ISSN: 2320-7329

http://www.ayurlog.com

July-Sept: 2025 | Volume: 13th | Issue: 3rd

NATIONAL JOURNAL OF RESEARCH IN AYURVED SCIENCE

Article Received Date: 12/08/2025 Reviewed on Date: 24 /09/2025 Accepted on: 23/10/2025

The Role of AI Tools and Their Implementations in *Śālākya-Tantra* in the Present Era

Rajendra Dhate, *M.S. (Shalakyatantra)* Professor & HOD, Department of *Śālākya-Tantra*, R. A. Podar Medical College (*Ayu*), Worli, Mumbai-18

Author Correspondence: rajudhate@gmail.com

Abstract

Śālākya-Tantra, encompassing *Netra* (ophthalmology), *Karṇa* (otology), *Nāsā* (rhinology), *Mukha–Danta* (oral/dental), *Kaṇṭha* (laryngo-pharyngeal), and *Śira* (head), addresses the supraclavicular region and traditionally relies on keen observation, careful history, and deft procedures. Simultaneously, modern Artificial Intelligence (AI) has advanced in medical imaging, language understanding, signal processing, clinical decision support, and simulation. This work maps the landscape of AI tools relevant to *Śālākya-Tantra*.

The methodology utilized a narrative review and practice-oriented synthesis, integrating current AI capabilities with classical *Ayurvedic* principles, including *nidāna pañcaka*, *doṣa-doṣya-saṃmūrcchanā*, *srotas*, and *kriyākalpās* such as *tarpana*, *putapāka*, *anjana*, *nasya*, and *karṇapūraṇa*. A pragmatic roadmap and evaluation framework were also proposed.

Five main clusters of impact emerged: (1) AI for vision and otoscopy triage and follow-up; (2) acoustic analysis for *kaṇṭha* and naso-sinusal disorders; (3) Natural Language Processing (NLP) over regional-language and *Sanskrit* texts for classical–contemporary knowledge mapping; (4) educational auto-feedback systems, such as *OSCE* auto-scoring, aligned to *Miller's Pyramid*; and (5) operational AI for *tele-Śālākya*, outcome tracking of *kriyākalpās*, and appointment prioritization.

AI holds the potential to strengthen *Śālākya-Tantra* by enhancing standardization, early detection, and continuity of care while still respecting *Ayurvedic* therapeutics and diagnostics. Safe and equitable adoption necessitates explainability, contextual datasets, bias control, rigorous prospective evaluation, and data governance aligned with *ABDM*.

Keywords: *Śālākya-Tantra*, *Ayurveda*, Ophthalmology, Otology, NLP, Medical Imaging, Telemedicine, *Kriyākalpā*, *Miller's Pyramid*, Ethics.

1. Introduction

Śālākya-Tantra is recognized as one of the eight major branches of *Ayurveda*. It specifically deals with diseases situated above the clavicle, focusing on the ear, eye, head, nose, throat, and oral cavity. Classical texts place high importance on *pratyakṣa* (inspection), *anumāna* (inference), *upamāna* (comparison), and a rich procedural armamentarium. This procedural scope includes therapies such as *tarpana*, *putapāka*, *anjana*, *nasya*, *karṇapūraṇa*, and *śirobasti*.

AI is currently capable of pattern recognition and prediction at scale. For *Śālākya-Tantra*, AI naturally intersects with areas that are image-intensive (e.g., nasal endoscopy, otoscopy, slit-lamp images, fundus photos), signal-rich (e.g., breathing acoustics, voice), and heavy in knowledge text (e.g., case records, *Sanskrit ślokas*). This research connects the capabilities of AI with the specific needs of *Śālākya-Tantra*, proposing a staged adoption plan and necessary guardrails for *AYUSH* teaching hospitals.

2. Background and Rationale

2.1 Diagnostic Pillars in *Śālākya-Tantra*

The foundation of *Śālākya-Tantra* diagnosis rests upon several pillars:

1. ***Nidāna pañcaka***: This includes *nidāna*, *pūrvarūpa*, *rūpa*, *upaśaya*, and *samprāpti*.
2. ***Doṣa–doṣya–saṃmūrcchanā*** and *srotas* considerations, particularly within *Netra*/*Karṇa*/*Nāsā*.
3. ***Pramāṇa parīkṣā***: Methods such as inspection, special tests, local examination, and palpation.
4. ***Kriyākalpā***: Procedures aimed at restoring local tissue function and *doṣic* balance.

2.2 Rationale for AI Adoption Now

AI adoption is timely due to several developments:

- The growing utility of smartphone-grade otoscopes and cameras.
- Policy momentum in India supporting interoperable data and digital health records.
- Improvements in NLP for low-resource languages, including *Kannada*, *Marathi*, *Sanskrit*, and *Hindi*.
- The growth of on-device inference and explainable imaging AI.

3. Taxonomy of AI Tools for *Śālākya-Tantra*

A taxonomy of relevant AI tools can be clustered into six categories:

1. **Imaging AI (Computer Vision)**:
    - ***Netra***: Involves classification and segmentation for *OCT/OCT-A*, *meibography*, corneal topography, anterior segment, and fundus photos.
    - ***Karṇa***: Uses otoscopy image classifiers to determine *tympanic membrane* status, or

identify otitis *externa*/*media*, and otomycosis.

- ***Nāsā* & *Kaṇṭha***: Applies endoscopy video analysis for identifying laryngitis, deviated septum, or polyps, along with dental/oral lesion detection.

2. **Signal/Audio AI**: Used for assessing *TMJ*, chewing sounds, screening *OSA* risk via breathing and snore sounds, and analyzing voice acoustics for nasality indices, vowel perturbation, and dysphonia.
3. **Natural Language Processing (NLP)**: Involves knowledge graphs that link *kriyākalpā* ↔ signs/symptoms ↔ *rūpa*. It also includes aligning *Sanskrit*/*Prakrit* verses to modern terminology and automating case-sheets in regional languages.
4. **Decision Support & Prediction**: Provides triage scores by combining images, vitals, *avasthā*, *hetu*, and *doṣa prakṛti*. It also facilitates relapse-risk prediction following *nasya* or *tarpana* and appointment prioritization.
5. **Education & Simulation**: Offers *OSCE* auto-scoring using checklists and video mapped to *Miller's Pyramid* (*Knows* → *Knows How* → *Shows How* → *Does*). Examples include virtual otoscopy or slit-lamp simulators.
6. **Operations & *Tele-Śālākya***: Includes procedural safety checklists, remote triage, reminder systems, and stock forecasting for *disposables*, *lepa*, *taila*, and *ghṛta*.

4. High-Value Clinical Use-Cases

4.1 *Netra* (Ophthalmology)

AI assists in screening and triage by providing on-device detection of red-flags, such as *papilledema* cues, proliferative changes, and corneal ulcer risk. For dry eye and lid margin disease, AI measures tear film breakup analysis and *meibography*. Progress dashboards help evaluate *śirobasti*, *tarpana*, and *anjana* adjuncts. Automated visual acuity workflows are provided via gamified apps for follow-up and camps.

4.2 *Karṇa* (Otology)

Smart otoscopy uses image classifiers to flag suspicion of cholesteatoma, perforations, or otomycosis, which is relevant for clinical studies. AI-assisted audiometry and classification of tympanograms are available for hearing health. Adherence nudges can be provided for ear-drop regimens, including *arka taila* or other medicated oils, where safety and tradition permit.

4.3 *Nāsā* (Rhinology) & *Kaṇṭha* (Laryngology)

Endoscopy analysis aids in scoring mucosal edema and polyp burden, and visualizing treatment response for *nasya* protocols. Voice analytics provide objective measures of *śabda* quality in *kaṇṭhagat rogas* and track progress following herbal steam or *kaval*/*gaṇḍūṣa*.

4.4 *Mukha–Danta* (Oral/Dental) & *Śira*

AI screening aids in camps for detection of precancer, lichen planus, or ulcers. For headache patterns, AI assists in phenotype clustering to differentiate migraine patterns from *vāta-kapha* dominated sinusitis, helping tailor *nasya*, *śirobasti*, or diet counsel.

5. Aligning AI with *Ayurvedic* Diagnostics

AI outputs must serve to augment *yukti* (clinical reasoning), not replace it. This requires careful alignment:

1. **Feature mapping**: Model features (e.g., corneal staining area) should be linked to *pūrvarūpa*/*rūpa* descriptors.
2. **Contextual priors**: Models must incorporate *Ayurvedic* context by including *prakṛti*, *āhāra-vihāra*, *deśa* (locale), and *ṛtu* (season).
3. **Outcome measures**: Beyond simple accuracy, models should learn from labels tracking *upaśaya–anupaśaya* responses following *kriyākalpā*.

6. Education: *Miller's Pyramid*, *OSCE*, and Competency

AI can be integrated into competency assessment using *Miller's Pyramid*:

- ***Knows***: AI generates *MCQs* from classical texts and lecture notes.
- ***Knows How***: Short-answer stations test *doṣa* inference based on lid signs.
- ***Shows How***: Video *OSCE* assesses the student performing a slit-lamp exam, with AI checking the sequence, illumination angle, hand hygiene, and documentation of findings.
- ***Does***: AI provides feedback trends and summarizes case-mix in workplace-based assessment.

An *OSCE* Auto-Feedback Checklist provides specific assessment criteria, such as systematic inspection of *vartma* margins, *pakṣma*, and *bhru*. It identifies *meibomian* plugging, *trichiasis*, and *madarosis*, and integrates the *upaśaya* plan and *doṣa* inference. AI provides a skill-gap report and timestamped feedback.

7. Research Opportunities Unique to *Śālākya-Tantra*

Opportunities for unique research include:

- NLP over classical texts to map *śloka*-level evidence to modern phenotypes and create open ontologies for *Netra*/*Karṇa*/*Nāsā*.
- Prospective validation of AI triage for dry eye and otomycosis within *kriyākalpā* care pathways.
- Digital twins used to predict patient response to *karṇapūraṇa*/*nasya*/*tarpana* using local signs and baseline constitution.
- *Herbo-pharmacology* mining through knowledge graphs linking *dravya guṇa* to tissue tropism in *ENT*/*ocular* contexts.
- Community screening models utilizing village-level smartphone *fundus* capture/*otoscopy* combined with AI triage and *AYUSH* follow-up.

8. Ethics, Safety, and Governance

AI tools must be treated as a "second reader," ensuring the clinician retains primacy and clear fail-safes are in place for red-flag escalation, prioritizing patient safety.

Ethical deployment requires curating datasets from Indian and regional populations to ensure representativeness, covering different age ranges, comorbidities, and skin tones. Explainability features, such as *saliency maps* and feature attributions, are mandated to support *yukti* and learning. Data privacy must comply with national digital health frameworks, including *ABDM* alignment, consent, and de-identification. Informed consent and transparency are crucial, ensuring patients understand when AI is utilized and its influence on decisions. It is vital to guard against the oversimplification or "algorithmic reductionism" of *doṣa-dhātu-mala* concepts.

9. Implementation Roadmap

A suggested roadmap for an *AYUSH* Teaching Hospital involves four phases:

- **Phase 0 (Readiness)**: Form an *AI-Śālākya* Task Force (IT, clinicians, ethics, legal). Define priority use-cases (e.g., voice analysis for dysphonia, dry-eye follow-up, smart otoscopy for otomycosis triage). Approve consent forms and data governance *SOPs*.
- **Phase 1 (Pilot)**: Deploy a basic classifier and smartphone otoscope (offline capable). Start a prospective registry documenting *rūpa*, images, *śārīrika prakṛti*, demographics, interventions (*kriyākalpā*), and outcomes. Train clinicians, calibrate thresholds, and minimize false reassurance.
- **Phase 2 (Scale)**: Integrate with *EMR*. Launch *OSCE* auto-feedback for two procedures (e.g., otoscopy and lid exam). Enable *tele-Śālākya* for follow-ups via voice/photo uploads. Add *NLP* templates for bilingual case-sheets (English + local language), mapping terms to *ICD* descriptors and classical terms.
- **Phase 3 (Sustain & Publish)**: Audit equity (subgroup performance), safety metrics, and patient experience. Expand to oral-lesion screening and nasal endoscopy. Publish pilot results and, when feasible, open-source de-identified datasets/ontologies.

10. Conclusion

AI can significantly augment *Śālākya-Tantra* by standardizing documentation, sharpening observation, and extending care into communities, while successfully preserving classical therapies and reasoning. Responsible deployment demands clinician leadership, context-rich data, ethical guardrails, and rigorous evaluation. When these factors are in place, AI serves as a *sahakārī* (ally) to the *Śālākya* clinician, improving outcomes across *Kaṇṭha*, *Mukha–Danta*, *Nāsā*, *Karṇa*, *Netra*, and *Śira*.

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Conflict of Interest: None

Source of funding: Nil

Cite this article:

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Ayurlog: National Journal of Research in Ayurved Science- 2025; (13) (03): 01-06