EXPLORING THE POTENTIAL OF AYURVEDIC BHASMAS - THE NANOMEDICINE

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***Abstract*- Ayurvedic medicine is a holistic system of healing practiced in India for thousands of years. It relies on using natural substances such as herbs and minerals to promote health and well-being. Metallic remedies known as ayurvedic Bhasmas are used in Indian traditional medicine to cure a wide range of illnesses. The heavy, toxic, and unabsorbable substances are metals and minerals. The metals are most absorbable and therapeutically beneficial when transformed into fine compounds. It is in the form of a powder made from a substance obtained by calcination (Bhasmikarana). Bhasma does not metabolize; hence they do not cause any hazardous metabolite instead, it breaks heavy metals in the body. They are 25 to 50 nm in size. The materials large surface area and small particle size, which enable them to be effectively carried into the cell nucleus and to specific target sites as necessary, may be the cause of Bhasmas therapeutic effects. According to the Puta technique of Ayurveda, metals or minerals should be heated to high temperatures to cause melting before being quenched for a certain amount of time in a suitable medium, such as herbal juices or decoction. These procedures are repeatedly repeated to produce the Bhasma (incinerated metals). Through this process, the metals negative effects are neutralized and transformed into nanoparticles that are physiologically active. Bhasma is currently thought of as Ayurvedic nanomedicine and offers a chance for medication discovery using the contemporary idea of nanomedicine.**

***Key words*: Therapeutically, Bhasmas, Bhasmikarana, Calcination, Puta system.**

INTRODUCTION:

Nanomaterials and structures have extremely unique features owing to their tiny size compared to larger bulk materials, making them attractive candidates for innovative applications. Nanotechnology [1] has gotten much interest in medicine because of how easily nanostructures interact with the body at the molecular level. Veda (knowledge) and Ayush (life) are combined in the science of ayurveda to produce living knowledge. A recognized ancient Indian science is ayurveda [2]. Medicinal herbs were mostly used to make therapeutic remedies during Charaka and Sushuruta. The Indian alchemist Nagarjuna invented the use of metals and minerals as medicines in the eighth century AD. These included Swarna (gold), Rajat (silver), Tamra (copper), Abhrak (mica), Makshika (pyrites), and Rasa (mercury). Ayurvedic chemistry Rasa-Shastra branch uses Bhasmas, or herbal, mineral, metal, and nonmetal treatments.

A well-designed metals/nonmetals preparation has the properties of rasayana (immunomodulation and anti-aging property) and yogavahi (ability to target medications to the spot), in addition to being nontoxic, gently absorbable, adaptable, and digested in the body.

According to the Ayurvedic puta system, which has been used on the Indian subcontinent since the 7th century A.D., Bhasma [3] is an ayurvedic metal/mineral preparation that is treated with herbal juices or decoctions and heated to a specific degree. Bhasma are nanoparticles produced naturally that are utilized in combination with other Ayurvedic treatments. The most serious problem with heavy or poisonous metals, according to Bhasmas, is whether or not the body excretes them adequately. Metals in compound form, known as the Bhasma, which is thought to be human-safe, must be treated separately from heavy or harmful metals in elemental form, also known as toxic metals [4].

Bhasmas are made from metals like zinc, lead, gold, silver, tin, copper, metal alloys, jewels, coral, mica, and other minerals. They are created in a precise, specified procedure by calcining the parent material (metal or mineral), either alone or in combination with additional substances such as minerals, etc., after being carefully cleaned and emasculated with herbal juices or minerals. The Bhasmas must be taken orally in modest amounts since they are extremely finely powdered, often as a single tablet in a suitable vehicle. They can cure a variety of chronic illnesses and are quite successful. Compared to Bhasmas created with white arsenic or mercury, Bhasmas made purely from herbal liquids are thought to be milder in nature.

The ability of properly prepared Bhasmas particles to float in the water due to surface tension is a traditional test. The metals are thoroughly crushed and reduced to the fewest possible pieces before the operation. The size dispersion of the Bhasma [5] particles is initially wide. However, additional calcinations lead to ever-smaller particle sizes and a more constrained range. Eventually, particle sizes (from a few microns to a few nanometers) approach colloidal proportions. These results demonstrate that stable particle sizes are in the 10-15 nm region. Therefore, Bhasmas are nanoparticles.

PHYSICAL CHARACTERISTICS OF BHASMA:

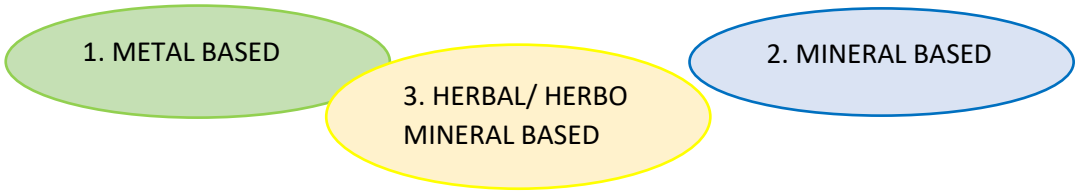
1**. Colour (Verna):** Each Bhasma is assigned a specific colour. Bhasmas are typically white, pastel, or reddish in colour. The parent material mainly determines the colour.

2. **Lusterless (Nishchandratvam):** Before being used therapeutically, Bhasma must be lusterless. In order to do this test, Bhasma is viewed in direct sunlight to see if lustre is present; if it is, further incineration is necessary.
3. **Lightness and Fineness (Varitara):** Bhasma floats on top of the water. The surface tension law provides the foundation for this test. A properly burnt Bhasma must float on the water surface.
4. **Tactile sensation:** The mucous membrane of the gastrointestinal system can be absorbed and metabolised by the body without producing pain.
5. **Particle size:** Bhasma should be made into a powder. Bhasma particles should resemble pollen grains from the (Pondanus odoratissimus) flower, also known as the ketaki rajah.

CHEMICAL CHARACTERISTICS OF BHASMA:

1. **Apunarbhavata:** The inability to change back into one`s metallic form. This test involves mixing equal parts of Bhasma, Abrus precatorius seeds, honey, ghee, and borax before sealing the mixture in clay pots and heating it to the same temperature. After then, a certain Bhasma is discovered during self-cooling.
2. **Niruttha:** The metallic Bhasmas incapacity to assume its metallic form will be put to the test by Niruttha. In this test, Bhasma is combined with a predetermined amount of silver leaf and kept in sealed clay pots. Next, a comparable amount of heat is applied, and after self-cooling, the amount of silver is retrieved. Increased silver leaf weight is suggestive of Bhasma that was not created properly [6].

CLASSIFICATION AND IMPORTANCE OF BHASMAS:



IMPORTANCE:

1. Keep optimal alkalinity for good health.
2. Purify your liver, kidney and intestine.
3. Maintain stronger bones and teeth.
4. Neutralize acid to achieve a healthy alkaline level.
5. Give calcium that is easily used and absorbed.
6. Relieve insomnia and depression.
7. Maintains a rhythmic heartbeat.
8. Aids in the metabolization of iron in the body.
9. Supports the nervous system.
10. Neutralizes toxic acids that cause sickness [7].

NANOPARTICLE BHASMA:

Transmission electron microscopy and atomic force microscopy revealed a globular gold particle measuring 56–57 nm to be the main constituent of Swarna Bhasma. Atomic absorption spectroscopy and infrared spectroscopy experiments have shown that Swarna Bhasma is devoid of any other organic compounds or heavy metals.

Mercury sulphide is also present in the sublimated mercury complex Ras-Sindoor [8]. This organic macromolecule was generated from a plant extract. Numerous macro/trace components that are bio-available and support Ras-Sindoor therapeutic effects may be present in variable amounts.

The particles are oxygen deficient and many of them are in the nanometer size range, according to the studies physicochemical characterization of Jasada Bhasma using "X-ray photoelectron spectroscopy (XPS), inductively coupled plasma (ICP), elemental analysis with energy dispersive X-ray analysis (EDAX), dynamic light scattering (DLS), and transmission electron microscopy (TEM). The observed size range of Jasada Bhasma [9] might be a factor in its therapeutic benefits. The table 1 gives a description of some of the Bhasma [10,11,12] that were found with nanoparticles.

Table.1: Nanoparticles in different bhasmas

Bhasmas	**Nanoparticle - size**
Rajata Bhasma	Silver sulphide - 1.04 µm
Shankh Bhasma	Calcium oxide - 600 nm
Swarna Bhasma	Gold - 9.9 µm and 5657 nm
Vanga Bhasma	Tin dioxide - 10100 nm
Praval Bhasma	Calcium oxide - 1015 µm
Tamra Bhasma	Different oxides of copper - 100 nm

PREPARATION OF BHASMA:

General method:

Bhasma is the word used to describe all metallic and non-metallic materials that are burned and converted to ash. In pits containing cow dung cakes, metals, minerals, and animal products are calcined in sealed crucibles (puttam). The ashes [13] produced by triturating and macerating in herbal extracts after calcined preparation of metals and minerals were known as Bhasma. The medications created using this technology were more efficient, took less medication to work, and had a quicker onset of action. They developed a longer shelf life and improved taste. As a result, using metals and minerals became an important component of Ayurveda medicine.

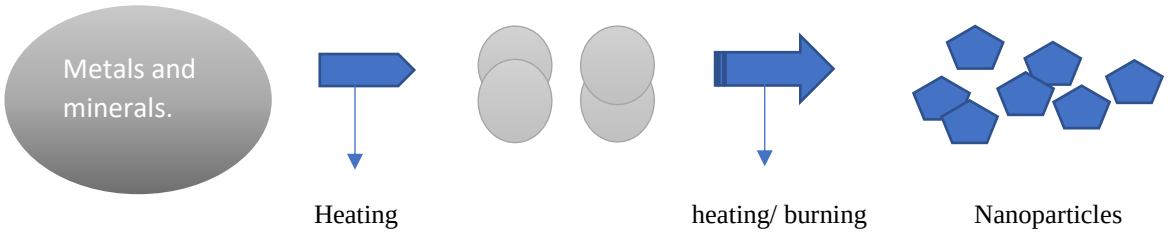


Fig.1: After multiple rounds of heating and burning, poisonous metals, minerals, and gems are transformed into non-toxic nanoparticles.

Methods used in preparation of Bhasmas:

Putapaka Method:

Metals or minerals are subjected to three-stage processes to make Bhasma [14] (Shodhana, Bhavana and Marana). From a levigated doughy mass, chakrikas (pellets) are made and put in two clay crucibles confronted with mud-covered garments to seal the joint. Next, using a traditional Puta (heating grade) or an electric muffle boiler, heat is given to this apparatus (Sarava Samputam) for a certain amount of time. Putapaka is the Ayurveda term for this operation. These materials are cooled in a Sarava Samputa after having been burned for a specific amount of time. The created Bhasma (incinerated metal) is collected after repeating these procedures for a certain period of time. Between the Shodhana and Bhavana processes, the intermediate method known as Jarana (polling) is used for metals with low melting points, such as lead, tin, and zinc. In order to fully powder the metals, they are first melted, combined with plant medicinal powders, then scraped with an iron ladle against the pots inside surface.

Kupipakwa Method:

Metals (such as gold, silver, copper, etc.) are placed through four phases in this procedure Shodhana, Kajjali preparation, Bhavana, and Kupipaka to create Bhasma. Metals are amalgamated using mercury, and the resulting mixture is then blended with pure sulphur to form a dull, black product. The action is referred to as "Kajjali preparation." Prepared Kajjali is maintained in a certain liquid media for a specific period of time. It is placed in a glass container (Kachkupi) and covered with seven layers of mud-smeared fabric once it has had enough time to completely dry. After that, the bottle is submerged in a sand bath (Valukayantra) for indirect and uniform heating. The bottle is broken, the sublimed product is removed from the neck as soon as it has self-cooled, and the Bhasma [15] is removed from the bottom and ground into powder.

Table.2: Some of the marketed Bhasmas products

Name	Ingredients	Uses
Swarna basant malti ras	Gold, piper-nigrum, white pear powder	Tonsillitis, fevers, cough, bronchitis, decreased immunity, cancers, autoimmune disorder
Loknath ras	Mercury, sulfur, conch shell	Diarrhea, respiratory disorders, immunity disorders, cancers, ovarian cysts
Navrattankalp amrit ras	Calcined ash of expensive gems, minerals like ruby, sapphire, emerald, cat's eye stone, pearl, coral, silver, gold, iron, zinc	Cancers of all types, anemia, complications of diabetes
Heerak Bhasma	Diamond	Useful in cancers, immunity disorders, crippling rheumatoid arthritis, bone marrow depression
Rajat Bhasma	Silver ash (Calcined silver)	Irritable bowel syndrome, acidity, pitta disorders
Shwaskuthar ras	Black sulfide of mercury, aconitum ferox, sodium bicarbonate, piper nigrum, Trikatu	Cough, pneumonia, bronchitis
Tsrailokya chintamani ras	Diamond, gold, silver, iron	Severe respiratory tract infections, bone marrow depression, ovarian cysts, uterine fibroids
Kaharva pishti	Amber of succinite (trinkantmani), rosa centifolia (rose)	Bleeding
Yogender rasa	Red sulfide of mercury, gold (calcined), magnetic iron, mica, myristica fragrans	Polio, paralysis, muscular weakness, insomnia, headache

Mukta pishti	Pearls powder (moti pishti)	Calcium, cooling and soothing, blood pressure, acne, headaches, acidity, ulcers, heat disorders

Some of the common metals used in preparation of Bhasmas:

1. Aayasa or loha (Iron) Bhasma: Ayasa or Loha has been used since ancient civilizations in various doses for both internal and external applications for several clinical complaints. Iron compounds were often advised for anemia and other associated illnesses when the hemopoietic system malfunctioned or the blood became iron deficient. Rasashastra [16] claims that loha is restorative, promotes life and vigour, kills a range of illnesses, and enhances the functional activity of almost all organs. Rasa Vagbhata thinks that the best kind of iron to use is the Kanta variety, which contains Munda (Cast Iron), Kanta (Wrought Iron), and Teekshna (Carbon Steel). Calcium oxide (0.3%), magnesium oxide (0.8%), ferric oxide (96.5%), ferrous oxide (2.5%), and trace quantities of potassium and phosphorus make up Lauha Bhasma.

2. Swarna (Gold) Bhasma: Indians have long employed Sara luha or Swarna for medicinal purposes. The usage of this Bhasma is mentioned in the Charaka Samhita. The Swarna Bhasma is composed of metallic gold (96.76%), ferric oxide (0.14%), silica (1.14%), phosphates (0.78%), salt (0.078%), potash (0.16%), and minor amounts of magnesium and copper. [17] The antipruritic drug gold elemental has been used for a long time to treat itchy hands. Treatment of chronic illnesses, including Yakshma (Tuberculosis), Kasa (Cough), Swasa (respiratory diseases), and Pandu, using Swarna formulations is useful (Anaemia). The dosing range for Swarna Bhasma is 15–30 mg.

3. Bhasma Rajata (Silver): Silver is a noble metal that ancient Acharyas employed for therapeutic purposes since the time of Charaka and his contemporaries. Rajata or Silver, as described, is a transparent, hefty, and lustrous metal with a metallic sheen that turns dazzling white when cut or heated. Rajata, which lacks furrows and ridges, can be used for therapeutic purposes. Rajata Bhasma is made up of pure silver metal (52%59%), ferric oxide (14.33%), free sulphur (0.675%), calcium (10.769%), and silver chloride (0.479%), with traces of other metals such as potassium, sodium, and aluminium.

4. Parada (Mercury) Bhasma: Mercury is found in only a few formulations listed in the Charaka Samhita. There is disagreement over the therapeutic value of Parada, with just a few academics interpreting the term Rasa in the passage Chikitsa Sthana 7/71 as Parada. The commentator Chakrapani interprets the phrase Rasa as Parada in Dwivraniya Chikitsa. The two formulas listed above are only suitable for external use.

5. Tamra (Copper) Bhasma: Copper, or Tamra [18] is an ancient metal known to human civilization since pre-Vedic times and used in daily existence. Brass and bronze were the primary metals employed in the alloy formation. Tamras desirable features for medical usage were metallic sheen, vivid crimson colour, hefty, supple with high tensile strength, and absence of contaminants.

6. Sisaka/naga Bhasma (Lead): Naga [19] is also a significant Puti Loha (easy fusing metals) that has been recognized since ancient times and is referred to in ancient manuscripts as Sisaka or Sisa. According to Charaka, this metal should be utilized externally for therapeutic purposes, particularly in Mandala Kushta (Dermatological Disorders). Externally black in colour and hefty, Naga is wanted for therapeutic reasons since it melts quickly and shines with a dazzling black sheen when incised. Naga Bhasma has a high concentration of lead oxide (75.6%) and ferric oxide (7.5%), as well as traces of magnesium and calcium chlorides and carbonates.

7. Vanga/Trapu (Tin) Bhasma: Ancient Indian doctors called Vanga, a kind of Putiloha (readily fusing metals), by the name Trapu.Bright white, smooth, soft, quickly melts, shining, and weighty are the preferred properties for therapeutic uses in Vanga. Vanga Bhasma [20] is a chemical compound composed of stannic oxide (91.4%), potassium (2.9%), ferric oxide (2.9%), calcium oxide (2%), aluminium (2%), and magnesium (0.6%) oxides.

8. Bhasma kamsya (bronze): A copper and tin alloy is called kamsya. Only Pushpa Kamsya, which makes a sharp sound, is smooth and gentle to the touch, is slightly grey in colour, becomes red when heated, and is uncontaminated, is suited for therapeutic use. Therapeutic dosages of 60–120 mg of Kamsya Bhasma benefit conditions like Kusta (Skin Disease) and Krimi (Worms).

9. Bhasma Pittala (Brass): Pittala, a zinc and copper alloy, is another important Misra Loha known from the Samhita Kala (era). Pittala Bhasma formulations are effective in disorders such as Krimi (Worms), Pandu (Anemia), and Kusta (Skin Disorder).

10. Abhrak Bhasma: Abhrak Bhasma is a strong cellular regenerator that blends biotite (mica) with the juices of numerous regenerative plants. It is a well-liked hepatoprotective Ayurvedic remedy for a number of illnesses, including hepatitis. [21] Additionally, it is a nervine tonic frequently used to treat anaemia and respiratory infections. Iron, magnesium, potassium, calcium, and aluminium levels in trace amounts are present. Abhrak Bhasma is a dry powder. Iron, magnesium, and aluminium silicates are also present. [22]

11. Yashada Bhasma: Yashada Zinc is used to process Bhasma. Sprue, diabetes, leucorrhea, and hyperhidrosis may all be

treated with it. In one investigation, Bhasmas function in preventing myopia was examined. [23] The plants used to prepare Bhasmas are likely to be polluted, which will cause the growth of polycyclic aromatic hydrocarbons (PAHs). Bhasmas were among the preparations inspected and were confirmed to contain PAH (2.32-9.55 ppm). Benzo[a] pyrene was also present, with 9.7 ppm being the highest concentration. [24,25]

12. Sankha Bhasma: Sankha Bhasma is a powder that is created from the calcined shell of a conch. Magnesium, iron, and calcium make up the bulk of the elements. The antacid and digestive benefits of Sankha Bhasma are widely recognized. Hepatosplenomegaly, colic, sprue, and hyperchlorhydria may all be treated with it. [26] Ayurvedic treatments using Sankha Bhasma and the herbs Glycyrrhiza glabra, Terminalia chebula, and Piper longum protected rats against duodenal ulcers.

STANDARDIZATION:

Standardization of Bhasma is critical for confirming its identification and determining its quality and purity. It will also ensure the products safety, efficacy, and acceptance. Standardization is a quality assurance measure used to characterize all steps done throughout the production process and quality control that result in reproducible quality. It plays a significant part in herbal compositions from the origin of a plant through its therapeutic use. Adjusting the herbal medication preparation to the specific component content or a combination of compounds with established therapeutic action by adding excipients or combining herbal medicines or herbal [27,28] drug preparations is also included.

There is a critical need for a scientific strategy incorporating the elements described below:

a) Raw material and end product physical standards and elemental analysis.
b) Metal oxidation state determination and metal association with acidic radicals in the end product.
c) Pharmacokinetics of Bhasmas main metallic component utilizing tracer techniques or metal extraction from tissues.
d) Investigations on metal buildup in various tissues and organs.
e) Toxicology, both acute and chronic.
f) Heat shock protein expression.
g) The effect of Bhasmas on physiological and antioxidant markers.
h) Cellular and molecular therapeutic response of Bhasmas to the specified illness model (based on claims written in ayurvedic texts).
i) The function of Bhasmas as medication carriers.
j) The involvement of Bhasmas in body immunomodulation and gastrointestinal tract (GI) physiology (site of jataragani).

These studies will give proof of the safety of Bhasmas as well as an understanding of their mode of action.

Methods of standardization:

The following approaches are used in the standardization process:

Primary testing

(a) Floating test: If a tiny amount of Bhasma is dusted on the water surface, it should float.
(b) Fineness test: When a tiny amount of the sample is rubbed between the fingers, it should penetrate the lines on the fingers.
(c) Removal of metallic shine: No metallic luster should be visible when visually checked, ideally in sunlight.
(d) Metallic state loss: This entails heating a fragile silver sheet (600 nm thickness) with a small amount of Bhasma to red hot for around 5 minutes. After cooling the sheet to average temperature, no residues of this sample should remain on the silver sheet, showing that no alloy formation occurs. This demonstrates that the metal has completely changed into Bhasma, its oxide form.

Physicochemical analysis:

Colour, odour, pH, taste, fineness, loss on drying at 105ºC, total ash, acid insoluble ash, water soluble ash, and particle size mesh test are among the numerous physicochemical evaluations Heavy/toxic metal [29] tests should be performed for standard formulations, and the permitted limits as defined by WHO / FDA are provided in table 3.

Table 3. Permissible limits of heavy/toxic metals

Heavy/toxic metals	Permissible limit (ppm)
Lead	10.0
Cadmium	0.30
Mercury	1.00
Arsenic	10.0

Microbiological testing:

The microbiological analysis includes testing for specific pathogens such E. coli, Salmonella spp., S. aureus, and Pseudomonas aeruginosa as well as total viable aerobic count, total Enterobacteriaceae, and total fungal count. Table 4 lists the pathogen and microbial load permissible limits set by the WHO and FDA [30].

Table 4. Permissible limits of microbial load and pathogens

Microbial Load	For contamination in the crude plant materials	For plant materials that have been pretreated internal use (used as topical doses form)	For other plant material internal use

Total Viable aerobic count	-	$<10^7$ cfug $^{-1}$	$<10^5$ cfug $^{-1}$
E. Coli	10^4 g $^{-1}$	10^2 g $^{-1}$	10 g $^{-1}$
Total yeast mould count	10^5 g $^{-1}$	10^4 g $^{-1}$	10^3 g $^{-1}$
Total Enterobacteriaceae	-	10^4 g $^{-1}$	10^3 g $^{-1}$
Salmonellae spp.	-	None	None
S. aureus	Absent	-	-
Pseudomonas Aeruginosa	Absent	Absent	Absent
Coliforms	Absent	Absent	Absent

Analytical evaluation:

Atomic Absorption Spectroscopy (AAS), Atomic Force Microscopy (AFM) [Particle size, size distribution], X-Ray Diffraction (XRD) [Phase analysis], and X-Ray Fluorescence (XRF) [Bulk chemical analysis after producing pellets] are examples of contemporary analytical assessment methods [31]. Metal element detection], X-ray photo electron microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy dispersive x-ray analysis (EDAX), infrared spectroscopy (IR), characterising organic matter (if > 20% wt/wt), and wet inorganic analysis (Anion and cation analysis), among other techniques.

CONCLUSION:

One of the first systems of medicine was ayurveda. Bhasma is harmless when used in therapeutic levels and is a type of nanomedicine. The size of Bhasma particles, which rapidly shrinks to 1-2 microns, may aid in the biological systems assimilation and absorption of drugs. The Bhasmas of several metals and stones are particularly notable for being used as medicines in the Indian medical systems. Careful scientific investigation is necessary before using the Bhasma as medication. It is also vital to evaluate the risk-benefit ratio of these herbal-mineral/metal-based medicines. By guaranteeing safety, effectiveness, and batch-to-batch uniformity, this would unquestionably help to build trust in utilising these products for treatment.

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DATA AVAILABILITY

Not declared.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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AUTHORS CONTRIBUTION:

Geetha has designed the current review. Girija Nandini and Harshika has collected the literature which supports the work and also framed the manuscript.

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