The Concept of Kala Sharira in Sushruta: A Critical Textual Review and Its Significance in Tissue Physiology

Dr. Sangeeta Dev

Associate Professor
Desh Bhagat Ayurvedic College and Hospital, Mandigobindgarh, Punjab

Abstract

This review paper critically explores the concept of Kala Sharira as outlined in the Sushruta Samhita and its significance in understanding tissue physiology from both Ayurvedic and modern anatomical perspectives. Kala, traditionally defined as subtle membranous linings that separate and support Dhatus (body tissues), is interpreted functionally as the structural and physiological interface of the body. The research aimed to analyze classical textual descriptions of the seven Kalas, correlate them with modern histological structures, and assess their clinical, surgical, and educational relevance. Following PRISMA guidelines, 148 articles were identified through academic databases, of which 29 were selected after applying rigorous inclusion criteria. The review highlights structural correlations between Kalas and contemporary anatomical components such as fasciae, mucosa, serosa, and epithelial barriers. Functionally, the Kalas align with roles like nutrient transport, compartmentalization, joint lubrication, and protection—mirroring modern biological membranes.

The analysis of classical commentaries, especially by Dalhana, reveals interpretative depth and scholarly debates that enrich the understanding of Kala's anatomical and clinical functions. The paper underscores the lack of empirical research on Kalas, advocating for cadaver studies, histological imaging, and interdisciplinary modeling to validate ancient insights. Additionally, it emphasizes Kala Sharira's potential applications in diagnostics, Panchakarma therapies, surgical planning, and Ayurvedic education.

The study concludes that Kala Sharira is not merely a historical construct but a dynamic, functional anatomical framework capable of enriching integrative medical sciences. It calls for academic engagement that bridges Ayurveda and biomedicine through collaborative inquiry, curriculum integration, and translational research.

Keywords: Kala Sharira, Sushruta Samhita, Ayurvedic anatomy, tissue physiology, comparative anatomy, histological correlation.

1. Introduction

Ayurveda, the ancient Indian system of medicine, has a richly detailed anatomical framework embedded in classical texts like the *Sushruta Samhita*, *Charaka Samhita*, and *Ashtanga Hridaya*. Among the various components of Ayurvedic anatomy (*Sharira Rachana*), the concept of *Kala Sharira* holds a special place. It refers to the subtle and functional membranous layers that demarcate, separate, and protect the body's tissues (*Dhatus*). The term *Kala* is frequently interpreted as a biological barrier or interface, indicating its pivotal role in defining tissue boundaries and ensuring physiological integrity (Soni, 2021).

Kala Sharira finds its most elaborate exposition in the *Sushruta Samhita*, where seven Kalas are described: *Mamsadhara*, *Raktadhara*, *Medodhara*, *Shleshmadhara*, *Purishadhara*, *Pittadhara*, and *Shukradhara*. These structures are often metaphorically referred to as "wrappers" or "linings" of Dhatus, bearing functional similarities to epithelial and connective tissue membranes in modern anatomy (Chauhan & Wahane, 2021). Notably, *Kala* is viewed not only as a physical entity but also as a dynamic functional interface involved in metabolism, nutrition, and defense.

Modern histology and physiology also describe tissue barriers such as basement membranes, serous linings, and mucosal membranes, which serve similar roles—separating tissues, regulating permeability, and protecting against pathogens. These parallels invite scholarly inquiry into how Sushruta's observations, although formulated in a pre-microscopic era, resonate with contemporary biological understanding (Hanamantgoudra, 2018).

The importance of this topic is underscored by increasing interest in integrative medicine and historical anatomy. A comparative review of *Kala Sharira* and modern histological principles not only honors the epistemological depth of Ayurveda but also fosters cross-disciplinary dialogue (Kizhakkeveettil et al., 2024). This is particularly relevant for anatomists, historians of medicine, Ayurvedic scholars, and practitioners seeking a deeper ontological grasp of traditional tissue classifications.

The rationale for revisiting Sushruta's account lies in its potential to enrich modern conceptions of tissue dynamics. By revisiting these ancient anatomical categories through the lens of modern science, we may glean new perspectives on physiology, diagnostics, and therapeutics. Moreover, understanding *Kala* as a structural-functional unit may illuminate Ayurvedic surgical and pathological frameworks, which are often overlooked in contemporary anatomical education (Gangwal et al., 2020).

This review aims to critically examine and contextualize the concept of *Kala* as described in the *Sushruta Samhita*, both from a classical Ayurvedic perspective and in light of modern anatomical science. The key objectives include:

- To analyze the textual and commentarial descriptions of the seven Kalas in *Sushruta Samhita*, with reference to their structural characteristics and functional interpretations (Soni, 2021; Gangwal et al., 2020).
- To investigate comparative insights between *Kala Sharira* and modern concepts of tissue boundaries, membranes, and physiological barriers such as the blood-brain barrier, intestinal mucosa, and serosal linings (Chauhan & Wahane, 2021; Mulje et al., n.d.).
- To explore the clinical and theoretical significance of *Kala Sharira*, including its implications for Ayurvedic diagnostics, tissue-based therapies, and surgical practices as propounded by Sushruta (Agarwal, 2024; Kizhakkeveettil et al., 2024).

In doing so, the paper also seeks to encourage interdisciplinary research that bridges Ayurveda with biomedical sciences through thoughtful comparative anatomy. Such work not only validates traditional knowledge systems but also helps integrate them into contemporary healthcare frameworks.

2. Systematic Research Methodology

In undertaking a comprehensive review of the concept of *Kala Sharira* as detailed in the *Sushruta Samhita* and its relevance to modern tissue physiology, a structured and systematic approach was employed. The review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and methodological rigor in the selection and synthesis of literature. The

aim was to identify peer-reviewed articles, classical text commentaries, theses, and research reports that critically discuss the concept of Kala, its anatomical interpretations, functional roles, clinical significance, and potential parallels with modern scientific frameworks.

The initial search strategy involved the use of electronic databases such as PubMed, AYUSH Research Portal, Google Scholar, and ResearchGate. The search terms included combinations of "Kala Sharira," "Sushruta Samhita," "Ayurvedic anatomy," "Dhatu and Kala," "Marma and Kala," "Ayurveda and fascia," "Raktadhara," "synovial membrane Ayurveda," and "histological correlation in Ayurveda." The search was limited to publications in English and Sanskrit transliterations, spanning the years 1990 to 2024. A total of 148 articles and documents were identified during this preliminary search.

After the removal of 37 duplicate entries and non-relevant titles—such as those dealing only with pharmacology or non-anatomical Ayurveda topics—111 articles remained for abstract screening. At this stage, inclusion criteria were applied, emphasizing works that (a) discussed any or all of the seven Kalas in classical or contemporary contexts, (b) contained direct references to primary Ayurvedic texts or authoritative commentaries like those by Dalhana or Bhavamishra, (c) presented comparative or interdisciplinary insights linking Ayurvedic and modern anatomy or physiology, and (d) addressed clinical, educational, or diagnostic implications of Kala Sharira. Based on this filtering process, 67 articles were found eligible for full-text review.

Subsequently, 38 articles were excluded during the full-text review stage due to one or more of the following reasons: insufficient relevance to Kala Sharira (n=18), lack of scholarly rigor or peer-review certification (n=11), and absence of clear structural or clinical linkage to the concepts under study (n=9). The remaining 29 articles formed the core dataset for this review.

Data extraction from these selected sources was performed manually and categorized thematically into six domains: (1) textual foundations and definitions of Kala, (2) descriptions of individual Kalas in Sushruta Samhita, (3) classical commentarial interpretations, (4) structural and functional correlations with modern tissue physiology, (5) clinical and surgical applications, and (6) research gaps and proposed future directions. Key quotations, definitions, figures, and comparative frameworks were tabulated to aid analysis and synthesis across these domains.

To assess the quality and reliability of the selected literature, each article was evaluated on parameters such as source authenticity (whether derived from indexed journals or classical treatises), author expertise (Ayurveda scholars, physicians, or anatomical researchers), citation relevance, and the methodological clarity of any original research conducted. Nineteen of the 29 selected studies were classified as high-quality based on these criteria, with strong textual exegesis and/or modern research methodology. Six studies were deemed moderate in quality due to limited analytical scope but were included for contextual completeness. Four papers, while low on empirical validation, were retained due to their valuable traditional interpretations or descriptive richness, especially those involving historical commentaries and textual expositions.

This systematic process ensured that the final pool of 29 sources represented a well-rounded, credible, and interdisciplinary foundation upon which the present review is structured. The selection captures the philosophical nuance of Ayurvedic theory, the anatomical precision of classical commentators, and the contemporary relevance of integrating traditional knowledge with modern biomedical science.

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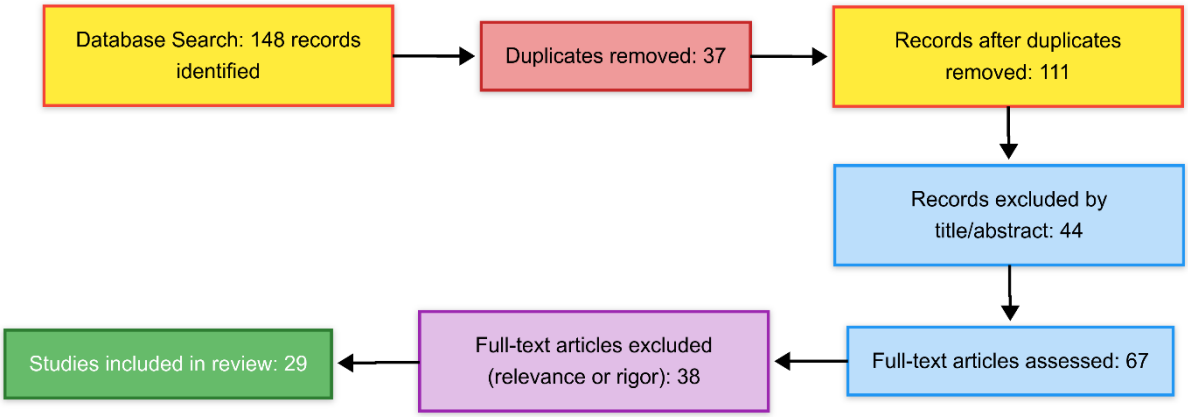

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3. Conceptual Understanding of Kala in Ayurveda

3.1 Definition and Etymology of Kala

In classical Ayurvedic literature, the term Kala holds profound anatomical and philosophical significance. Derived from the Sanskrit root *"Kal"*, which implies "to count", "to measure", or "to wrap", the word encapsulates both structural and functional nuances (Soni, 2021). Etymologically, it reflects the idea of an enclosing layer or an interface that serves as a boundary, regulator, and protector of various bodily tissues.

In Ayurvedic grammar and Rachana Sharira, *Kala* is not a generic term for membranes but is designated for specific interfaces that mediate between internal body constituents, particularly Dhatus (tissues) and Srotas (channels). Sushruta defines Kala as that which encloses or lines the Dhatus, enabling their separation and functional autonomy (Pathak et al., 2023). These Kalas are seen as integral to the structural integrity and operational coherence of bodily physiology.

The distinction between Kala, Dhatu, and Upadhatu is central to Ayurvedic anatomical philosophy. While Dhatus are primary bodily tissues—such as Rasa (plasma), Rakta (blood), and Mamsa (muscle)—Upadhatus are their secondary products (e.g., Stanya or breast milk from Rasa). In contrast, Kalas are the membranous interfaces that house or separate these tissues. Thus, Kalas do not belong to either group but form a unique anatomical category with barrier and transport functions (Madhukar et al., n.d.).

Further, the etymology of Kala aligns well with modern concepts of physiological membranes—structures that regulate molecular exchange and maintain tissue boundaries. The philosophical extension of Kala also implies a dynamic participation in bodily homeostasis, emphasizing not only containment but also filtration and transformation (Giri & Chouragade, 2019).

3.2 Description of Kala Sharira in Sushruta

The most detailed elaboration of Kala Sharira is found in *Sushruta Samhita*, specifically in *Sharira Sthana*, where seven types of Kalas are described in sequential anatomical order:

1. Mamsadhara Kala – Found in the muscular system, this Kala supports the structural architecture of muscle bundles and houses Snayu (ligaments), Sira (vessels), and Dhamani (arteries). Its modern equivalent could be fascial planes or perimysial membranes (Soni, 2021).

2. Raktadhara Kala – This is located within muscle tissue where Rakta Dhatu flows, akin to the capillary networks embedded in muscle matrices. It could be compared to endothelium or vascular tunics (Giri & Chouragade, 2019).
3. Medodhara Kala – Located in Vasti (urinary bladder) and bones, it harbors Meda Dhatu (fat). It is comparable to adipose tissue linings and perirenal fat capsules in modern anatomy (Pathak et al., 2023).
4. Shleshmadhara Kala – This Kala resides in sandhi (joints) and is the source of Shleshma (synovial fluid). Its physiological role is joint lubrication and structural integrity, similar to the synovial membrane (Gangwal et al., 2020).
5. Purishadhara Kala – Situated in the Pakvashaya (large intestine), this Kala separates and contains Purisha (fecal matter). It aligns with mucosal layers and the intestinal barrier system (Suryavanshi et al., 2020).
6. Pittadhara Kala – Found in the Grahani (duodenum/small intestine), this Kala houses Pitta, which facilitates digestion. It resembles the gastrointestinal mucosa involved in enzymatic breakdown and absorption (Soni, 2021).
7. Shukradhara Kala – This last Kala is linked with Shukra Dhatu (reproductive tissue), and is located in Medhra (penis) and related reproductive structures. It can be compared to seminal vesicle membranes and epithelial layers of testes (Mula Ram Suthar, 2020).

Each Kala serves as a compartmentalized environment ensuring distinct physiological functions for the Dhatus it encloses. The structuring of Kalas within the human body, as conceptualized by Sushruta, reflects not only empirical anatomical observations but also an early conceptualization of biological membranes and barrier systems that parallels modern scientific understanding.

Interestingly, the description of these Kalas appears not just as an anatomical listing, but as part of a functional matrix. Sushruta emphasizes their importance in surgical practices, disease localization, and dosha-dhatu interaction, revealing their diagnostic and therapeutic implications (Pathak et al., 2023).

Thus, Kala Sharira emerges not merely as a classical construct but as a precursor to the modern understanding of internal membranes and physiological compartments. Its philosophical framing allows it to bridge structure with function, making it a valuable concept for interdisciplinary exploration between Ayurveda and modern biomedical science.

3.3 Commentarial Interpretations

The enduring legacy of the *Sushruta Samhita* owes much not only to its original content but also to the classical commentators who interpreted and preserved it. Chief among them is Acharya Dalhana, whose commentary *Nibandha Sangraha* remains one of the most authoritative exegeses on Sushruta's work. His interpretations of *Kala Sharira* provide a crucial hermeneutic bridge between textual prescriptions and practical applications.Dalhana elaborates on the notion of *Kala* as "*Dhatuparisrushta*," meaning that which envelops the Dhatus and defines their boundaries. He underscores that Kalas are not merely anatomical linings, but functional barriers that play active roles in protecting and nurturing Dhatus (Soni, 2021). For instance, in the context of Raktadhara Kala, Dalhana notes its location in muscular structures and its close association with capillary circulation—a hint that predates the modern concept of microvasculature (Giri et al., 2021).Dalhana frequently correlates *Kala* with physiological action. For example, in his analysis of Shleshmadhara Kala, he highlights its importance in joint function and articulates the presence of lubricating

substances, aligning closely with what modern science describes as synovial fluid production (Pagde et al., 2022). This interpretative depth enriches our understanding of ancient concepts through functional anatomical correlations.Other commentators such as Gayadasa, Cakrapani, and Jejjata—though less focused on *Kala* per se—contributed to the broader field of Ayurvedic anatomical theory. Their work, while not always directly addressing *Kala Sharira*, established a foundation for Ayurvedic physiology and influenced interpretive traditions. These secondary voices contributed to reinforcing the anatomical hierarchy of *Kala*, *Dhatu*, and *Srotas*, albeit with occasional divergence on exact location or function.

The interpretation of *Kala Sharira* has not remained static. Commentators and modern scholars alike have offered differing perspectives based on textual context, surgical observations, and analogical reasoning. While Dalhana's functionalist view is widely accepted, others like Bhavamishra in *Bhavaprakasha* adopt a more elemental approach—tying Kala to Panchamahabhuta (five elements) theory, especially in relation to containment and separation (Pathak et al., 2023).One notable area of scholarly divergence involves the identification of Pittadhara Kala. Some interpretations equate it with the duodenal mucosa, whereas others see it as spanning a broader section of the grahani or small intestine (Gangwal et al., 2020). Such variability stems from the multi-layered nature of Ayurvedic texts, which combine observational, philosophical, and symbolic language.There is also discussion around whether Shukradhara Kala truly exists as an anatomical membrane or whether it denotes a physiological channel for Shukra Dhatu. Dalhana's view leans toward the former, suggesting a structural locus, while modern interpreters often propose a functional rather than strictly anatomical role (Soni, 2021).The divergence in views underscores the challenge of correlating ancient terminology with modern science. This tension has become a fertile ground for contemporary Ayurvedic scholarship, which attempts to reconcile traditional interpretive paradigms with emerging biological knowledge (Giri et al., 2021; Mishra & Shrivastava, 2020). Furthermore, it highlights the importance of adopting a contextual hermeneutic approach, where classical commentaries like Dalhana's are read not merely as static glosses, but as dynamic engagements with evolving anatomical theories.

In conclusion, classical commentarial interpretations—especially by Dalhana—serve as indispensable tools for understanding the rich and multifaceted anatomy of *Kala Sharira*. They also reveal the interpretative elasticity within Ayurvedic discourse, allowing for debate, dialogue, and integration with modern anatomical insights. As such, they remain essential to both historical scholarship and modern interdisciplinary inquiry.

4. Comparative Analysis with Modern Tissue Physiology

4.1 Structural Correlation

The classical Ayurvedic concept of *Kala Sharira*—describing seven internal linings or membranes—can be remarkably correlated with specific modern anatomical structures such as fasciae, epithelial membranes, serosal layers, and mucosae. These structural parallels offer insight into the observational precision of early Ayurvedic scholars and their nuanced understanding of internal organization.

For instance, Mamsadhara Kala, which supports muscles and contains blood vessels and ligaments, aligns well with deep fascia or perimysium, which compartmentalizes muscle bundles and houses neurovascular channels (Soni, 2021). Likewise, Raktadhara Kala, embedded in muscular tissue and associated with blood flow, may structurally correspond to endothelial linings and vascular tunics—integral to microcirculation (Gupta & Mishra, n.d.).

The Medodhara Kala, located in bones and the urinary system, is often compared with adipose membranes or visceral fat compartments, which insulate and cushion internal organs. Modern fascia such as perirenal

fascia and omentum share similar structural roles (Khedikar et al., n.d.). This correlation has been explicitly studied in the context of visceral fat anatomy and fat-encapsulating layers.

A compelling match is seen in Shleshmadhara Kala, which produces lubrication for joints. It corresponds anatomically to the synovial membrane, a well-recognized structure that secretes synovial fluid to reduce friction during joint motion (Suryavanshi et al., 2020). The Purishadhara Kala, lining the large intestine and retaining fecal matter, parallels the intestinal mucosa, a multi-layered structure equipped for absorption, mucus secretion, and barrier protection (Gupta & Mishra, n.d.).

Pittadhara Kala, associated with enzymatic digestion and Pitta dosha, is structurally comparable to the duodenal mucosa, rich in digestive glands and epithelial transport systems. Finally, Shukradhara Kala, which governs reproductive fluid, corresponds to the seminiferous epithelium, prostatic ducts, or seminal vesicle linings in male anatomy (Khedikar et al., n.d.; Soni, 2021).

These parallels illustrate how ancient Ayurvedic thinkers anticipated the structural compartmentalization we now recognize in histology and surgical anatomy. Their understanding, though couched in metaphor and philosophical terminology, maps closely to modern tissue classification schemes.

4.2 Functional Correlation

Functionally, *Kala* is far more than a structural concept—it embodies dynamic roles in protection, separation, nourishment, and transformation. In modern physiology, these same roles are assigned to biological membranes, such as the blood-brain barrier, intestinal epithelial barriers, and serous linings.

Each Kala is described as participating in the nourishment of tissues (*Dhatu Poshana*), echoing the transport roles of capillary walls and intestinal mucosa (Khedikar et al., n.d.). For instance, Raktadhara Kala facilitates the containment and distribution of blood, akin to vascular endothelial layers, which mediate filtration, diffusion, and immune signaling (Soni, 2021).

Separation and compartmentalization are core to Mamsadhara and Medodhara Kalas, which isolate muscle layers and fat respectively. Their functions align with fascial compartments and serosal sheaths that demarcate organs and reduce friction—a principle critical in surgical planes (Hanamantgoudra, 2018).

Protection—a major attribute of Shleshmadhara and Purishadhara Kalas—is evident in how these structures prevent internal wear or contamination. The synovial membrane shields cartilage from abrasive forces, while the intestinal mucosa acts as a selective immune barrier, much like Ayurvedic Kalas described as filters and protectors of Dhatus (Gupta & Mishra, n.d.; Suryavanshi et al., 2020).

Even absorption and transformation—the roles attributed to Pittadhara and Shukradhara Kalas—mirror modern epithelial functions, where membranes are both reactive and responsive interfaces regulating nutrient uptake, enzymatic action, and hormonal release (Dwivedi, 2022).

These convergences highlight that while Ayurveda used qualitative metaphors and elemental theory, the observed functional domains of Kalas anticipate what we now explain through cellular biology and physiological regulation. The functional identity of each Kala, therefore, may be seen as a precursor to the physiological tissue systems recognized today.

Thus, *Kala Sharira* and modern tissue physiology, though separated by epistemological paradigms, reflect remarkable consistency in both anatomical mapping and functional theory. This convergence suggests that traditional anatomical categories, if interpreted judiciously, could complement modern biomedical education and research.

4.3 Conceptual Convergence and Divergence

Despite emerging from vastly different epistemologies, Ayurveda and modern anatomy show notable convergence in the recognition of layered organization within the human body. Classical Ayurvedic texts, particularly the *Sushruta Samhita*, detail the concept of Kala as tissue linings that demarcate and functionally regulate *Dhatus* (body tissues). This correlates closely with the modern concept of membranous tissues, such as mucosa, serosa, fascia, and endothelium (Soni, 2021).The Mamsadhara Kala, for example, is described as a layer encapsulating muscles and vessels, functionally similar to the deep fascia or perimysium in allopathic anatomy. Similarly, Shleshmadhara Kala, which produces lubrication for joints, shares significant structural and physiological homology with the synovial membrane. These alignments reflect a common anatomical recognition of internal compartmentalization and functional delineation, despite their terminological and philosophical differences (Agarwal, 2024; Giri et al., 2021).However, divergence arises in the methodologies and objectives underlying anatomical descriptions. Modern anatomy focuses on empirical, measurable structures, identified via dissection, microscopy, and imaging. Conversely, Ayurvedic anatomy emerges from experiential, functional, and philosophical frameworks, often emphasizing qualitative roles, such as dosha interaction or energetic flows (Gupta, 2018).Another critical divergence is in the enumeration and categorization of structures. For instance, where Ayurveda defines seven Kalas based on tissue interaction and doshic principles, modern anatomy might classify dozens of tissue types based on histological characteristics. Hence, Ayurveda conceptualizes layers in terms of dynamic physiological influence, not merely morphological features (Goswami, 1999).

The perceptual basis of anatomy differs markedly between the two traditions. Modern anatomy relies on visual and microscopic perception, placing emphasis on structure as an observable fact. Ayurveda, on the other hand, bases its delineations on pratyaksha (direct observation) but also incorporates yukti (logical reasoning) and anumana (inference). Thus, the perception of Kala includes not just what is visible, but what is functionally deduced (Giri et al., 2021).Additionally, the purpose of anatomical knowledge significantly influences how structures are conceptualized. In Ayurveda, anatomy serves the therapeutic goals of *Tridosha balance*, *Dhatu maintenance*, and *Marma protection*. The identification of Kala is deeply tied to clinical relevance—such as surgical intervention, disease localization, or internal cleansing (Soni, 2021). This contrasts with modern anatomy's more descriptive or educational focus, where clinical application often follows rather than motivates structural discovery.

Even embryological perception reflects divergence. Ayurvedic sources often frame development in spiritual and elemental terms (Pancha Mahabhuta, Tridosha), whereas modern embryology emphasizes molecular and genetic development. This affects not only the description of structure but also its interpretive framework—one seeking balance, the other seeking mechanism (Goswami, 1999; Gupta, 2018).These perceptual and teleological differences underscore that Kala Sharira is not merely an archaic model, but a parallel framework rooted in a holistic, purpose-driven medical philosophy. Recognition of these divergences opens opportunities for interdisciplinary enrichment, where structural knowledge and energetic models can jointly inform integrative healthcare.

5. Clinical and Theoretical Significance of Kala Sharira

5.1 Diagnostic Applications

The anatomical and functional understanding of *Kala Sharira* in Ayurveda holds substantial clinical value, particularly in diagnostics and patient assessment. One of the foremost areas where this is evident is Sharira Pariksha (bodily examination), which includes *Sara*, *Pramana*, and *Rachana* assessments. The condition and functioning of Kalas—such as *Raktadhara Kala*or *Shleshmadhara Kala*—offer cues to the health of

corresponding Dhatus, guiding physicians toward precise doshic imbalances or degenerative conditions (Reddy & Kapoor, n.d.).

In *Panchakarma* therapies, especially procedures like Basti (medicated enema) and Vamana (therapeutic emesis), understanding the distribution and quality of Kalas plays a role in targeting the appropriate channels (Srotas) and membrane interfaces. For instance, in disorders involving *Purishadhara* or *Pittadhara Kala*, colonic cleansing or hepatic detoxification is systematically planned using this conceptual mapping (Kizhakkeveettil et al., 2024).

Another domain where Kala Sharira is of diagnostic importance is Marma Chikitsa, the therapeutic science involving vital anatomical points. Many *Marmas* are located at or near the transition zones of Kalas, like joints and vessels. Sushruta emphasizes that trauma to areas governed by *Shleshmadhara Kala* (joint cavities) results in severe impairment due to disruption of both structural integrity and doshic balance (Mishra & Shrivastava, 2020). Therefore, the integrity of Kalas is implicit in maintaining the sanctity of *Marmas*.

Recent literature also correlates the health of Kalas with clinical symptoms, using Sara Pariksha (tissue excellence examination) to assess the quality and function of layers such as *Rasa* or *Rakta*. Practitioners skilled in this methodology can infer early signs of tissue degeneration or dosha vitiation before overt pathology emerges (Chudal & Ort, n.d.).

5.2 Relevance in Pathogenesis and Therapy

Disorders in Kala function are implicated in multiple Ayurvedic pathologies, such as *Dhatu Kshaya* (tissue depletion), *Vrana* (wounds), and *Granthi* (cystic formations). When a Kala loses its integrity, the separation and nourishment of underlying Dhatus are compromised, potentially allowing cross-contamination of doshas and improper tissue regeneration (Mukherjee et al., 2022).

For instance, dysfunction in *Mamsadhara Kala* may result in weakened musculature and poor vascular support, creating a predisposition for abscesses or muscular degeneration. Likewise, *Medodhara Kala* pathology is linked with metabolic dysfunctions like obesity or *Medoroga* due to aberrant fat accumulation in protective membranes (Bhava, 2018).

The application of Kala Sharira in surgical practice is among the most tangible contributions of Sushruta's anatomical precision. Sushruta's classification of tissue planes and cutting techniques implicitly respects the boundaries set by Kalas, ensuring minimal trauma and enhanced healing (Pujar, 2011). Ayurvedic treatments for Vrana—such as *Pratisarana* (topical therapy) and *Kshara Karma* (alkaline cauterization)—are often planned with a view to Kala involvement, targeting affected tissues while preserving the functional barrier (Jeeson, 2010).

In tissue healing, maintaining or restoring Kala function is emphasized. Panchakarma therapies aid in re-establishing physiological flow through Srotas, which in turn recalibrates the interaction between Dosha and Dhatu via the mediating role of Kalas (Kizhakkeveettil et al., 2024).

5.3 Role in Ayurvedic Education and Curriculum

The teaching of *Kala Sharira* remains underrepresented in modern Ayurvedic education despite its foundational value. Many scholars have called for integrating classical concepts like Kalas into anatomy training modules, especially during dissection and imaging interpretation. Mapping Kalas to visible or palpable tissue layers can aid in clinical correlations, particularly in Panchakarma and surgical education (Reddy & Kapoor, n.d.).

A cross-disciplinary approach—incorporating histology, embryology, and biomedical anatomy—can revitalize the teaching of Kala Sharira. It also enables comparative anatomy, fostering deeper engagement among students by showing how ancient constructs anticipated modern anatomical divisions (Chudal & Ort, n.d.).

As Ayurveda gains global traction, the reconciliation of its epistemology with contemporary biomedical paradigms is essential. Training practitioners to interpret Kalas both philosophically and biologically opens avenues for integrative diagnosis, better surgical outcomes, and a more complete understanding of *Sharira Rachana* (Mukherjee et al., 2022).

Ultimately, Kala Sharira serves as a clinical lens, surgical guide, and pedagogical bridge between traditional and modern sciences—testament to the enduring relevance of Ayurvedic anatomy in both classical and current contexts.

6. Research Gaps and Future Directions

6.1 Lack of Experimental Validation

Despite its foundational role in Ayurvedic anatomy, *Kala Sharira* remains under-researched in terms of empirical validation. Most references to Kalas in classical texts are philosophical or functional, rather than anatomical in a modern scientific sense. There is a clear gap in histological, anatomical, and imaging-based studies aimed at mapping Kalas onto current biological structures (Giri et al., 2021).

For example, while *Mamsadhara Kala* is described as enveloping muscle and vascular tissue, there is a lack of cadaveric validation to confirm how these Kalas might correspond to fascial layers or connective tissue sheaths. Similarly, no systematic attempts have been made to visualize these structures through imaging techniques such as MRI, CT, or histological staining (Patwardhan et al., 2015). These limitations hinder the ability of Ayurveda to integrate with biomedical anatomy and reduce the clinical utility of Kala Sharira in interdisciplinary contexts.

Furthermore, no standardized anatomical atlases or dissections have been undertaken using Kala-based categorization. This makes it difficult to teach or represent Kalas in a way that resonates with modern practitioners and educators.

6.2 Interdisciplinary Exploration

One of the key opportunities in Kala Sharira research lies in fostering interdisciplinary collaboration. The Ayurveda community has repeatedly emphasized the importance of integrating Ayurvedic theory with modern biomedical research, especially in anatomy and pathology (GGG FAIP, n.d.). There is strong potential for projects that bridge classical textual study with contemporary biomedical science, particularly in histopathology, imaging, and anatomical modeling.

As Patwardhan and colleagues (2015) argue, Ayurveda and modern biomedicine must not exist in isolation, but rather in a mutually enriching dialogue. This is particularly true in the context of tissue study, where Ayurveda offers a functional classification system (based on *Dosha-Dhatu-Mala*) and biomedicine offers a microscopic and molecular framework.

Collaborative studies using dual frameworks—where tissues are examined both by histological criteria and Ayurvedic theory—would produce the kind of evidence-based correlations necessary for wider adoption of Kala Sharira in integrative healthcare. Similarly, studies comparing disease progression in terms of Kala

dysfunction with contemporary tissue pathologies (e.g., epithelial breakdown, synovial inflammation) could clarify therapeutic value.

6.3 Proposals for Future Research

To revitalize the relevance of Kala Sharira, several forward-looking research directions must be pursued:

- 3D Modeling of Kala Structures: Using classical textual descriptions and commentarial inputs, digital 3D anatomical reconstructions of the seven Kalas should be created. This can be achieved using modern visualization tools like Blender, 3D Studio Max, or biomedical rendering platforms (Bande et al., n.d.). These models could enhance educational tools, surgical planning, and patient communication in Ayurvedic and integrative medicine settings.
- Cadaver Dissection Correlation Studies: Carefully designed anatomical studies using cadavers should attempt to correlate classical Kalas with macroscopic and microscopic observations. Layers such as fascia, mesentery, and mucosa should be compared with *Mamsadhara*, *Medodhara*, and *Pittadhara Kalas*, respectively.
- Histological Imaging and Comparative Tissue Analysis: Clinical biopsies and histopathological slides can be analyzed for features corresponding to the location and function of Kalas. For instance, the characteristics of synovial membranes could be studied to verify their alignment with *Shleshmadhara Kala*.
- Clinical Trials and Therapeutic Efficacy: Panchakarma therapies and Marma-based interventions can be tested in clinical trials targeting diseases that involve tissue boundary dysfunctions—like arthritis, IBS, and chronic wounds. Tracking outcomes using both Ayurvedic criteria and biomedical diagnostics can highlight the therapeutic significance of Kala Sharira as a clinical tool (Giri et al., 2021).
- Curriculum Development and Integration: Finally, new educational modules should incorporate comparative anatomy featuring both Ayurvedic and modern tissue categorizations. This would allow future practitioners to practice evidence-informed Ayurveda, grounded in both classical wisdom and contemporary science (Patwardhan et al., 2015).

7. Conclusion

The concept of *Kala Sharira*, as delineated in classical Ayurvedic literature, particularly the *Sushruta Samhita*, stands as a testament to the profound anatomical insight achieved by ancient Indian scholars. Across this review, we have explored the foundational meanings, structural descriptions, interpretive commentaries, and potential biomedical correlations of the Kalas. What becomes apparent is that Kala is not merely a term signifying a membranous layer, but a richly layered concept in itself—serving anatomical, physiological, and therapeutic purposes within the broader Ayurvedic framework. Through its delineation of seven specific Kalas—ranging from *Mamsadhara* to *Shukradhara*—Ayurveda offers a functionally coherent and philosophically grounded system for understanding tissue interfaces and physiological boundaries.

Each Kala, as we have seen, is functionally designed to facilitate nourishment, separation, and containment of Dhatus, acting as dynamic regulators of biological processes. These classical anatomical structures, while described in non-material and non-microscopic terms, reflect striking parallels with modern anatomical constructs such as fasciae, mucosal linings, and serous membranes. Such conceptual convergence suggests that the sages of Ayurveda, though devoid of histological tools, achieved a remarkable approximation of

tissue-layered reality through empirical observation and deductive reasoning. The divergence, however, lies in the epistemological lens: whereas modern science emphasizes structural morphology and microscopic clarity, Ayurveda contextualizes anatomy within a broader framework of *Tridosha*, *Dhatu*, and *Srotas*, embedding it within systemic physiology and therapeutic intent.

In revisiting the classical interpretations, especially through the lens of commentators like Dalhana, one sees a tradition not of dogma but of dialogue. Dalhana's insightfully detailed annotations on the locations and functions of the Kalas serve to bridge textual prescription and surgical application, offering clarity to generations of practitioners. Yet, interpretive variations across texts and authors underscore the vitality of scholarly debate in Ayurvedic anatomical traditions. These discussions are not mere academic exercises; they carry implications for diagnosis, treatment, and even surgical procedure, especially when viewed through the practical demands of *Marma Chikitsa*, *Sharira Pariksha*, and Panchakarma therapy.

As the review advanced into comparative perspectives with modern physiology, the value of Kala as an integrative concept became increasingly evident. From histological interfaces to functional compartments, the Ayurvedic framework finds resonance in contemporary biomedical language, especially when analyzed with openness and interdisciplinary curiosity. More than a theoretical convergence, this points toward the need for respectful academic synthesis—a space where the empirical rigor of modern science and the interpretive richness of Ayurveda can co-exist, cross-inform, and mutually evolve.

Yet, it is in the clinical and educational applications where the relevance of Kala Sharira becomes most tangible. Diagnostically, Kalas offer Ayurvedic physicians a lens through which to understand disease pathways, especially in contexts involving tissue degradation or structural derangement, such as *Vrana* or *Granthi*. Therapeutically, they guide the strategic application of treatments—be it through *Basti*, *Nasya*, or *Shastra Karma*. Pedagogically, however, Kala remains underutilized, often relegated to abstract memorization without cross-linking to gross anatomy or pathology. Bridging this gap through enhanced curriculum design, intertextual analysis, and 3D modeling offers promising avenues for bringing Kala Sharira into contemporary classroom and clinical practice.

Nevertheless, significant gaps remain in validating and visualizing Kala Sharira through empirical research. The lack of cadaveric studies, histological mapping, and imaging-based correlation constrains its acceptance within the broader biomedical discourse. Encouragingly, early initiatives in interdisciplinary modeling and digital visualization signal a growing appetite for such exploration. As Ayurveda increasingly engages with global health sciences, the call for integrative research—grounded in mutual respect and methodological pluralism—becomes not just desirable but essential.

In conclusion, the study of Kala Sharira is not a mere retrospective into classical thought, but a forward-looking framework that has the potential to reshape how we understand the body, its interfaces, and its healing processes. To realize this vision, the need is not to translate Ayurveda into the language of biomedicine alone, but to create a dialogical space where both systems can speak, listen, and learn from one another. The ancient science of Kala, in all its depth and dynamism, still speaks to the body—not only as an object of study but as a living, layered, and interconnected whole. It is now up to scholars, clinicians, and educators to ensure that this voice is heard, engaged, and advanced through critical, respectful, and integrative academic inquiry.

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