

Integrating Ayurvedic and Biomedical Perspectives on Shleshaka Kapha and Synovial Fluid: A Scoping Review

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ABSTRACT

In Ayurveda, Shleshaka Kapha is described as the lubricating and stabilizing factor of the joints, ensuring smooth movement and structural integrity. Modern biomedical science attributes similar functions to synovial fluid, a viscoelastic secretion that reduces friction, absorbs shock, and nourishes cartilage. However, a systematic mapping of the conceptual and physiological parallels between Shleshaka Kapha and synovial fluid has not yet been undertaken. This scoping review aimed to identify, synthesize, and analyze classical Ayurvedic and biomedical literature that correlate Shleshaka Kapha with synovial fluid function in joint physiology and pathology, thereby outlining integrative perspectives and future research opportunities. The review followed the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines, with searches conducted across PubMed, AYUSH Research Portal, TKDL, Google Scholar, and ResearchGate between 2000-2025. Classical Ayurvedic texts such as Charaka Samhita, Sushruta Samhita, and Ashtanga Hridaya were also screened. Eligible records included conceptual, narrative, and empirical studies addressing Shleshaka Kapha, Shleshmadhara Kala, or synovial fluid in relation to joint physiology. Sixty records were identified, of which fifteen met inclusion criteria for qualitative synthesis. Three overarching themes emerged: (1) Physiological function correlation-both Shleshaka Kapha and synovial fluid provide lubrication, cohesion, and shock absorption; (2) Anatomical equivalence-Shleshmadhara Kala corresponds to the synovial membrane; and (3) Pathological parallels-Shleshaka Kapha mirrors osteoarthritis and other degenerative joint conditions characterized by reduced synovial fluid quality. The findings suggest that Shleshaka Kapha and synovial fluid represent analogous constructs within Ayurvedic and biomedical paradigms. Bridging these perspectives may enrich understanding of joint physiology and inform integrative approaches to musculoskeletal disorders. Future interdisciplinary studies are warranted to empirically validate these conceptual links through biochemical and clinical models.

Keywords: Ayurveda, Joint physiology, Scoping review, Shleshaka Kapha, Synovial fluid.

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INTRODUCTION

The Tridosha theory, foundation of Ayurveda system, explains physiological functions at the cellular, systemic, and organism levels. Balanced doshas i.e vata pitta and kapha ensure metabolic harmony among body, mind, senses, and soul (Joshi *et al.*, 2021).

The Tridosha system emphasizes the functional rather than structural nature of doshas. Acharya Charaka identifies the chest

as Kapha's main site, with other key areas including the head, neck, joints, stomach, and fatty tissues (Suśruta Samhitā, Sūtra Sthāna 21/7) (Kapha's properties-heaviness (Guru), coldness (Sheeta), softness (Mridu), unctuousness (Snigdha), sweetness (Madhura), stability (Sthira), and sliminess (Pichhila)-maintain structure and function, while imbalance is treated with opposing qualities (Charaka Samhitā, Sūtra Sthāna 1/61,18/53)Kapha provides stability (Sthiratva), lubrication (Snehatva), cohesion (Sandarbhatva), and strength (Balam) and is classified into five subtypes: Avalambaka, Kledaka, Bodhaka, Tarpaka, and Shleshaka (Aṣṭāṅga Hṛdayam, Sūtra Sthāna 11/15). Among these, Shleshaka Kapha, located in the joints (Sandhis), acts as a lubricant enabling smooth, pain-free movement and maintaining joint health (Suśruta Samhitā, Sūtra Sthāna 21/14 and Aṣṭāṅga Hṛdayam, Sūtra Sthāna 12/18).



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This concept parallels modern synovial fluid, a viscous secretion from the synovial membrane in diarthrodial joints. Composed mainly of hyaluronic acid, lubricin (PRG4), and glycoproteins, it reduces friction, absorbs shocks, nourishes cartilage, and modulates immune activity. Kapha Dosha is predominantly composed of the Jala (water) and Prithvi (earth) Mahabhutas (Suśruta Saṃhitā, Sūtra Sthāna 15/6 and Aṣṭāṅga Saṃgraha, Sūtra Sthāna 20/2) which contribute to its cohesive and stabilizing properties. These elements provide moisture, flexibility, and structural integrity, underscoring Kapha's crucial role in maintaining joint health (Aṣṭāṅga Hṛdayam, Sūtra Sthāna 11/3). The concept reflects Ayurveda's advanced understanding of joint physiology, similar to the role of synovial fluid as a biological lubricant maintaining smooth movement and homeostasis (Hui *et al.*, 2012).

Despite detailed Ayurvedic descriptions, few studies correlate Shleshaka Kapha with synovial fluid biology. Biochemical and pathological parallels such as inflammatory effects on Kapha and synovial viscosity require deeper investigation. Clarifying these links may enhance integrative diagnostic and therapeutic approaches.

Thus, this scoping review aims to examine literature connecting Shleshaka Kapha and synovial fluid concerning joint physiology and pathology. It explores classical interpretations, biochemical and functional correlations, and comparative studies, while identifying research gaps and promoting interdisciplinary collaboration. The study follows the PRISMA-ScR framework to ensure methodological rigor and transparency.

METHODOLOGY

This scoping review explores the Ayurvedic concept of Shleshaka Kapha in relation to the biomedical understanding of synovial fluid, emphasizing their shared roles in joint lubrication, nutrition, and protection. The review followed the PRISMA Extension for Scoping Reviews (PRISMA-ScR, 2020) framework to ensure transparency, replicability, and methodological rigor.

A structured and comprehensive literature search was performed using multiple sources. Primary databases included PubMed, Google Scholar, AYUSH Research Portal, Research Gate, and the Traditional Knowledge Digital Library (TKDL). Manual searches were also conducted in classical Ayurvedic texts-Charaka Samhita, Sushruta Samhita, Ashtanga Hridaya, and Bhava Prakasha Nighantu-with English translations and scholarly commentaries. Relevant grey literature and institutional publications, including sources from platforms such as EasyAyurveda.com, were reviewed.

The search covered publications from 2000 to 2025 without study design restrictions. Only English-language sources or reliable translations were considered. Eligible studies discussed Shleshaka Kapha, Shleshmadhara Kala, or Kapha Dosha in relation to

joint physiology, or examined synovial fluid composition and function-including hyaluronan, lubricin (PRG4), and cartilage interactions. Both conceptual and empirical works were included.

In PubMed, the Boolean query used was: ("Shleshaka Kapha" OR "Kapha Dosha") AND ("Synovial Fluid" OR "Hyaluronan" OR "Joint Lubrication" OR "PRG4") AND ("Ayurveda" OR "Ayurvedic medicine"). Filters applied were English language, publication years 2000-2025, and human studies.

Search phrases for Google Scholar and AYUSH Portal included:

- "Shleshaka Kapha AND Synovial fluid AND Ayurveda".
- "Shleshmadhara Kala AND joint physiology".
- "Sandhigata Vata AND joint lubrication".

On TKDL, manual keyword searches such as "Kapha in joints," "Shleshaka," and "Snehana" were used, as advanced Boolean queries were unsupported.

Across all sources, 60 records were identified. After removing duplicates and irrelevant items, 45 records were screened by titles and abstracts, and 15 full-text articles met inclusion criteria for the final qualitative synthesis. The selection process is summarized in the PRISMA flow diagram, and the search strategy details are presented in the accompanying Table 1.

Data Extraction and Results

Data from the selected studies were systematically extracted and organized under the headings: author, publication year, study type, Ayurvedic or biomedical focus, and summary of key findings. The collected data were narratively synthesized to identify recurring themes, conceptual similarities, and existing research gaps.

A total of 60 records were initially identified through database and manual searches. After duplicate removal, 45 titles and abstracts were screened, and 15 full-text articles were reviewed. Of these, 7 conceptual or narrative studies and 8 classical Ayurvedic sources were included in the final synthesis. The article selection process is detailed in the PRISMA-ScR flow diagram (Figure 1).

The included literature was analyzed for themes related to the physiological, anatomical, and pathological aspects of Shleshaka Kapha and its parallels with the synovial fluid system in modern biomedical science. The findings were categorized into three main thematic areas.

Ayurvedic Aspects of Kapha and Shleshaka Kapha

The term Kapha originates from "kenajalenaphalati iti kapha," signifying its basis in water (Amarakośa, Dvitiya Kāṇḍa, Ṣaṣṭha Varga 62). Shleshma, another name for Kapha, comes from "shlisha alingane," meaning to adhere or maintain

cohesion (Suśruta Saṃhitā, Sūtra Sthāna 21/5). Kapha governs autonomous bodily functions but depends on Vata for movement (Śārṅgadharma Saṃhitā, Pūrva Khanda 5/43). Its key roles include promoting growth, anabolism, and physiological stability. Kapha provides lubrication (Snehana), moisture, and cohesion among body structures, maintaining joint integrity (Bandhana), strength (Sthirata/Dardhyata), and mass (Gauravata). It also supports reproductive vitality (Vrishta), endurance (Kshama), physical and mental strength (Bala), patience (Dhriti), nourishment (Upachaya), and emotional balance, fostering freedom from greed (Alobha) (Caraka Saṃhitā, Sūtra Sthāna 12/12). Together, these functions highlight Kapha's importance in sustaining physical and mental health.

Shleshaka Kapha, a subtype of Kapha, resides in the Sandhis (joints) and provides essential lubrication (Suśruta Saṃhitā, Sūtra Sthāna 21/7). Its attributes-shleshma (slickness), shweta (whiteness), guru (heaviness), snigdha (smoothness), and pichhila (slipperiness)-maintain joint structure and function (Suśruta Saṃhitā, Sūtra Sthāna 21/15). By imparting snigdha (smoothness), shlakshnata (softness), and picchilata (slipperiness), it minimizes friction between cartilage surfaces (Suśruta Saṃhitā, Sūtra Sthāna 21/14). The Shleshmadhara Kala (Suśruta Saṃhitā, Śārīra Sthāna 4/13-14) the connective tissue enveloping joints, further facilitates lubrication, acting like oil that enables smooth, pain-free motion (Aṣṭāṅga Hṛdayam, Sūtra Sthāna 11/15). In the Janu Sandhi (knee joint), Shleshaka Kapha plays a key role in cushioning and shock absorption, protecting bones during movement.

Synovial Fluid in Modern Science

In modern anatomy, synovial fluid closely corresponds to Shleshaka Kapha. This viscous, pale-yellow fluid fills the cavities of synovial joints, providing lubrication, reducing friction, and enabling smooth movement (Tortora and Derrickson, 2016). Its main function is to minimize friction between articular cartilages during motion. The synovial membrane, lining the inner surface of the fibrous and vascular synovium surrounding each joint, secretes this fluid (Tamer, 2013). Key components such as Proteoglycan 4 (PRG4), Surface-Active Phospholipids (SAPL), and hyaluronan are vital for boundary lubrication, preventing adhesion and reducing wear over time (Schmidt *et al.*, 2007). Synovial fluid forms a thin protective layer within the articular capsule, ensuring low friction, high viscosity, and joint durability. It also absorbs shocks, delivers oxygen and nutrients to chondrocytes, removes waste products, and maintains joint cleanliness through phagocytic activity (Tortora and Derrickson, 2016).

Correlation Between Shleshaka Kapha and Synovial Fluid and Their Functional Attributes

Synovial fluid, secreted by the synovial membrane, shows strong resemblance to Shleshmadhara Kala (Suśruta Saṃhitā, Śārīra

Sthāna 4/13-14) and Shleshaka Kapha. It contains Hyaluronic Acid (HA), lubricin, proteins, and synoviocytes. HA provides viscosity and elasticity, enabling smooth joint movement, while Shleshaka Kapha offers similar lubricating and cohesive functions that prevent degeneration and maintain joint integrity.

Proteoglycan 4 (PRG4) and Hyaluronan

Modern Equivalents of Shleshaka Kapha's Role Lubricin, or Proteoglycan 4 (PRG4), a mucin-like glycoprotein found in articular cartilage and synovial fluid, is vital for maintaining joint function and integrity (Kwieciński *et al.*, 2011). Reduced levels of this lubricant after injury increase cartilage wear, accelerating post-traumatic degeneration and osteoarthritis (Elsaid *et al.*, 2008). Hyaluronan, a high-molecular-weight glycosaminoglycan, acts as a lubricant and shock absorber due to its hydrophilic nature, helping retain water to keep cartilage hydrated and resilient (Gupta *et al.*, 2019).

These properties parallel Shleshaka Kapha's soft, cohesive, and lubricative qualities that protect joints during movement. Hyaluronan also facilitates nutrient transport within the joint, reflecting Shleshaka Kapha's supportive function in tissue nourishment (Suśruta Saṃhitā, Sūtra Sthāna 15/5).

The term Kapha originates from "kenajalenaphalatiitikapha," indicating its water-based nature, analogous to HA's hydrophilic properties. Based on Ayurvedic principles, Kapha predominantly arises from Jala Mahabhuta, as noted by Acharya Sushruta, emphasizing its Saumya (watery) origin. Thus, both synovial fluid and Kapha share foundational roles in sustaining joint stability and function. Table 2 demonstrates the conceptual similarity between synovial membrane and synovial fluid functions in modern medicine and the Ayurvedic concepts of Śleşmadhara Kalā and Śleşaka Kapha.

It suggests that lubrication, shock absorption, hydration, cartilage resilience, nutrient transport, and anti-inflammatory protection can be understood through the Kapha attributes of guru, picchila, sthira, and jala-mahābhūta predominance.

Table 3 compares the synovial fluid changes observed in rheumatoid arthritis and osteoarthritis with the Ayurvedic concepts of Āmavāta and Sandhigata Vāta. It highlights the role of Śleşaka Kapha in maintaining joint lubrication and explains how its vitiation or depletion contributes to disease pathogenesis.

Summary of Extracted Data Of the 15 studies reviewed:

- 7 were conceptual or narrative reviews connecting Shleshaka Kapha with synovial fluid.
- 5 were classical Ayurvedic texts describing its anatomical and functional aspects.
- 3 provided comparative or visual analyses of Ayurvedic and biomedical joint anatomy.

Most sources recognized a strong functional correlation between Shleshaka Kapha and synovial fluid, though empirical validation remains limited.

A detailed summary of the extracted data is shown in Table 1, and the PRISMA flow diagram illustrating study selection is provided in Figure 1.

Jain *et al.* (2025), published in Journal of Ayurveda and Integrated Medical Sciences (J Ayu Int Med Sci), conducted a conceptual review exploring the correlation between Shleshaka Kapha and synovial fluid. The study emphasized that both entities share essential physiological functions such as lubrication, shock absorption, and maintaining cohesion within the joints. The authors highlighted the close functional resemblance between Ayurvedic concepts of joint stability and modern understanding of synovial fluid dynamics.

Suthar *et al.* (2024), in the Asian Journal of Biological and Life Sciences, carried out a PRISMA-based review focusing on the

physiological and anatomical mapping of Kapha. Their findings suggested that synovial secretions closely mirror the functions attributed to Kapha in Ayurveda. The review particularly emphasized the importance of lubricin and hyaluronan, explaining how these substances contribute to lubrication and cushioning, analogous to the role of Shleshaka Kapha in maintaining joint health.

Sharma *et al.* (2024), writing in JETIR, presented a conceptual analysis examining the functional overlap between the doshas and joint structures. The authors equated the qualities of Shleshaka Kapha with the viscosity and stabilizing properties of synovial fluid. Additionally, they proposed that Shleshaka Kapha may also have an immunomodulatory role, similar to the protective and regulatory functions of synovial components within the joint environment.

Kumar *et al.* (2024), through a comparative physiology study available on ResearchGate, analyzed the relationship between Shleshmadhara Kala and the synovial membrane. Their work

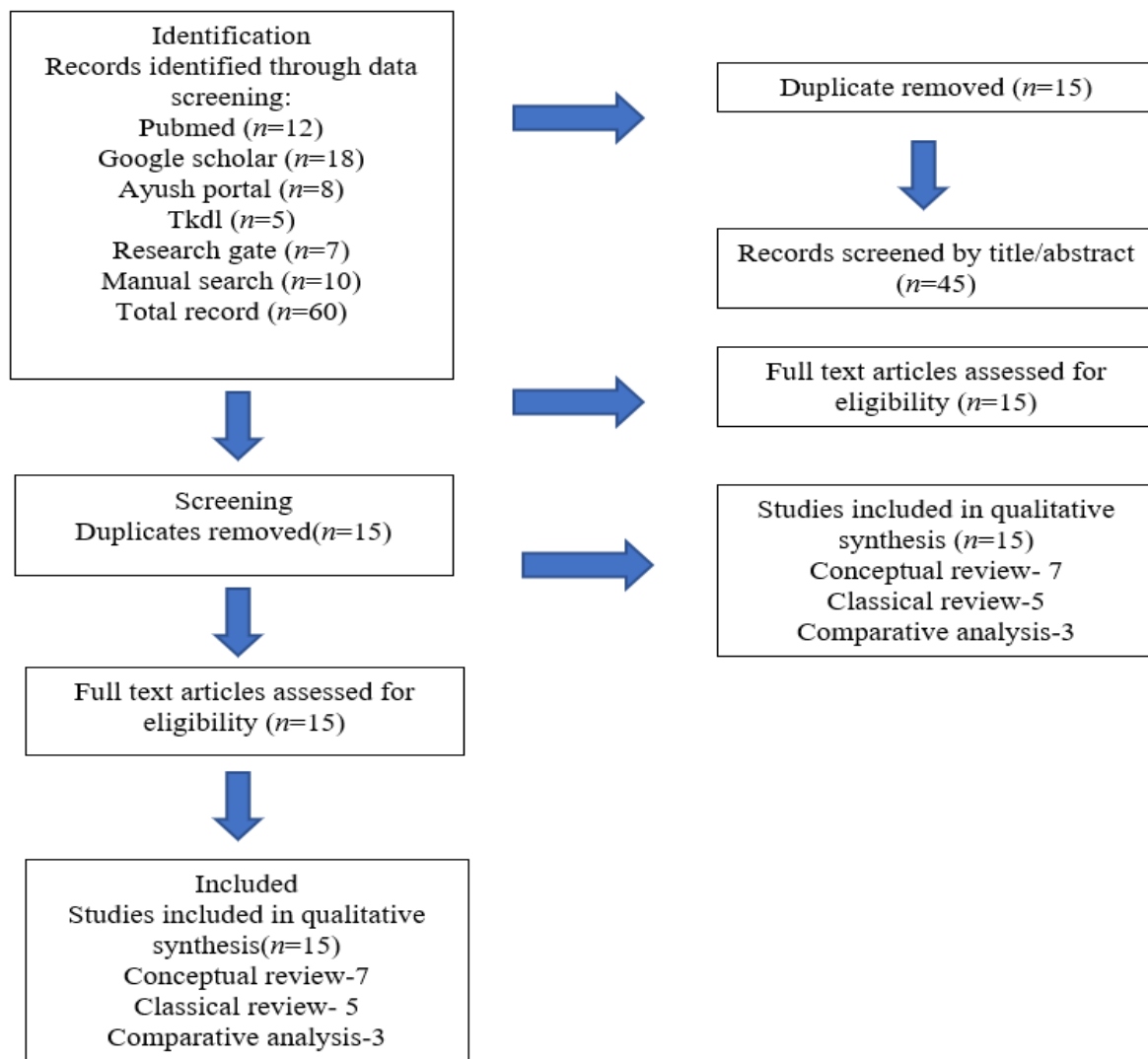


Figure 1: PRISMA 2020 Flow diagram- scoping review of shlesaka kapaha and synovial fluid.

Table 1: Search strategy details.

Database / Source	Search Query	Filters Applied	Results Retrieved	Records Screened	Records Included
PubMed	("Shleshaka Kapha" OR "Kapha Dosha") AND ("Synovial Fluid" OR "Hyaluronan" OR "Joint Lubrication" OR "PRG4") AND ("Ayurveda" OR "Ayurvedic medicine")	English; 2000-2025; Humans	12	10	4
Google Scholar	"Shleshaka Kapha" AND "Synovial Fluid" AND Ayurveda	Year: 2000-2025	18	14	3
AYUSH Research Portal	"Shleshaka Kapha", "Shleshmadhara Kala", "Sandhigata Vata AND Synovial Fluid"	Language: English; Year: 2000-2025	8	6	2
TKDL	"Kapha in joints", "Shleshaka", "Snehana"	Manual search	5	3	1
ResearchGate	"Shleshaka Kapha and Synovial Fluid", "Ayurveda Joint Lubrication"	Open-access, peer-reviewed	7	5	2
Manual Search	Charaka Samhita, Ashtanga Hridaya, Easy Ayurveda, Bhava Prakasha Nighantu (English translations); Articles from institutional repositories and Ayurvedic commentaries	Not applicable	10	7	3
Total	-	-	60	45	15

Table 2: Presents a comparative overview of synovial fluid components and Shleshaka Kapha as described in Ayurveda.

Modern Concept	Ayurveda Corelation
Synovium Membrane	Shleshmadhara kala
Synovial Fluid -Hyaluronan, Lubricin, PRG4	Shleshaka Kapha
a high-molecular-weight glycosaminoglycan	Guru Guna of kapha- heaviness
Provides lubrication	sliminess (Pichhila)
Shock absorption	Protection and cushioning
maintaining the hydration	Udakakarmana- main work of kapha
Resilience of cartilage.	stability (Sthira) quality of kapha
Protection of articular cartilage and the transport of nutrients to cartilage. Protection against inflammatory damage	Prakruta karma of kapha - ropana, purana, bala provider
Hydrophilic nature of HA	Jala Mahabhuta Predominant

suggested a structural equivalence between the synovial membrane and the secretory functions attributed to Shleshaka Kapha. The study proposed that Ayurvedic descriptions of tissue layers and secretions can be meaningfully compared with modern anatomical concepts of synovial structures.

The EasyAyurveda article (2018), categorized as a web-based traditional commentary, provided a public educational explanation of Kapha subtypes. The resource discussed the

dual forms of Kapha and clearly paralleled the functions of Shleshaka Kapha with those of synovial fluid, particularly in terms of lubrication, nourishment, and maintaining smooth joint movements.

The Charaka Samhita, a primary classical Ayurvedic text, describes Shleshaka Kapha as being located in the joints (Sandhi). It explains that this subtype of Kapha is responsible for stabilizing and lubricating the joints, thereby ensuring proper articulation and protection from friction-related degeneration.

Similarly, the Ashtanga Hridaya, another foundational Ayurvedic medical treatise, elaborates on the subdivisions of doshas and their functional anatomy. It states that Shleshaka Kapha governs joint articulation, provides unctuousness, and prevents dislocation. These descriptions closely resemble the biomechanical and lubricating roles attributed to synovial fluid in modern medicine.

The Bhava Prakasha, an important Ayurvedic reference text, discusses the pathological consequences of Shleshaka Kapha depletion (Shleshaka Kshaya). It describes degeneration and dysfunction of the joints arising from this depletion, drawing a strong parallel with the pathology of osteoarthritis and the deterioration of synovial lubrication recognized in contemporary medicine.

The TKDL Search (2025), based on the Traditional Knowledge Digital Library archival database, extracted formulations and references related to Kapha functioning in the joints. Although indirect, the database descriptions highlighted the secretory and lubricating aspects of Kapha, supporting the conceptual association between Shleshaka Kapha and synovial fluid.

Table 3: Outlines these synovial fluid alterations and their Ayurvedic interpretation.

Condition	Ayurveda Correlation	Changes in synovial fluid	Ayurveda Explanation
Inflammatory (RA)	Amavata	- Increased SF volume - Reduced HA concentration- Decreased viscosity- High polymorph count- Presence of inflammatory mediators	The Guru (heavy), Snigdha (unctuous), and Drava (fluidic) qualities of Ama exacerbate similar qualities in Shleshaka Kapha. This further vitiates Shleshaka Kapha, in conjunction with aggravated Vata, resulting in Sandhi Shotha (joint swelling), Shoola (pain), and Gaurava (heaviness).
Non-inflammatory (OA)	Sandhigata vata	- Reduced HA concentration - Lower viscosity- Altered lubricant quality- Early cartilage wear evident	Ruksha (dry) and Khara (rough) qualities of vitiated Vata in Sandhigata vata deplete the Shleshaka Kapha, reducing its protective and lubricating properties.

The AYUSH Portal Summary (2023), categorized as grey literature, reviewed clinical observations and trials concerning Sandhigata Vata associated with joint effusion. The summary reported that loss of lubrication and pain in affected joints were conceptually interpreted as manifestations of Shleshaka Kapha depletion, reinforcing the Ayurvedic explanation of degenerative joint disorders.

Patel *et al.* (2023), in an integrative narrative review published by IntechOpen, explored the relationship between the dosha-kala-srotas system and modern anatomy. The authors proposed an integrative framework in which Shleshaka Kapha corresponds to synovial fluid, suggesting that Ayurvedic physiological concepts can be systematically mapped onto contemporary anatomical and functional understanding of joints.

DISCUSSION

Ayurveda's Tridosha theory governs biological functions at cellular, systemic, and organismal levels. Among the three doshas, Kapha maintains stability, growth, and cohesion, manifesting as heaviness, coolness, and lubrication-qualities vital for physiological and structural balance. The Shleshaka Kapha subtype specifically supports joint health by providing lubrication, stability, and frictionless motion. In weight-bearing joints like the knees, it aids in cushioning and shock absorption-functions closely resembling those of synovial fluid in modern anatomy.

Synovial fluid, a viscous joint-cavity secretion, reduces friction, absorbs shock, and maintains joint homeostasis. Composed of lubricin, hyaluronan, and proteins, it ensures lubrication, nutrient supply, and cartilage protection essential for joint integrity. Disruptions in synovial fluid composition, as seen in osteoarthritis, rheumatoid arthritis, and joint injuries, are associated with altered cytokine and growth factor activity and increased molecular transport across tissues (Hui *et al.*, 2012).

The parallels between Shleshaka Kapha and synovial fluid are evident: Shleshaka Kapha's cohesive and lubricative roles

reflect the properties of hyaluronan, while Shleshmadhara Kala corresponds anatomically to the synovial membrane-both essential for stability and lubrication.

CONCLUSION

This scoping review identifies strong conceptual and functional similarities between Shleshaka Kapha and synovial fluid. Both govern lubrication, cohesion, cushioning, and joint protection. Classical texts like Charaka Samhita and Ashtanga Hridaya describe Shleshaka Kapha as the force behind joint mobility, closely paralleling the role of synovial fluid. Anatomically, Shleshmadhara Kala aligns with the synovial membrane, and Shleshaka Kshaya symptoms-stiffness, dryness, and painful motion-mirror osteoarthritis and rheumatoid arthritis, where synovial fluid degradation occurs.

Despite conceptual harmony, empirical evidence connecting these systems is limited. Interdisciplinary research using biomolecular studies, imaging, and clinical trials is needed to validate these relationships. Such integration may advance evidence-based Ayurveda and improve joint disease management.

In essence, Shleshaka Kapha and synovial fluid represent equivalent constructs in their respective paradigms, offering complementary insights into joint physiology and pathology. Bridging these perspectives can enhance both preventive and therapeutic approaches in integrative musculoskeletal care.

FURTHER SCOPE

This review demonstrates conceptual alignment but limited empirical support between Shleshaka Kapha and synovial fluid. Future research should include biochemical studies on joint lubricants, histological mapping of Shleshmadhara Kala, and clinical evaluation of Ayurvedic therapies such as Snehana and Rasayana on synovial properties. These efforts could create measurable biomedical correlates for Ayurvedic concepts.

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ABBREVIATIONS

HA: Hyaluronic Acid; **J Ayu Int Med Sci:** Journal of Ayurveda and Integrated Medical Sciences; **OA:** Osteoarthritis; **PRG4:** Proteoglycan 4; **PRISMA-ScR:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews; **RA:** Rheumatoid Arthritis; **SAPL:** Surface-Active Phospholipids; **SF:** Synovial Fluid; **TKDL:** Traditional Knowledge Digital Library.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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