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FROM PUSTA TO PLASTINATION: EVOLUTION OF ANATOMICAL TEACHING MODELS

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ABSTRACT

Background: Anatomical education has evolved from early simulation-based training methods to advanced preservation techniques that improve accessibility, durability, and educational effectiveness. Classical Ayurvedic literature describes *Pusta* (dummy models) as teaching aids for repeated surgical and obstetric practice, while Western medicine later developed artificial anatomical models to overcome ethical and practical limitations associated with cadaveric dissection. Plastination represents a significant advancement in this historical continuum by preserving authentic human tissues for long-term educational use. **Objective**: To examine plastination as a modern teaching model in anatomy by comparing its educational role with the simulation-based learning approach of *Pusta* and the historical evolution of Western anatomical models. **Methods**: A narrative review was conducted using classical Ayurvedic texts, historical literature on Western anatomical models, and contemporary evidence on plastination in anatomical education. The analysis focused on educational purpose, material selection, anatomical fidelity, durability, and learner engagement. **Results**: Classical texts describe *Pusta* as models constructed from materials such as cloth, leather, clay, wood, and metal to facilitate repeated practice of surgical procedures and obstetric manipulations. Contemporary evidence indicates that plastinated specimens preserve three-dimensional anatomical relationships while providing durable, odorless, and reusable teaching resources. Studies further demonstrate that plastinated specimens improve visualization of complex anatomical structures, enhance spatial

understanding, and provide safe, accessible learning environments that complement traditional cadaveric teaching. **Conclusion**: Plastination represents the technological maturation of simulation-based anatomical education. When viewed alongside *Pusta* and historical Western anatomical models, it demonstrates that the fundamental educational principles of repeated practice, ethical resource utilization, and anatomical understanding have remained consistent while preservation materials and teaching technologies have progressively evolved.

KEYWORDS: Plastination, Anatomical Education, Simulation - Based Learning, *Pusta*, Anatomical Models, Medical Education.

1. INTRODUCTION

Anatomy forms the foundation of medical education, providing the structural knowledge essential for clinical reasoning, surgical practice, and diagnostic interpretation. Traditionally, cadaveric dissection has been regarded as the gold standard for learning human anatomy because it offers direct exposure to authentic anatomical relationships and natural anatomical variations. However, contemporary medical education has witnessed a gradual transformation in teaching methods due to reduced curricular hours, limited availability of cadavers, ethical considerations, maintenance requirements, and the increasing need for durable and accessible teaching resources. Consequently, anatomical education has progressively incorporated complementary instructional models that preserve anatomical realism while improving safety, accessibility, and long-term educational value.

The concept of learning through repeated practical experience is deeply rooted in classical Ayurvedic literature. The *Sushruta Saṃhita*, *Astanga Hṛidaya*, and *Astanga Sangraha* emphasize *Abhyasa* (repeated practice) as an essential prerequisite for developing surgical competence. These texts describe *Pusta* (dummy models) as teaching aids that enabled students to repeatedly practice procedures such as incision (*chedana*), excision (*bhedana*), suturing (*sivana*), bandaging (*bandhana*), and obstetric manipulations without relying on cadaveric dissection. Constructed from readily available materials including cloth, leather, clay, wood, and metal, these models were designed to approximate the form and consistency of different parts of the human body, allowing learners to develop practical skills within the ethical and cultural framework of ancient India.

Centuries later, Western medicine encountered comparable educational challenges. Restrictions on human dissection and the scarcity of cadavers during the medieval and early modern periods encouraged the development of artificial anatomical models made from wax, wood, ivory, plaster, fabric, rubber, and other materials.[1] These models became valuable teaching resources for anatomy, surgery, midwifery, and artistic anatomy by providing opportunities for repeated practice and observation while reducing dependence on human remains. Although their materials and anatomical accuracy differed, they reflected a common educational objective of making anatomical learning more accessible, ethical, and practical.

Within this historical progression, plastination represents a significant advancement in anatomical teaching. Developed by Gunther von Hagens in 1977, plastination preserves authentic biological tissues by replacing water and lipids with curable polymers such as silicone, epoxy, and polyester, producing dry, odorless, durable, and anatomically accurate specimens suitable for long-term educational use.[2] Unlike conventional wet specimens, plastinated specimens can be repeatedly handled, transported, and incorporated into classroom teaching, small-group instruction, radiological correlation, and museum-based learning while preserving the three-dimensional organization of human anatomy. Contemporary educational research has further demonstrated that plastinated specimens enhance the visualization of complex anatomical relationships, improve spatial understanding, and provide safer learning environments by eliminating continuous exposure to formalin.

Viewed collectively, *Pusta*, historical Western anatomical models, and plastination represent successive developments in anatomical teaching. While the materials evolved from clay and leather to wax and ultimately to advanced polymers, the underlying educational principles of repeated practice, ethical use of teaching resources, and accurate understanding of human anatomy have remained remarkably consistent.

Therefore, the aim of this study was to examine plastination as a modern teaching model in anatomy by comparing its educational role with *Pusta* described in classical Ayurvedic literature and the historical development of Western anatomical models.

2. MATERIALS AND METHODS

2.1 The Concept of *Pusta* - *Ayurveda's* Classical Learning Model

The *Sushruta Samhita* provides clear guidance on the necessity of practice before surgical performance.

"पुस्तमयपुरुषाङ्गप्रत्यङ्गविशेषेषु बन्धनयोग्या"

This verse, found in both the *Sushruta Saṃhita*[3] and the *Astanga Sangraha*[4], highlights the practice of *Bandhana Karma* (bandaging) on *Pusta*, dummy models crafted from materials such as cloth (*vastra*) and other materials.

Aachrya Dalhana,[5] in his commentary *Nibandha Sangraha on Sushruta samhita*, explains:

पुस्तमयेत्यादि पुस्तमयः पुरुषो वस्त्रादिरचितो मनुष्यः।

In this context, "*Pustamaya*" refers to a training human figure made from cloth or other materials.

Similarly, *Bhanumati commentary*[6] *on Sushruta samhita sutra sthana* interprets:

"पुस्तमयो वस्त्रादिरचितः पुरुषः।"

"Pustamaya" is a man-like figure constructed from cloth and other materials."

In order to serve as ethical teaching tools, these models were created to mimic human body parts (*Anga-Pratyanga*).

Further, In *Astanga Hridya, Arundutta's* commentary,[7] it is stated:

"पुस्तो दार्य्यादिमय्याः ख्याद्याकृतेरुपादानकारणं यद्वस्तु तदुच्यते।"

"मृदा वा दारुणा वाऽथ वस्त्रेणाप्यथ चर्मणा। लोहरत्नैः कृतं वाऽपि पुस्तमित्यभिधीयते।

Which means a *Pusta* is an object made of clay (*mṛda*), wood (*daruṇa*), cloth (*vastra*), leather (*carma*), or metals (*loha-ratna*), crafted into a recognizable form for surgical training.

These models were particularly useful for simulating anatomical parts, allowing safe practice of incisions (*chedana*), excisions (*bhedana*), suturing (*sivana*), and obstetric manipulations.

Classical texts such as the *Sushruta Samhita* (with *Dalhana* and *Bhanumati's* commentary), the *Ashtanga Hridaya* (with *Arundatta's* commentary), and the *Ashtanga Sanghraha* clearly describe their composition from clay, leather, and wood, despite the fact that no physical models of *Pusta* have survived. These texts consistently highlight *Pusta* as a remarkable educational innovation in *Ayurveda.*

Ayurveda's strong commitment to ethics and responsible medical teaching was reflected in the creation of *Pusta*, which was more than just a temporary solution. The dead were considered holy in ancient India, and touching a corpse was frequently regarded as ritually impure, particularly in *Brahmanical* communities. However, *Ayurveda* was a science that required practice in addition to theory. Students needed to figure out how to learn without crossing these spiritual and cultural lines in order to become competent and safe surgeons. Simulation, an early development in technology-based learning that struck a balance between moral considerations and the requirement for skilled medical training, provided the solution. In obstetrics, this is particularly noticeable. Water-filled leather *Pusta* simulated the amniotic sac, enabling trainees to practice fetal repositioning for the purpose of managing *Mudhagarbha* (complicated pregnancies) and studying *Prasava Kalin Gatiyan* (labor movements).[8] *Pusta* is therefore a prime example of how *Ayurveda* applies *Yukti*, or rational ingenuity, as demonstrated by the creation of cutting-edge teaching resources for medical education.

2.2 Plastination – The Modern Technological Parallel

The continuing challenges of cadaver availability, ethical considerations, specimen deterioration, and formalin exposure have encouraged the adoption of plastination as an advanced teaching model in anatomical education. Developed by Dr. Gunther von Hagens in 1977, plastination preserves biological tissues by replacing water and lipids with curable polymers such as silicone, epoxy, and polyester, producing dry, odorless, durable, and anatomically accurate specimens that retain their three-dimensional morphology for long-term educational use.[9]

The plastination process involves fixation, dehydration, forced polymer impregnation under vacuum, and curing, resulting in stable specimens that can be repeatedly handled without significant deterioration. Unlike conventional wet specimens, plastinated specimens can be transported, displayed, and used in classrooms, small-group teaching sessions, museums, and clinical demonstrations without the continuous maintenance required for formalin-preserved tissues.

The educational value of plastination extends beyond preservation. Silicone (S10) plastination, considered the gold standard for whole-body and organ preservation, maintains life-like morphology and is particularly valuable for gross anatomy teaching. Epoxy (E12) sheet plastination produces transparent anatomical sections that facilitate the study of

sectional anatomy and radiological correlations, while polyester (P40) plastination provides superior visualization of brain architecture and other complex soft-tissue relationships. These specialized polymer techniques allow educators to select the most appropriate specimen type according to specific learning objectives rather than relying on a single preservation method.[10]

Evidence from medical education research further supports plastination as an effective teaching modality.[11] Undergraduate students consistently report that plastinated specimens improve the identification of anatomical structures, enhance understanding of complex three-dimensional relationships, and are easier to handle than conventional wet specimens.[12] Their dry, non-hazardous nature also minimizes discomfort associated with formalin exposure, creating a more accessible and engaging learning environment.

Importantly, plastination is best viewed as a complementary rather than a replacement teaching tool.[14] While cadaveric dissection remains essential for developing exploratory and manual anatomical skills, plastinated specimens preserve authentic human anatomy in a reusable format that supports repeated observation, radiological integration, pathology teaching, and self-directed learning. Comparative educational studies further demonstrate that plastinated specimens provide tactile and spatial learning experiences while achieving learning outcomes comparable to other modern teaching technologies, including virtual reality.

3. RESULT

Classical *Ayurvedic* literature consistently documents *Pusta* as a structured and intentional educational innovation. These models enabled students to safely practice surgical procedures such as *chedana* (incision), *bhedana* (excision), *sivana* (suturing), and obstetric maneuvers.

In obstetrics, water-filled leather *Pusta* was used as a teaching aid to represent the amniotic sac, enabling trainees to practice fetal repositioning, understand *Prasava Kalina Gatiyan* (mechanics of labor), and manage *Mudhagarbha* (obstructed labor). These models provided opportunities for repeated practical training while avoiding patient risk and respecting the ethical and cultural restrictions surrounding cadaver use.

Plastinated specimens retained natural structural detail and were suitable for repeated handling in anatomical and clinical teaching.

Table no – 1 - A comparison between *Pusta*, historical Western anatomical models, and plastination revealed strong conceptual continuity.

Aspect	Pusta *(Ayurveda)*	Western Anatomical Parallels[1]	Plastination
Motivation	Ethical and ritual	Ethical bans , cadaver scarcity	Ethical and logistical
Materials	Clay, wood, leather, cloth, metals	Wax, ivory, fabric, plaster, rubber	Polymers
Educational aim	Surgical and obstetric practice	Anatomy and midwifery training	Anatomy and clinical training
Durability	Temporary	Variable	Long lasting
Anatomical authenticity	Symbolic	Limited	High

4. DISCUSSION

Anatomical teaching has evolved over centuries in response to ethical, cultural, and practical challenges associated with studying the human body. Therefore, plastination should be viewed not as an isolated innovation but as an important advancement in a long-standing tradition of developing effective anatomical teaching models. As documented by Olry (2000), Western medicine employed models made from wax, wood, ivory, fabric, plaster, and rubber to overcome cadaver scarcity and support the training of medical students, surgeons, and midwives.

The concept of Pusta described in classical Ayurvedic literature reflects a comparable educational approach. Models constructed from cloth, leather, clay, wood, and metal were created using available materials to approximate the form and consistency of the human body, allowing repeated practical training while respecting the ethical and cultural restrictions surrounding cadaver use. Similarly, Western anatomical models pursued the same objective of making anatomical education more accessible and reusable.

Plastination advances this tradition by preserving authentic biological tissues with greater anatomical fidelity and long-term durability. Unlike earlier teaching models, plastinated specimens retain three-dimensional anatomical relationships while remaining dry, odorless, and suitable for repeated handling. Contemporary educational studies indicate that they improve visualization of complex structures, enhance spatial understanding, and provide a safer learning environment by eliminating continuous exposure to formalin.

Viewed within this historical continuum, plastination represents the technological maturation of anatomical teaching models. While the materials have evolved from cloth, leather, and clay to advanced polymers, the fundamental educational principles of repeated practice, ethical resource utilization, and accurate understanding of human anatomy have remained remarkably consistent.

5. CONCLUSION

The evolution of anatomical teaching from *Pusta* to Western anatomical models and ultimately to plastination reflects a continuous effort to improve practical anatomy education while addressing ethical and material challenges. Although the materials have progressed from cloth, leather, clay, and wax to advanced polymers, the emphasis on repeated practice, accessibility, and effective anatomical understanding has remained consistent across historical periods. Plastination has significantly advanced this tradition by preserving authentic human tissues with high anatomical fidelity, long-term durability, and safe reusability, making it an effective teaching model in contemporary anatomy education. Viewed within this historical continuum, plastination represents the technological maturation of anatomical teaching models, bridging traditional educational approaches with modern preservation techniques.

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8. Conflict of interest

None declared.

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