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Research Applications of Plastination: A Thematic Review of Epoxy Resin Techniques in Morphological Investigation

Aplicaciones de la Plastinación en la investigación: Una Revisión Temática de las Técnicas de Resina Epoxi en la Investigación Morfológica

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SUMMARY: Plastination, introduced by Gunther von Hagens in 1977, has become a transformative tool for preserving biological specimens and investigating human morphology. Over 400 institutions worldwide currently employ this technique for education and research. Among the diverse plastination methods, epoxy resin (E12 Biodur) sheet plastination has proven particularly valuable in morphological research due to its transparency, dimensional stability, and compatibility with imaging and histological analyses. This review, based entirely on documented evidence from recent decades, synthesizes the methodological evolution, technical refinements, and multidisciplinary applications of epoxy resin plastination in anatomical research. Studies across multiple regions of the body have demonstrated its capacity to preserve intricate structures, arterial, venous, neural, and fascial, while maintaining spatial accuracy. Integration with micro-CT, MRI, confocal microscopy, and histological staining has expanded plastination's research scope into histo-morphology, surgical anatomy, and medical education. Epoxy plastination remains the gold standard for high-fidelity morphological visualization, bridging macroscopic anatomy, imaging, and microstructural science.

KEY WORDS: Plastination; Epoxy resin; Sheet plastination; Morphological research; Anatomical preservation.

INTRODUCTION

Since the introduction of plastination by Gunther von Hagens in 1977 (von Hagens & Knebel 1978; von Hagens, 1979; von Hagens, 1986; von Hagens *et al*., 1987; Ottone *et al*., 2018; Ottone, 2023), this preservation method has profoundly influenced the anatomical sciences. Initially designed for long-term conservation of biological specimens, plastination has evolved into a multidisciplinary research tool, extending far beyond its pedagogical origins. Over the past four decades, more than 400 institutions worldwide have incorporated plastination into education, research, and applied morphology (Ottone, 2023). A bibliometric overview covering the period 1979–2023 reports approximately 470 indexed studies on plastination, reflecting its consolidation as a reliable scientific technique for both qualitative and quantitative analysis.

Among the different plastination methods, silicone, polyester, and epoxy resin, the epoxy resin (E12 Biodur) technique has proven the most suitable for scientific research because of its transparency, minimal shrinkage, and

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dimensional stability (Fritsch, 1988; Fritsch, 1989; Sittel *et al*., 1997; Johnson *et al*., 2000; Sora *et al*., 2005). The thin, translucent slices obtained with this technique allow the observation of both soft and hard tissues without decalcification, maintaining the integrity of delicate structures such as nerves, vessels, and fascial planes (Zhang and An, 2000; Xu *et al*., 2018). Because of these advantages, epoxy sheet plastination has become indispensable for topographical, radiological, and histological correlation studies in human morphology.

Over time, the application of epoxy plastination has expanded to multiple anatomical regions, head and neck, thorax, pelvis, and limbs, demonstrating its ability to preserve the original relationships between tissues and to correlate these with modern imaging techniques such as MRI, CT, and micro-CT (Hammer *et al*., 2017; Hedderwick *et al*., 2017; Wiersbicki *et al*., 2019). This combination enables precise in vivo–in vitro comparison, contributing to a renewed understanding of complex areas such as the skull base, pelvic floor, and fascial systems (Qiu *et al*., 2004; Porzionato *et al*., 2005; Macchi *et al*., 2008; Scali *et al*., 2015a,b). In parallel, methodological refinements, such as cryogenic impregnation, ultrathin slicing, and improved polymer curing, have optimized color fidelity and minimized tissue distortion (Sora & Cook, 2007; Sora & Matusz, 2010). The adaptability of the E12 Biodur technique has also fostered integration with optical and microscopic methods. Studies have demonstrated the natural autofluorescence of collagen and neurofilaments in epoxy-embedded tissues under 488 nm excitation, enabling confocal and fluorescence imaging without the need for additional dyes (Phillips *et al*., 2002; Ottone *et al*., 2018; Ottone, 2023; Correa-Aravena *et al*., 2025). Other investigations have combined plastination with histology and immunohistochemistry to elucidate muscular and connective structures in the pelvis and perineum (Sebe *et al*., 2005; Porzionato *et al*., 2017).

Furthermore, the refinement of processing parameters, such as controlled freezing between -20 °C and -80 °C, dehydration in 95–100 % acetone at -25 °C to -30 °C, and vacuum impregnation with mixtures of E12/E1/AE10/AE30 or E12/E6/E600, has made it possible to obtain highly stable and reproducible results (Ottone *et al*., 2018; Ottone, 2023). These improvements have transformed plastination into a robust and versatile system suitable for long-term research collections.

In summary, epoxy plastination represents the convergence of chemical precision, morphological fidelity, and technological innovation. It bridges the gap between classical gross anatomy and contemporary digital morphology, supporting investigations that integrate histological, radiological, and 3D reconstruction methods (Ottone *et al*., 2018; Ottone, 2023). The following section presents a detailed overview of the methodological principles of epoxy plastination and its subsequent impact on modern anatomical research.

Methodological Overview of Epoxy Plastination

The methodological foundations of epoxy plastination have evolved over four decades of anatomical research, giving rise to highly refined protocols that ensure structural integrity, color fidelity, and long-term durability of biological tissues. The E12 Biodur system remains the benchmark method for sheet plastination due to its capacity to maintain both macroscopic and microscopic detail in transparent slices that can later be correlated with histology and imaging.

The process begins with fixation, generally performed by immersion in 10% formalin for variable periods ranging from 24 hours to several weeks, depending on tissue size and density. Some authors, such as Fritsch (1988, 1989), applied pre-staining prior to fixation using Biodur CB muscle dye to enhance color differentiation before dehydration.

Following fixation, dehydration is carried out at low temperatures in acetone (95–100 %) between -25 °C and -30 °C for 3–9 weeks, often with weekly solvent replacement to ensure complete water removal. Defatting with methylene chloride or acetone at room temperature for 1–2 days further enhances optical clarity and prevents tissue opacity.

The core step is forced impregnation under vacuum, which replaces the acetone within the specimen with an epoxy resin mixture. Fritsch (1988) described using a ratio of two parts E12 resin, one part E6 hardener, and 0.2 mL E600 accelerator per 100 mL mixture. Pressure is progressively reduced to about 5 mbar to facilitate resin penetration, and impregnation typically continues for 6–10 days until all gas bubbles disappear. Some more recent studies have reported cryogenic impregnation between -8 °C and 0 °C for 48 h (Nash *et al*., 2010; Skalkos *et al*., 2019), further minimizing shrinkage.

After impregnation, curing (polymerization) is performed to harden the resin. Classical methods use ovens at 50 °C for 5–7 days, though variations include initial room-temperature pre-curing or immersion in warm water at 35 °C to accelerate polymerization (Scali *et al*., 2015a,b). Alternative resin mixtures such as E50/E7/AE15/E700 (100:80:25 ppw + 0.1 %) have also been applied (Sittel *et al*., 1997) to modify flexibility and transparency during curing. In some protocols, slices are mounted between

tempered glass plates separated by 4 mm elastic joints and tilted at 15° to remove air bubbles before oven polymerization at 45 °C for 4 days (Sora *et al*., 2002).

Once hardened, sectioning and finishing are performed with diamond-blade saws to obtain slices typically 300–800 μm thick; these are then polished and thinned further to 150 μm when transillumination or microscopy is required. To mount the sections, Helga Fritsch (1989) introduced a mixture of E12 (10 parts), E1 (3 parts), and benzyl benzoate (4 parts) as an adhesive medium, followed by heating at 50 °C for 24 hours to bond the sample to glass slides and achieve full transparency.

Protocol variations have been reported for specific anatomical regions. Zhang and An (2000) developed epoxy plastination of the subarachnoid space using coronal, sagittal, and oblique sections of 2.5 mm thickness, while Bernal-Mañas *et al*. (2016) processed temporomandibular joint blocks frozen at -20 °C and -80 °C before cutting in four anatomical planes for MRI correlation. Similarly, Thorpe Lowis *et al*. (2016) applied the protocol of Nash *et al*. (2005) to study thoracic meningeal cysts, freezing samples at -80 °C for 5 days, dehydrating at -30 °C for 3 weeks, and curing at 45 °C for 5 days.

Across all adaptations, epoxy sheet plastination consistently yields transparent, dimensionally stable slices that retain precise anatomical relationships. The method's flexibility allows correlation with histological staining (hematoxylin–eosin, Stevenel blue, Alizarin red S), digital scanning at 1200 dpi, and even 3D reconstruction using open-source software (Liang *et al*., 2019).

In summary, the methodological evolution of epoxy plastination has established a reproducible and adaptable framework for morphological research. Controlled dehydration, cryogenic impregnation, and optimized curing have transformed the E12 Biodur process into a reliable system that combines chemical stability with exceptional anatomical fidelity, enabling quantitative imaging, histological integration, and digital modeling of plastinated specimens.

Advances in Morphological and Imaging Research

The use of epoxy plastination, particularly through the E12 Biodur method, has enabled a new level of precision in the analysis of human morphology. Its application in diverse anatomical regions has shown that transparent, dimensionally stable sections can retain the original relationships between structures, allowing detailed visualization and reliable comparison with radiological and histological techniques.

- Preservation of Macroscopic Relationships

One of the earliest demonstrations of this potential was provided by Sittel *et al*. (1999), who plastinated the human larynx using an epoxy-based mixture that produced dry, odorless specimens while maintaining their natural coloration and anatomical fidelity. Their results highlighted the technique's suitability for analyzing delicate cartilaginous and muscular elements without the need for decalcification. Similarly, Johnson *et al*. (2000) examined the organization of the connective tissue within the human nuchal ligament and adjacent musculature. Using serial sections obtained through the E12 method, they observed the continuity between muscular aponeuroses and ligamentous fibers, demonstrating how plastination allows the study of large regions without structural disruption.

- Advances in Neuroanatomical Visualization

The application of epoxy plastination to the head and neck has produced particularly significant findings. Zhang & An (2000) employed the method to investigate the subarachnoid space, successfully visualizing the complex arrangement of Liliequist's membrane and the trabecular network that bridges the arachnoid layers. Their work confirmed that plastinated specimens can reveal the microarchitecture of structures often inaccessible by dissection. Building upon this approach, Sora *et al*. (2002) utilized E12 plastination in the orbital region, obtaining exceptionally clear sections that preserved the spatial configuration of intraorbital tissues. The study also demonstrated the feasibility of generating three-dimensional reconstructions from serial plastinated slices, further enhancing the anatomical interpretation of confined spaces.

- Correlation with Radiological Imaging

The integration of plastination with imaging modalities has become one of the field's most productive intersections. In cardiovascular research, Skalkos *et al*. (1999) compared E12-plastinated heart sections with magnetic resonance imaging, confirming that myocardial fiber orientations were identical across both methods. In neurocranial studies, Liang *et al*. (2019) used ultrafine epoxy plastination of the jugular foramen to examine the meningeal layers and vascular structures surrounding cranial nerves. Their combination of microscopic staining and three-dimensional digital reconstruction established precise anatomical–radiological correspondence. Likewise, Wu *et al*. (2021) applied similar techniques to the skull base and cavernous sinus, illustrating how ultrathin epoxy sections can complement CT and MRI for pre-surgical planning.

- Fascial and Musculoskeletal Applications

In musculoskeletal research, epoxy plastination has enabled the analysis of fascial systems and muscle architecture with an unprecedented level of detail. Zhang & Lee (2002) used E12 plastination on five human cadavers to differentiate connective layers of the neck, demonstrating the absence of direct fibrous connections between the sternocleidomastoid and trapezius muscles, an observation not possible through conventional dissection. The study underscored the method's value for identifying fascial boundaries and connective continuity. Complementarily, Bernal-Mañas *et al*. (2016) examined the human temporomandibular region by preparing joint blocks in multiple planes, correlating the plastinated slices with MRI data to characterize the orientation of the lateral pterygoid muscle and its vascular surroundings.

- Technical Refinement and Three-Dimensional Reconstruction

Continuous refinement of the E12 Biodur process has further enhanced its research capabilities. Authors such as Nash *et al*. (2005) and Skalkos *et al*. (1999) introduced cryogenic impregnation at subzero temperatures and controlled polymerization conditions to reduce tissue shrinkage and improve transparency. High-resolution scanning of epoxy slices, ranging from 300 to 150 μm in thickness, has allowed the creation of digital models that faithfully reproduce anatomical complexity. These reconstructions, used in works like those of Sora *et al.* (2007, 2012) and Liang *et al.* (2019), have proven invaluable for correlating plastinated anatomy with radiological and surgical data.

In summary, the implementation of epoxy plastination in morphological and imaging studies has established a bridge between traditional anatomy and modern visualization techniques. Through its ability to preserve spatial relationships, support digital modeling, and integrate with radiological imaging, the E12 method stands today as one of the most powerful and precise tools for anatomical research.

Integration with Histology and Microscopy

The incorporation of plastination into histological and microscopic analysis has expanded the scope of morphological research, allowing a seamless transition between macroscopic anatomy and cellular-level observation. Epoxy resin plastination, in particular, has enabled this integration due to its transparency, rigidity, and compatibility with staining and imaging methods.

- The Origins of Plastination Histology

The foundations of histological plastination were established by Helga Fritsch (1988, 1989), who first demonstrated that epoxy-embedded specimens could be sectioned into thin slices suitable for microscopic study. Working with human fetal tissues, she modified traditional staining methods using methylene blue, azur II, and basic fuchsin to achieve sharp color differentiation within thick plastinated sections. Her procedure involved dehydration in cold acetone at -25 °C, defatting in methylene chloride, and impregnation with an E12/E6/E600 resin mixture. After polymerization at 50 °C, the blocks were cut into slices between 400 and 800 mm, polished, and mounted using a mixture of E12 resin, E1 hardener, and benzyl benzoate as an adhesive. The result was a translucent section that could be examined by transillumination, preserving the topography and histological arrangement of tissues within a single specimen.

This methodological innovation, later termed "plastination histology", bridged the gap between gross anatomical dissection and microscopic morphology. It permitted researchers to observe the microarchitecture of organs in situ, maintaining their three-dimensional relationships, something unachievable with conventional histological processing.

- Combination with Classical Staining and Microscopy

Subsequent studies adapted Fritsch's approach to integrate classical histological stains and microscopic techniques. Sora *et al*. (2002) developed an orbital plastination protocol that included post-curing slicing and staining with hematoxylin and eosin, achieving magnifications up to ×40 under light microscopy. These adaptations demonstrated that epoxy sections, once polished and properly mounted, could retain cellular detail comparable to that seen in paraffin-embedded tissues.

Liang *et al.* (2019) and Wu *et al.* (2021) expanded these methods by applying histological staining with Stevenel blue and Alizarin red S to ultrathin plastinated sections of the jugular foramen. The combination of plastination, staining, and high-resolution microscopy enabled precise three-dimensional reconstruction of vascular and meningeal structures, highlighting the compatibility of E12 resin with both histological dyes and digital visualization software.

- Autofluorescence and Confocal Imaging

A major step forward came from the discovery of the intrinsic optical properties of plastinated tissues. Nash *et al*.

(2004, 2005a,b) reported that epoxy-embedded specimens exhibit endogenous autofluorescence of collagen and neural fibers when excited at 488 nm, allowing confocal imaging without the addition of fluorescent dyes. This characteristic has since been exploited to generate high-resolution three-dimensional models of peripheral nerves and fascial structures.

Following these findings, Xu *et al*. (2018) applied confocal microscopy to epoxy plastinated sections of the puboprostatic and lateral femoral nerves. Their study demonstrated that autofluorescence could reveal the branching patterns and connective tissue envelopes surrounding nerves, combining morphological clarity with functional anatomical insight. These results underscored the potential of plastination not only as a preservation technique but also as an optical platform for advanced microscopy.

In a more recent contribution, Correa-Aravena *et al*. (2025) expanded these observations through the application of micro-plastination to the dentogingival junction (DGJ). Their study demonstrated that micro-thin epoxy plastinated slices (<150 µm) exhibit intrinsic autofluorescence of collagen fibers when excited at 488 nm, even without histological staining. This finding confirmed that the epoxy resin itself, combined with the structural organization of connective tissue, produces a distinctive fluorescent response that enables precise visualization of periodontal structures such as dentin, enamel, cementoenamel junction, and connective tissue fibers. The authors also emphasized that this is the first documented evidence of endogenous autofluorescence in micro-plastinated human and animal tissues, highlighting the potential of this technique as a hybrid histological and optical tool for confocal and cytometric imaging (Correa-Aravena *et al*., 2025)

- Integration with Immunohistochemistry and Developmental Anatomy

The combination of plastination with histological and immunohistochemical methods has also proved valuable for analyzing pelvic and perineal structures. Porzionato *et al*. (2005) employed epoxy plastination alongside conventional histology to characterize the rectourethral and longitudinal anal muscles, confirming the coexistence of smooth and striated fibers within these regions. Similarly, Macchi *et al*. (2008) used plastinated sections to study the connective tissue of the anal canal, integrating light microscopy and immunostaining to delineate the continuity between perineal muscles and fascial layers.

Developmental studies have also benefited from this integrative approach. Sebe *et al*. (2005a,b) examined fetal specimens through histological plastination, clarifying the organization of the pelvic diaphragm and revealing that the so-called “rectourethral muscle” is not a distinct structure but part of a broader rectoperineal complex. These investigations reaffirm the methodological versatility of epoxy plastination for developmental and comparative anatomy.

Together, these advances demonstrate that epoxy plastination serves as an effective bridge between anatomy, histology, and modern microscopy. Its optical transparency allows visualization of tissues from the macroscopic down to the microstructural level, while its chemical stability ensures long-term preservation and compatibility with staining and imaging techniques. By combining plastination histology, confocal imaging, and immunohistochemistry, researchers have developed a truly multidisciplinary tool for morphological investigation.

Surgical and Clinical Applications

The high precision and structural fidelity of epoxy plastination have made it an essential tool for surgical anatomy, particularly in fields where spatial accuracy is crucial for preoperative planning and training. Its transparency, rigidity, and capacity for ultrathin slicing allow detailed visualization of neurovascular, musculoskeletal, and pelvic structures, forming a bridge between morphological research and clinical application.

- Visualization of Metal Stents in Coronary Arteries with Epoxy Plastination

A recent advancement in cardiovascular applications of plastination was reported by Starchik *et al*. (2020), who successfully visualized metallic coronary stents using the epoxy plastination method. Their study demonstrated that E12 resin provides sufficient optical clarity to identify vascular stents embedded within arterial walls without the need for radiopaque contrast agents. Using plastinated slices of human coronary arteries, the authors revealed the fine relationship between the stent struts, the vessel wall, and surrounding connective tissues. The use of confocal and polarized light microscopy confirmed that the polymer resin maintains transparency and permits detailed imaging even in the presence of metal implants. This pioneering work not only extended the application of epoxy plastination to interventional cardiology but also provided a methodological framework for studying vascular prostheses, calcifications, and endoluminal devices in situ. Consequently, epoxy plastination emerges as a valuable complementary tool for both cardiovascular morphology and medical device research (Starchik *et al*., 2020).

- Neurosurgical and Otorhinolaryngological Applications

One of the most significant contributions to surgical anatomy using epoxy plastination was made by Liang *et al*. (2019), who prepared ultrathin slices of the skull base and jugular foramen impregnated with E12, E6, and E500 resins. After curing at 50 °C for twoweeks, the 700 μm sections were scanned and digitally reconstructed. When compared with computed tomography, the plastinated slices offered superior differentiation of small anatomical structures, proving their value for three-dimensional modeling and preoperative assessment in neurosurgery and otorhinolaryngology.

Similarly, Adds & Al-Rekabi (2014) reconstructed the ethmoidal arteries of the medial orbital wall through 3D modeling of plastinated sections. By injecting low-viscosity red silicone resin prior to epoxy embedding, they achieved clear visualization of the ophthalmic artery and its branches, contributing to safer approaches in orbital and endoscopic surgery.

- Spine and Orthopedic Research

In spinal research, Kaulhausen *et al*. (2012) utilized epoxy sheet plastination to study the positioning and biomechanical impact of interspinous spacers used in the treatment of lumbar spinal stenosis. Their plastinated specimens preserved the relationship betweenbone, ligament, and implant components, allowing precise correlation with radiographic findings and improving surgical technique evaluation.

In the field of orthopedics, Sora *et al*. (2008) investigated the topographic distribution of posteromedial neurovascular structures of the ankle using E12 plastination. Lower limbs from elderly donors were frozen, dehydrated, and plastinated in 1.5 mm slices. The resulting transparent sections, scanned before and after polymerization, provided detailed insight into the arrangement of vessels and nerves, supporting the development of minimally invasive surgical approaches.

- Pelvic and Urogenital Anatomy

Epoxy plastination has also contributed to a better understanding of pelvic and urogenital anatomy. Xu *et al*. (2018) applied E12 plastination combined with confocal microscopy to study the puboprostatic and pubococcygeal fibers associated with urinary continence. Their findings, obtained from plastinated male pelvises, clarified the spatial relationships of connective and neural structures relevant to nerve-sparing radical prostatectomy.

Complementary research by Porzionato *et al*. (2005) and Macchi *et al*. (2008) combined epoxy plastination with histology and immunohistochemistry to explore the morphology of the rectourethral and longitudinal anal muscles. These studies revealed the coexistence of smooth and striated fibers, enhancing anatomical understanding critical to reconstructive and rehabilitative pelvic surgery.

Technical Limitations and Future Perspectives

Although epoxy plastination has proven to be one of the most reliable and versatile methods for anatomical research, certain limitations persist, largely related to the complexity and duration of the process. The technique requires prolonged stages of dehydration and impregnation under vacuum, which can extend over several weeks and restrict sample throughput (Fritsch, 1988; Skalkos *et al*., 1999; Nash *et al*., 2004; Ottone, 2023). Additionally, despite the high dimensional stability of epoxy resin, some studies have reported minor shrinkage or deformation of soft tissues, particularly when the dehydration process is not tightly temperature-controlled (Scali *et al*., 2005a,b; Ottone, 2023).

Color preservation represents another technical challenge. Variations in curing temperature and resin composition may alter pigmentation or transparency, especially in large or highly vascularized specimens (Skalkos *et al*., 1999; Sora *et al*., 2005, 2007, 2008). Furthermore, the necessity of specialized equipment, such as vacuum chambers, cryogenic systems, and diamond-blade saws, limits the accessibility of the technique to a relatively small number of laboratories worldwide.

Nevertheless, ongoing methodological innovations continue to address these constraints. The introduction of cryogenic impregnation at temperatures between –8 °C and 0 °C has reduced shrinkage and improved optical clarity by moderating the exothermic polymerization reaction (Skalkos *et al*., 1999; Nash *et al*., 2005a,b). Adjustments in resin formulations, such as the inclusion of AE15 or E50 components to enhance flexibility and transparency, have also contributed to greater versatility (Sittel *et al*., 1997).

From a research perspective, the integration of epoxy plastination with advanced imaging and digital modeling is reshaping its scientific value. The generation of ultrathin (1–2 mm) sections suitable for three-dimensional reconstruction has made it possible to create accurate virtual anatomical models that reproduce the complexity of cadaveric structures. These reconstructions, derived from plastinated specimens, provide unparalleled realism and spatial accuracy, enhancing surgical planning and technical training (Liang *et al*., 2014; Ottone, 2023).

Future developments are expected to focus on the digitization and open-access dissemination of plastinated datasets, enabling remote visualization and educational interaction. The combination of plastination with micro-computed tomography, confocal microscopy, and artificial intelligence-based segmentation is likely to further expand the analytical capabilities of the technique. These innovations will continue to transform epoxy plastination into an even more efficient and informative tool for both research and education, consolidating its role as a fundamental resource in twenty-first-century morphological sciences.

CONCLUSIONS

Epoxy plastination has evolved from an educational preservation technique into a fundamental research methodology capable of uniting macroscopic, histological, and radiological anatomy within a single analytical framework (von Hagens, 1986; von Hagens *et al*., 1987; Ottone, 2023). The works compiled over the past decades confirm that the E12 Biodur system provides unmatched spatial fidelity, durability, and transparency, making it the standard method for detailed anatomical and morphometric investigation (Fritsch, 1988; Sittel *et al*., 1997; Ottone, 2023).

Through its application to diverse anatomical regions, head and neck, thorax, pelvis, and limbs, epoxy plastination has demonstrated its capacity to preserve complex topographies while maintaining the original relationships between soft and hard tissues. The resulting specimens have served as the basis for advances in neuroanatomy (Zhang & An, 2000; Sora *et al*., 2002), cardiovascular research (Skalkos *et al*., 1999; Didenko *et al*., 2013), pelvic and perineal morphology (Porzionato *et al*., 2005; Sebe *et al*., 2005a,b; Macchi *et al*., 2008), and musculoskeletal anatomy (Koslowsky *et al*., 2015; Sora *et al*., 2004, 2007, 2008).

The integration of plastination with radiological techniques such as MRI and micro-CT has further enhanced its diagnostic and educational relevance. Studies comparing plastinated sections with magnetic resonance images have validated the structural accuracy of the E12 method, confirming its value as a reference for imaging correlation and 3D reconstruction. Similarly, the incorporation of confocal microscopy and autofluorescence analysis has opened new avenues for examining neural and connective structures in their natural configuration (Ottone, 2023).

Despite minor technical limitations, such as long processing times and occasional color variations, the versatility and reproducibility of epoxy plastination remain unmatched. Ongoing methodological refinements, including cryogenic impregnation and improved resin formulations, are continuously enhancing the quality and accessibility of this technique.

Ultimately, epoxy plastination represents more than a technological achievement; it embodies a methodological synthesis that bridges the macroscopic and microscopic dimensions of anatomical science. By preserving biological structures with exceptional precision and enabling integration with digital imaging, plastination provides a lasting and ethical framework for research, education, and surgical innovation. As highlighted by Ottone (2023), the continued evolution of this field ensures that plastination will remain a cornerstone of morphological investigation in the twenty-first century, an enduring legacy of anatomical craftsmanship and scientific progress.

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RESUMEN: La plastinación, introducida por Gunther von Hagens en 1977, se ha convertido en una herramienta transformadora para la preservación de especímenes biológicos y el estudio de la morfología humana. Más de 400 instituciones en todo el mundo la emplean actualmente con fines docentes y de investigación. Entre los distintos métodos de plastinación, la plastinación con resina epoxi (E12 Biodur) ha demostrado ser especialmente valiosa en la investigación morfológica debido a su transparencia, estabilidad dimensional y compatibilidad con técnicas de imagen e histología. Esta revisión, basada exclusivamente en evidencia documentada de las últimas décadas, sintetiza la evolución metodológica, los avances técnicos y las aplicaciones multidisciplinarias de la plastinación con resina epoxi en la investigación anatómica. Diversos estudios en múltiples regiones del cuerpo han demostrado su capacidad para conservar estructuras complejas , arteriales, venosas, nerviosas y fasciales, manteniendo su precisión espacial. La integración con micro-CT, resonancia magnética, microscopía confocal y técnicas histológicas ha ampliado el alcance de la plastinación hacia la histomorfología, la anatomía quirúrgica y la educación médica. La plastinación epoxi sigue siendo el estándar de oro para la visualización morfológica de alta fidelidad, uniendo la anatomía macroscópica, la imagenología y la microestructura.

PALABRAS CLAVE: Plastinación; Resina epoxi; Plastinación de cortes; Investigación morfológica; Preservación anatómica

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