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Hypothesis

A Posterior Transosseous S1 Pedicle Approach for Accessing the Superior Hypogastric Plexus: A Hypothesis

Andre Luiz Loyelo Barcellos[1], Clara Martins Albuquerque[2] and João Antonio Matheus Guimarães[1*]

[1]*National Institute of Traumatology and Orthopedics, Rio de Janeiro, Brazil;* [2]*Estácio de Sá University, Rio de Janeiro, Brazil*

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Abstract

Chronic pelvic pain remains a significant clinical challenge, often refractory to conservative and interventional treatments. Superior hypogastric plexus block is an established technique; however, conventional anterior and posterior approaches may be limited by anatomical variability and potential risks to adjacent structures. Based on these anatomical findings, we propose that a posterior transosseous S1 pedicular approach represents a novel and anatomically robust corridor for accessing the superior hypogastric plexus. We hypothesize that the highly reproducible osseous anatomy of the S1 pedicle, combined with its consistent spatial relationship to the anterior sacral cortex and retroperitoneal compartment, may enable precise and fluoroscopically reproducible instrument guidance toward the plexus. Furthermore, this trajectory may mitigate the anatomical variability and procedural limitations associated with conventional anterior or paravertebral techniques while potentially reducing the risk of inadvertent injury to adjacent visceral, vascular, and neural structures. This concept is based on anatomical reasoning and fluoroscopic observations obtained during cadaveric anatomical orientation, suggesting that a transosseous trajectory through the S1 pedicle toward the anterior sacral cortex may offer improved spatial control and reproducibility compared with soft-tissue-based approaches. The proposed pathway remains conceptual and is not intended for clinical application at this stage. Further cadaveric, imaging-based, and clinical studies are required to evaluate its anatomical validity, safety, and potential clinical relevance.

Introduction

Chronic pelvic pain represents a significant clinical challenge, affecting quality of life and imposing a substantial physical and psychological burden.[1,2] Despite advances in pharmacological and interventional strategies, a considerable proportion of patients remain refractory to conservative treatment. Interventions targeting the superior hypogastric plexus have been widely employed for refractory pelvic pain of malignant and non-malignant origin.[3–6] Traditional anterior and posterior techniques, although effective, may be limited by anatomical variability, difficulty in fluoroscopic landmark identification, and potential risk to adjacent vascular and visceral structures.[7–9] In spine surgery, transosseous pedicle-based approaches are routinely used to access deep anatomical regions with a high degree of reproducibility and safety. The sacral pedicle, particularly at the S1 level, represents a well-defined osseous corridor with consistent anatomical landmarks.[10] Based on these observations, we propose a novel hypothesis: that a posterior transosseous approach through the S1 pedicle could provide a predictable and anatomically reliable route to the superior hypogastric plexus.

Hypothesis

We hypothesize that a posterior transosseous approach through the S1 pedicle, utilizing principles of sacral pedicle instrumentation, may allow controlled access to the retroperitoneal region adjacent to the superior hypogastric plexus, potentially reducing anatomical variability and procedural uncertainty associated with conventional approaches.

The S1 pedicle is characterized by consistent morphology and has been extensively studied in the context of spinal instrumentation.[10] Fluoroscopically guided pedicle access is a routine and reproducible technique in spine surgery, with a well-established safety profile. Anatomically, the anterior cortex of the S1 vertebral body lies in proximity to the retroperitoneal space where the

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***Correspondence to:** João Antonio Matheus Guimarães, National Institute of Traumatology and Orthopedics, Rio de Janeiro 22793-190, Brazil. ORCID: https://orcid.org/0000-0002-5647-2248. Tel: +55-21-99549-1959, E-mail: jmatheusguimaraes@gmail.com

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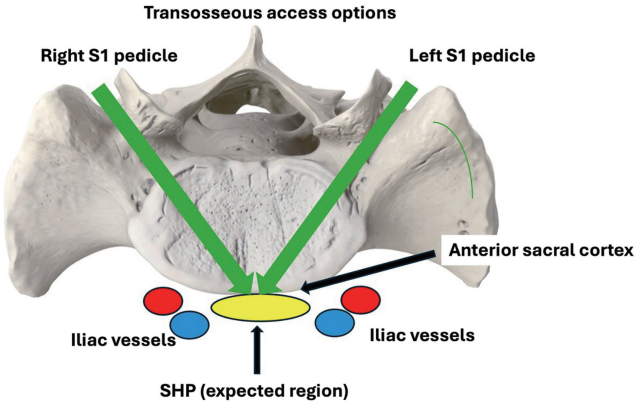

Fig. 1. Schematic representation of bilateral posterior transosseous S1 pedicle access trajectories toward the superior hypogastric plexus region. The proposed right and left transosseous pathways (black arrows) illustrate a convergent trajectory through the S1 pedicles toward the anterior sacral cortex and presacral space, where the superior hypogastric plexus is anatomically located (yellow area). The proximity of critical vascular structures, including the iliac vessels (red and blue), highlights the potential risk associated with anterior cortical transgression. This schematic underscores the conceptual advantage of a fixed osseous corridor while simultaneously illustrating the unresolved safety considerations related to anterior sacral anatomy. SHP, superior hypogastric plexus.

superior hypogastric plexus is located.[4,11] Controlled transosseous advancement through the pedicle and anterior vertebral cortex may theoretically allow access to this region while maintaining spatial orientation and minimizing reliance on soft-tissue trajectories. Fluoroscopic anatomical orientation performed in a cadaveric setting illustrated that accurate pedicle cannulation and controlled advancement to the anterior cortex of the S1 vertebral body can be achieved under fluoroscopic guidance. However, intentional transgression of the anterior cortex should be interpreted cautiously, as its safety in relation to adjacent vascular and visceral structures has not yet been established using standard spinal instrumentation principles. Although these observations do not constitute clinical or experimental validation, they support the anatomical plausibility of the proposed pathway. To further contextualize this anatomical rationale, a conceptual and illustrative description of the proposed transosseous S1 pedicle pathway is presented below.

The hypothesis proposed in this manuscript is grounded in established principles of sacral pedicle anatomy and techniques routinely employed in spine surgery. To illustrate the anatomical plausibility of a posterior transosseous S1 pedicle pathway toward the superior hypogastric plexus, fluoroscopic images were obtained during anatomical orientation using a cadaveric model. These images are presented solely for conceptual illustration and do not represent a validated procedural technique (Fig. 1). In this illustrative framework, the subject was positioned prone on a radiolucent table, and fluoroscopic guidance was used to obtain anteroposterior and lateral views of the sacrum. After identification of the S1 pedicle on a true anteroposterior projection with slight craniocaudal angulation, a transosseous cannula was advanced to the lateral border of the S1 pedicle, serving as an anatomical reference point. Subsequent lateral fluoroscopic views demonstrated a straight transosseous trajectory oriented parallel to the superior endplate of the S1 vertebral body and directed toward the sacral promontory (Fig. 2). Progressive advancement of the cannula allowed controlled contact with the anterior cortex of the S1 vertebral body, illustrating the theoretical point at which access to the

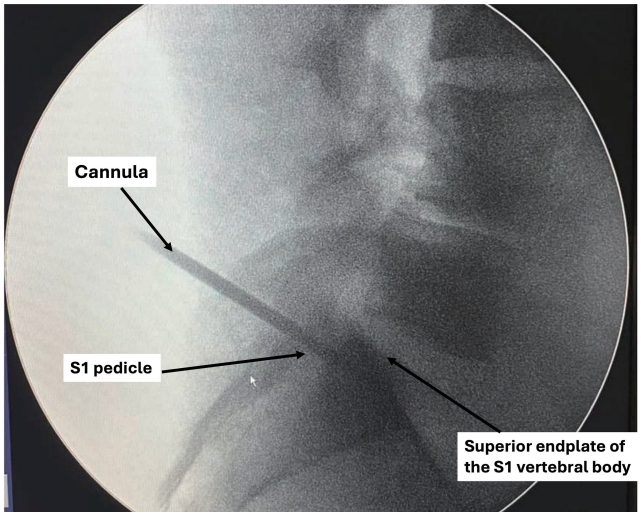

Fig. 2. Lateral fluoroscopic view demonstrating cannula advancement through the S1 pedicle. The trajectory is oriented parallel to the superior endplate of the S1 vertebral body and directed anteriorly toward the sacral promontory, illustrating the proposed transosseous pathway.

retroperitoneal region adjacent to the superior hypogastric plexus may occur (Fig. 3). Introduction of a probe through the cannula demonstrated disruption of the anterior cortical boundary within this conceptual pathway (Fig. 4). Injection of contrast medium further illustrated contrast spread compatible with the expected anatomical region of the superior hypogastric plexus, without direct anatomical confirmation (Fig. 5). These images are intended to support the anatomical plausibility of the proposed hypothesis rather than to establish feasibility, safety, or clinical efficacy. The described pathway should be interpreted as a conceptual model designed to stimulate further anatomical, experimental, and clinical investigation.

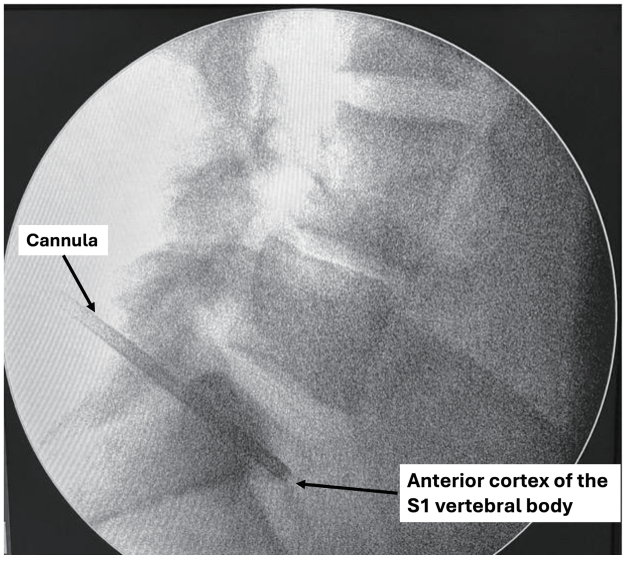

Fig. 3. Lateral fluoroscopic view showing transosseous cannula positioning with controlled contact with the anterior cortex of the S1 vertebral body, supporting the anatomical plausibility of accessing the retroperitoneal space via this route.

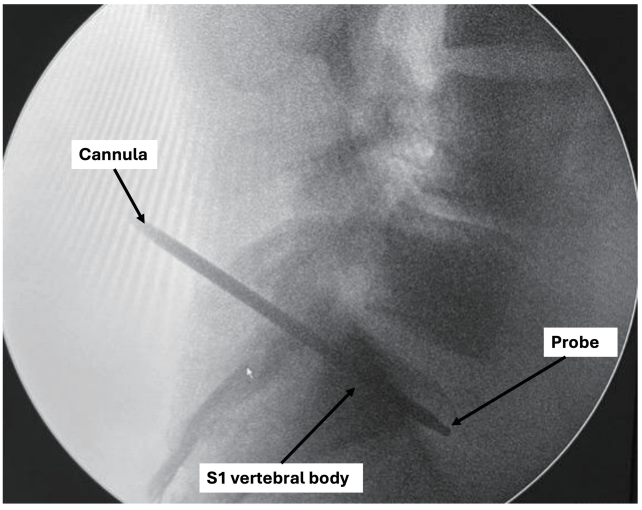

Fig. 4. Lateral fluoroscopic view demonstrating insertion of a probe through the transosseous cannula to verify anterior cortical breach of the S1 vertebral body within the proposed anatomical pathway.

The proposed posterior transosseous approach may offer theoretical advantages when compared with conventional techniques, which rely primarily on soft-tissue corridors and may be influenced by patient-specific anatomical variability.[7–9,11] By relying on an osseous corridor with fixed anatomical landmarks, this approach could potentially reduce variability related to body habitus or visceral displacement. Furthermore, familiarity with pedicle-based techniques among spine surgeons may facilitate reproducibility and procedural confidence. However, these potential advantages remain hypothetical and require systematic evaluation.

Evaluation of the hypothesis

The present hypothesis introduces a transosseous paradigm for accessing the superior hypogastric plexus, leveraging principles traditionally applied in spine surgery. Unlike conventional superior hypogastric plexus block techniques, which rely on soft-tissue trajectories and may be influenced by patient-specific anatomical variability, the proposed approach is based on a fixed osseous corridor, potentially improving reproducibility and spatial orientation. Previous studies have described posterior and transdiscal approaches to the superior hypogastric plexus, including the posteromedian transdiscal technique.[8] However, these methods traverse intervertebral disc structures and may be associated with disc injury or variability in trajectory. In contrast, the proposed S1 pedicle pathway utilizes a well-established anatomical corridor, potentially offering greater procedural control and consistency. Advances in ultrasound-guided superior hypogastric plexus block techniques have improved safety profiles by enabling real-time visualization of vascular structures.[11–14] However, these approaches remain operator-dependent and may be limited by patient habitus and acoustic window constraints.[15] The proposed transosseous approach could represent an alternative strategy in selected cases where conventional techniques are technically challenging. Importantly, the proposed technique is conceptually derived from spine surgery and may be more familiar to spine surgeons than to pain specialists or anesthesiologists, who traditionally perform superior hypogastric plexus blocks. Therefore, its clinical adoption would require targeted training and interdisciplinary collaboration to ensure safety and reproducibility.

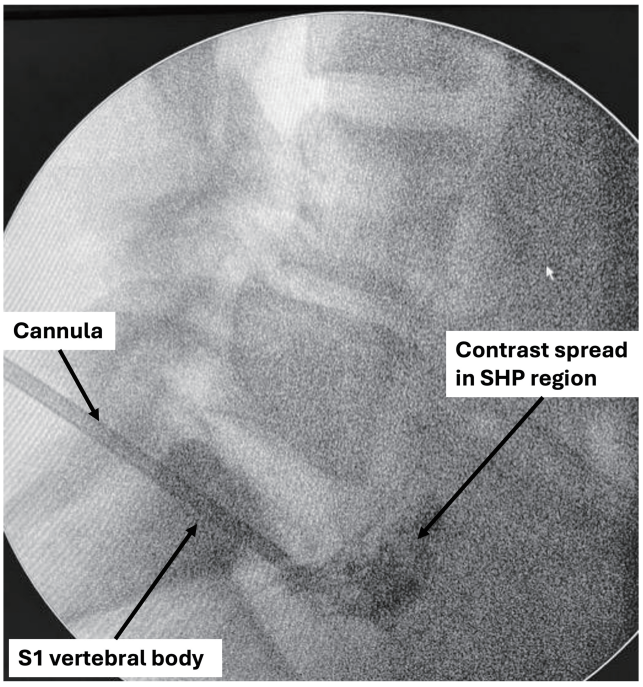

Fig. 5. Fluoroscopic image demonstrating contrast spread compatible with the expected anatomical region of the superior hypogastric plexus, without direct anatomical confirmation. This image supports the conceptual plausibility of the proposed approach. SHP, superior hypogastric plexus.

At present, this hypothesis should be interpreted with caution. The absence of cadaveric validation, quantitative anatomical measurements, and clinical data precludes any conclusions regarding safety or efficacy. The relationship between the anterior sacral cortex and adjacent vascular structures, particularly the iliac vessels, remains a critical consideration requiring further investigation. Nevertheless, this concept introduces a novel anatomical perspective that may expand current approaches to deep pelvic neural targets and stimulate further research integrating spine surgery techniques with interventional pain management.

The proposed hypothesis should be evaluated through a structured, stepwise research framework:

- *Step 1 – Cadaveric Study:* Detailed cadaveric dissection combined with fluoroscopic and CT imaging should be performed to define the anatomical relationship between the S1 vertebral body, anterior cortex, and the superior hypogastric plexus. Primary endpoints would include successful anatomical access and measurement of distances to critical structures such as the iliac vessels.
- *Step 2 – Imaging-Based Study:* Three-dimensional CT reconstructions in a representative patient population should be used to assess anatomical variability and feasibility of the proposed trajectory.
- *Step 3 – Clinical Feasibility Study:* A prospective pilot study may be conducted comparing the proposed approach (intervention group) with standard anterior or posterior techniques (control group). Primary endpoints should focus on safety, including procedure-related complications. Secondary endpoints may include technical success rate, procedure time, and pain relief outcomes.
- *Statistical considerations:* As this is a hypothesis-driven manuscript, no formal statistical analysis was performed. Future vali-

dation studies should include appropriate sample size estimation based on predefined primary outcomes. Statistical analyses should be conducted using a two-sided approach, with a significance level set at $P < 0.05$.

If validated, this hypothesis could expand the conceptual framework for superior hypogastric plexus interventions by integrating principles of spine surgery with interventional pain management. Beyond chronic pelvic pain, this concept may encourage exploration of other transosseous pathways for deep neural targets. Although this approach is based on techniques familiar to spine surgeons, superior hypogastric plexus blocks are typically performed by pain specialists and anesthesiologists. Therefore, the clinical implementation of this technique would require specific training and interdisciplinary collaboration to ensure safety and reproducibility.

Limitations

This study presents a conceptual hypothesis based primarily on anatomical reasoning and fluoroscopic observations, without cadaveric dissection or quantitative imaging measurements. Therefore, the spatial relationship between the anterior sacral cortex and adjacent critical structures, such as the iliac vessels and retroperitoneal organs, has not been precisely defined. Anatomical variability among individuals represents an additional limitation, which may affect the reproducibility and safety of the proposed approach. Furthermore, the interpretation of contrast spread as indicative of proximity to the superior hypogastric plexus is indirect and lacks anatomical confirmation. Selection bias may also be present, as the anatomical observations were performed under controlled conditions that may not reflect real clinical scenarios. These limitations highlight the need for systematic anatomical, imaging-based, and clinical validation before any clinical application.

Future directions

Future research should prioritize cadaveric validation of the proposed transosseous S1 pedicle pathway, followed by imaging-based studies to assess anatomical variability. Subsequent clinical trials should focus primarily on safety, with later studies evaluating procedural efficiency and comparative effectiveness against established techniques. Interdisciplinary collaboration between spine surgeons and pain specialists will be essential for the clinical translation of this concept.

Conclusions

This article proposes a novel hypothesis suggesting that a posterior transosseous S1 pedicle approach may provide an anatomically plausible pathway to the superior hypogastric plexus. While preliminary anatomical observations support the anatomical plausibility of this concept, further anatomical, experimental, and clinical studies are required to assess its safety, reproducibility, and potential clinical relevance.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions

Anatomical hypothesis development, anatomical analysis, fluoroscopic anatomical orientation, manuscript review, final approval of the manuscript (ALLB), literature review, methodological contribution, manuscript editing, final approval of the manuscript (CMA), conceptualization, study design, methodological support, manuscript drafting, and final approval of the manuscript (JAMG).

Ethical statement

The present manuscript is a hypothesis-driven conceptual study and does not involve human participants, patient data, or experimental interventions. The fluoroscopic images presented were obtained during an institutional spinal osteosynthesis training program conducted at the National Institute of Traumatology and Orthopedics, Rio de Janeiro, Brazil, using a cadaveric specimen legally acquired and maintained according to institutional regulations for educational purposes. The images were used solely for anatomical orientation and illustrative purposes. Publication of these educational cadaveric fluoroscopic images was permitted according to institutional policy, and no additional consent was required. No experimental procedures, research interventions, or data collection were performed on the specimen. According to institutional policies governing educational cadaveric training activities, formal Research Ethics Committee approval was not required for this non-experimental anatomical demonstration. Future anatomical or clinical studies designed to validate this hypothesis will require appropriate ethical review and approval. This concept is not intended for clinical application and should not be implemented without prior anatomical and clinical validation.

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