhana* (Bandage)

Understanding the principles of fractures and their management in Ayurveda and their importance in the modern era current review is being taken into consideration to assess the role of plants and their derivatives in bone healing mentioned in Ayurveda.

Materials and Methods

To review the efficacy of plants and their derivatives mentioned in Ayurveda in the form of drugs in concern of bone or fracture healing. Collection of data was done manually through Textbooks, search engines of Scopus, PubMed, and Ayush Portal, and other internet sources using the term "*Bhagna*" "Natural Bone healer" and "*Asthi Sandhana*." Resources containing knowledge and information about natural bone healers were collected and analyzed. Only plants described in Ayurveda were selected for the current paper for consideration.

Table 1. Types of *Kanda Bhagna* and *Sandhimoksha* (14)

S.N.	Bheda (Type)	Lakshana (Sign /Symptoms)
<i>Kanda Bhagna</i>		
1	<i>Karkata</i>	Bone is elevated from both sides with a fracture in the middle, and formed hematoma
2	<i>Ashwakarna</i>	Elevated portion of bone-like horse's ear i.e., sharply expelled edge or broken bone
3	<i>Churnita</i>	Crepitation on the rubbing of a fractured surface of bone
4	<i>Picchita</i>	Crushed bone with severe pain
5	<i>Asthichhalita</i>	The integrity of broken bones is displaced downward while another end gets elevated
6	<i>Kandabhagna</i>	Mobile broken bone on moving with efforts
7	<i>Majjanugata</i>	Impact of one broken bone on the bone marrow of another bone
8	<i>Atipatita</i>	Complete breaking of a bone and moving downward from its anatomical position like a TMJ Fracture
9	<i>Vakra</i>	Bone is bent but does not get fractured like pathological fractures
10	<i>Chhinna</i>	Bone fractured from one end and normal on the other end
11	<i>Patita</i>	Bone is fissured or cracked with pain
12	<i>Sphutita</i>	Feeling like filled with grains with crushed characteristics and pain
<i>Sandhi Moksha</i> (Joint - dislocation)		
1	<i>Utpishita</i>	Oedema and pain on both sides of bone's articulation region, pain rises at night time
2	<i>Vishlishata</i>	Lesser oedema, continuous pain, and appearance and functionality of the joint become abnormal
3	<i>Vivartita</i>	Due to displacement of the joint, the affected area becomes painful and abnormal in appearance
4	<i>Avakshipta</i>	Downward displacement of bones in joints along with severe pain
5	<i>Atikshipta</i>	Complete displacement of joint with pain
6	<i>Tiryakshipta</i>	The end is obliquely placed with severe pain

Table 2. Plants Used for in making Poultices and Splints

S.No,	Mode of preparation	Vernacular Name of the plant	Scientific name	Family	Reference
1	Lepa	Manjistha	<i>Rubia cordifolia</i>	Rubiaceae	Su. Chi. 3/7 (15)
2	Lepa	Yasthimadhu	<i>Glycyrrhiza glabra</i>	Leguminosae	
3	Lepa	Rakta Chandana	<i>Pterocarpus santalinus</i>	Fabaceae	
4	Kusha	Madhuka (Fig.1.)	<i>Neolmarckia cadamba</i>	Rubiaceae	Su. Chi. 3/6 (16)
5	Kusha	Udumbar	<i>Ficus recemosa</i>	Moraceae	
6	Kusha	Ashwatha	<i>Ficus religiosa</i> L.	Moraceae	
7	Kusha	Palasha (Fig.2.)	<i>Butea monosperma</i>	Fabaceae	
8	Kusha	Arjuna	<i>Terminalia arjuna</i>	Combretaceae	
9	Kusha	Vansha	<i>Bambusa arundicea</i>	Poaceae	
10	Kusha	Sarja	<i>Vateria indica</i>	Dipterocarpaceae	
11	Kusha	Vata (Fig. 3)	<i>Ficus banghalensis</i>	Moraceae	

**Fig.1.** Madhuka (*Neolmarckia cadamba*)**Fig.3.** Vata (*Ficus banghalensis*)**Fig.2.** Palasha (*Butea monosperma*)

Results and Discussion

Ayurvedic Plants for Bone Healing

It is being observed that in developing countries nearly 80% of individuals depend on traditional medicine either plant-derived or animal-derived for their initial health care (17). Traditional medicine mainly herbal medicine is in rising popularity and demand which is due to their efficacy, least side effects, and availability economically

(18). As per recent reports, the Ayurveda-based medicine market is rising nearly 20 % annually (19). Ayurveda holds a rich collection of plants which are natural bone healers. Among these multiple studies are carried out on their application and reported a significant efficacy of these in promoting bone health. Various plants or their derivatives are mentioned as *Bhagna Sandhakar* (fracture healers) or *Asthi Sandhakar* (bone healers) in Ayurveda literature but the following are reasons that these drugs do not get exposure for proper validation

- Availability of drugs
- Proper identification of drug
- Lack of applicability of drug
- Awareness about the efficacy of Natural healers

Apart from challenges the use of medicinal plants is popular among the rural and tribal population. The potential efficacy of traditional medicines has piqued the curiosity of scientists and medical professionals to resort to traditional medicines for the treatment of several chronic and difficult conditions, including the therapy for osteoporosis, as a result of some side effects or lack of efficacy of synthetic pharmaceuticals (20). In Ayurveda plants or their derivatives which are mentioned in the context of bone healing properties some of them are summed up in [Table 3]

Table 3. Plants used as *Bhagna Sandhakar* or *Asthi Sandhakar*

Sl. No	Vernacular Name of the plant	Scientific name	Family	Reported Properties	Reference
1	<i>Guggulu</i>	<i>Commiphora weightii</i>	Burseraceae	- Potent fracture healing and anti-analgesic property	(21)
2	<i>Asthisrinkhla</i>	<i>Cissus quadrangularis</i>	Vitaceae	- accelerates the physiological process of proliferative proliferation of the bone, which aids in bone fracture healing. It speeds up bone repair and enhances the flow of nutrients and blood to the bone.	(22)
3	<i>Godhuma</i>	<i>Triticum aestivum</i>	Poaceae	- High level of oxalic acid	(23)
4	<i>Vansha</i>	<i>Bambusa arundinacea</i>	Poaceae	- Used orally or locally in the form of poultice or paste as contains benzoic acid, calcium, phosphorus, zinc, cyanogenic glycosides, and some silicon substances which promote healing of fracture	(24)
5	<i>Lodhra</i>	<i>Symplococos recemosa</i>	Symplocaceae	- Chief active compounds like loturine, loturidine, coloturine, and harmine along with flavanol glucosides, betulin, linoleic acid, β -sitosterol, and α -myrin	(25)
6	<i>Saariva</i>	<i>Cryptolepis buchanani</i>	Apocynaceae	- possess analgesic, anti-inflammatory, and chondroprotective properties	(26)
7	<i>Rason</i>	<i>Allium sativum</i>	Amaryllidaceae	- possess Anti-diabetic Activity, hepatoprotective and oxidative properties	(27)
8	<i>Tandul</i>	<i>Oryza sativa</i>	Poaceae	- encourage osteoblast differentiation and stop bone degradation	(28)
9	<i>Nyogrodh</i>	<i>Ficus benghalensis</i>	Moraceae	For treating a bone fracture, a paste composed of delicate root tips and ginger is applied.	(29)
10	<i>Priyangu</i>	<i>Callicarpa macrophylla</i>	Verbenaceae	- the widely used north-east region of India where the Tribal people of Mizoram apply a paste of leaves to promote the healing of bone fracture	(30)
11	<i>Arjuna</i>	<i>Terminalia arjuna</i>	Combretaceae	- Bark is rich in tannins, calcium carbonate, arjunic acid, and sodium chloride. - Haemostatic and blood purifying make its oral application and as splint-like support to promote bone healing.	(31)
12	<i>Pipli (Fig.4)</i>	<i>Piper longum</i>	Piperaceae	- The fruit part of the plant is used in relieving pain in sciatica and bone fractures	(26)
13	<i>Haridra (Fig.5)</i>	<i>Curcuma longa</i>	Zingiberaceae	- Powder of root is used locally along with Ghee (clarified butter) to reduce inflammation and early healing of bone fractures. - promote the bone haemostatic and enhance the healing process.	(32)
14	<i>Guduchi</i>	<i>Tinospora cordifolia</i>	Menispermaceae	widely used in the treatment of bone fracture and joint dislocation, in the form of bandages from the paste made from the stem part of the plant	(33)
15	<i>Patha</i>	<i>Cissamplelos pareira</i>	Menispermaceae	- Have anti-inflammatory, analgesic, anti-pyretic, anti-arthritic, anti-diarrhoeal, anti-malarial, anti-diabetic, and anti-venom activities	(34)
16	<i>Ashwatha (Fig.6)</i>	<i>Ficus religiosa</i>	Moraceae	- For 21 days, two spoonfuls of stem bark paste are consumed each day. Additionally, the paste is put on the afflicted area and wrapped to promote bone healing	(35)
17	<i>Nagkeshar (Fig.7.)</i>	<i>Mesua ferrea</i>	Clusiaceae	- Extracts are used in treating bone fracture and nervous disorders	(36)
18	<i>Bhanga</i>	<i>Cannabis sativa</i>	Cannabaceae	- contains cannabinoid cannabidiol (CBD) and marijuana tetrahydrocannabinol which are found helpful in speeding the healing property	(37)
19	<i>Devdaru</i>	<i>Cedrus deodara</i>	Pinaceae	- widely used in chronic inflammatory arthritis, some preparation of it is used in bone fractures.	(38)
20	<i>Shweta Chandan</i>	<i>Osiris wightiana</i>	Santalaceae	- paste of the root is used as plaster	(39)
21	<i>Baboola</i>	<i>Acacia arabica</i>	Mimosaceae	- widely used in treating inflammatory arthritis, bone fractures, and muscular spasms. - Higher osteogenic activity and lower osteoclastic activity of its extract could promote fracture healing.	(40)
22	<i>Ankola</i>	<i>Alangium salvifolium</i>	Alangiaceae	- Rook bark methanolic extract reported analgesic and anti-inflammatory properties in Wistar albino rates	(41)



Fig 4. Pippli (*Piper longum*)



Fig. 5. Haridra (*Curcuma longa*)



Fig.6. Ashwatha (*Ficus religiosa*)



Fig.7. Nagkeshar (*Mesua ferrea*)

The above table depicts the usage of plants and their derivatives in traditional systems of medicine in various forms. Major leads from ancient knowledge can guide modern science with target target-based unidirectional approach as the human and nature bonding at the developed phase in ancient times, understanding of plants and their application was also at greater aspect. This indicates the biocompatibility of compounds used due to their lesser toxicity and adverse effects. Complex mixtures of compounds that work with holistic and synergistic effects provide significant therapeutic value in bone healing as they hold vitamins, minerals, bioactive compounds, and antioxidants. Plants and their compounds have defined pharmacological action in bone healing which can provide the natural base of scaffolds for bone cells, and extracellular matrix to promote proliferation and aid values to tissue regeneration.

Evidence-based Studies

To validate the concepts and medicaments mentioned in Ayurveda need to undergo scientific studies yet there is a lack of such evidence. Apart from these some of the Plant or their derivatives were used in some trials or clinical study are mentioned in Table 4

Safety and Toxicity Considerations

Even though Ayurveda uses plant-based treatments to treat various diseases, safety, and toxicity was always a prime concern. The availability of limited clinical studies especially bone healing does not much contribute to safety aspects. However, the safety and efficacy of plant-based treatment depend upon the Ayurveda practitioner, the drug's quality, dose, mode of application, duration, and interaction with other drugs. Monitoring of effects and adverse effects and further research are needed to validate the concepts and their efficacy. Bottom of Form

Challenges and Future Perspectives

Even though Ayurveda promotes a holistic approach to health and healing, including the use of plant-based treatments for bone health, it is important to keep in mind that Ayurvedic practices and treatments are primarily based on traditional knowledge and have not been thoroughly researched using contemporary scientific research methods, particularly when it comes to bone healing. As a result, there may be few explicit direct references in science that relate Ayurvedic practices to bone repair.

Table 4. Evidence-Based Studies

Sl no	Vernacular name of the plant	Scientific name of the plant	Family	Mode of application	Animal system/ invitro system studied	Outcome of the study	References
				Compared Tualang honey (0.2g/kg) and calcium supplementation	Rats	After administration for 6 weeks, honey showed better bone structural parameters which was marked by an increase in bone volume (BV/television), trabecular consistency, and trabecular number (Tb. N) while dwindling intertrabecular space	(42)
1	Madhu (Honey)	-	-	-	Rats	bone healing effect was observed in mandibular bone disfigurement and accelerated and enhanced bone healing property	(42)
				Created disfigurement at mandible angle filled with sterile honey in the experimental group (mineralization stage) compared with a control group (vascularization phase)	Rats	Four histomorphometry assessments revealed that new bone conformation in the experimental group was significantly better than the control group after two and four weeks. As per the study conclusion, honey could increase the speed of healing in rates' mandibular joints.	(43)
2	Ashwatha	<i>Ficus religiosa</i>	Moraceae	Paste, formulate by mixing with the urine of a 7-year-old boy	Human subjects administered twice a day for 21 days	- shows accelerated bone healing	(44)
3	Asthishrinkhla	<i>Cissusqua drangularis</i>	Vitaceae	Oral intake of Powder internally for 6 weeks along with local application for 6 weeks	Human subjects with 10 clinically diagnosed cases of Colles's fracture	- Analgesic efficacy of 84.62 % (p<0.001). - Swelling reduced by 64.29% (p<0.001) - tenderness – 60% (p<0.001)	(45)
				Methanolic extract	Dogs	promote the healing process of experimentally fractured radius-ulna - dropped bone mending scores, reduced imperfect area of the parietal bone, and increased the areas of bone trabeculae and cavities medullaris	(46)
4	Godhum	<i>Triticum aestivum</i>	Poaceae	SAPH	rabbit parietal bone disfigurement and mouse osteoblast cell line MC3T3- E1	- SAPH enhances bone mending and promotes the proliferation, isolation, and development of osteoblast by over-regulating BMP- 2 expression in osteoblastic cells	(47)
5	Krishna Saariva	<i>Cryptolepis buchanani</i>	Asclepiadaceae	Paste prepared with mustard oil and banana leaves Along with oral use, 200ml milk is used in place of mustard oil for the same combination and is given thrice a day for 5 days	tribal people in the South Asia region especially in Arunachal Pradesh	possesses antibacterial, analgesic, anti-inflammatory, and chondroprotective properties	(48)
6	Guggulu	<i>Commiphora weightii</i>	Burseraceae	Lakshadi Guggul 10 gm BD along with conservative treatment including Basti Karma	Case Study on Human Subjects in Fracture of femur shaft	Effective in managing fracture	(48)

Challenges

1. **Lack of Modern Clinical Trials:** Although Ayurveda has a long history of use, there are not any large-scale, randomized, controlled clinical trials that precisely assess the effectiveness and safety of Ayurvedic treatments for bone repair in the context of contemporary evidence-based medicine.
2. **Standardization and Quality Control:** Complex mixtures of herbs, minerals, and other components frequently go into ayurvedic medicines. It can be difficult to maintain these formulations' consistency in quality, purity, and standardization for research purposes.
3. **Recognizing Mechanisms:** Although Ayurvedic writings discuss the effects of herbs and treatments on bone health, the precise molecular mechanisms underlying these benefits are not well-documented by contemporary scientific standards.
4. **Integration with current Medicine:** To ensure compatibility, safety, and the best results, integrating Ayurvedic practices into current medical protocols calls for considerable thought and research.
5. **Lack of Modern Clinical Trials:** Although Ayurveda has a long history of use, there are not enough large-scale, randomized, controlled clinical trials that precisely assess the effectiveness and safety of Ayurvedic treatments for bone repair in the context of contemporary evidence-based medicine.
6. **Standardization and Quality Control:** Complex mixtures of herbs, minerals, and other components frequently go into ayurvedic medicines. It can be difficult to maintain these formulations' consistency in quality, purity, and standardization for research purposes.
7. **Understanding Mechanisms:** Although Ayurvedic writings discuss how individual medicines and treatments affect bone health, the precise biochemical mechanisms underlying these benefits are not well-documented by contemporary scientific standards.
8. **Integration with Modern Medicine:** To ensure compatibility, safety, and the best results, it is important to carefully consider and research the integration of Ayurvedic practices into modern medical protocols.

Potential Perspectives

1. **Holistic Approach:** When paired with contemporary medical treatment, the holistic approach of Ayurveda, which considers a person's constitution, lifestyle, and general health, may help improve bone healing outcomes.
2. **Beneficial Role:** Ayurvedic therapies may be beneficial in controlling conditions including inflammation, stress, and general well-being, all of which can indirectly impair bone healing.

3. **Combination Therapies:** Combining Ayurvedic concepts, such as particular herbal formulations or nutritional advice, with contemporary therapies may have supplementary advantages.
4. **Inspiration from herbal medicine:** Certain chemicals in Ayurvedic herbs may be used to produce novel pharmaceuticals that target the processes by which bones repair.
5. **Personalized Medicine:** Because Ayurveda emphasizes individualized care, personalized strategies for bone health that consider factors other than the bone injury itself may be developed.

It is important to recognize that Ayurveda is still being practiced and studied for its potential benefits to overall well-being, even though there may not be precise references in contemporary scientific literature connecting Ayurvedic practices to bone repair. Ayurvedic and other traditional systems' traditional wisdom is being progressively investigated by researchers to find new areas of study. It is important to acknowledge the historical importance of Ayurveda, its holistic approach, and the necessity for rigorous scientific study to confirm its effectiveness in certain medical circumstances while talking about it.

Conclusion

Ayurveda houses the biggest resource of nature and plants but due to a lack of validation and an evidence-based approach, the concept is still lacking for application. Even though thousands of years have passed the concept of fracture and dislocation remains the same, which states the potential of ancient science which is mostly based on natural resources using animal and plant products or derivatives to treat mankind. Yet a lot of research work has to be done as available data is not enough to rationalize the knowledge. As mentioned in *Charaka Samhita* the best knowledge of plants and their application is owned by villagers, tribal people, and those who go to feed their cattle in the forest. There is a need to compile that knowledge and to conduct the studies with a modern approach and scientific tools.

Authors' contributions

Poona Nath Chouhan has carried out thorough literature mining of Ayurveda Texts to find references related to bone healing and drafted the manuscript. Abdulahat Azimov guided to path to draft the manuscript and provided clinical evidence to selected plants. Dilduza Jabborova provided design-related guidance and a scientific basis for the manuscript. Sachidanand Singh coordinated the study, and reviewed, and supervised the manuscript. All the authors have gone through the manuscript and approved the finalized manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

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