Vol 7 | Issue 1 | Pages 572-578

Journal of Orthopedic Surgery and Techniques

ISSN: 2578-7187

Research Article

DOI: 10.36959/453/613

Fluoroscopically Guided Aspiration of Bone Marrow from the Posterior Superior Iliac Spine: A Novel Technique

Anand Saluja, BA, Akshay Saluja, BA and Rajit Saluja, MD

Midwest Orthopedic Specialty Hospital, Franklin, Wisconsin, USA

Abstract

Concentrated bone marrow aspirate (cBMA) is widely used to enhance tissue and healing. Traditional aspiration techniques from the Posterior Superior Iliac Spine (PSIS) carry risks of penetration into the sciatic notch or perforation through the ilium, and they are typically performed with the patient in the prone position. This limits marrow flow and complicates patient repositioning to the supine position if the patient is under anesthesia and has to undergo a concurrent surgical repair procedure. We present a novel, fluoroscopically-guided technique for bone marrow aspiration performed with the patient in lateral decubitus position. The PSIS is localized and trochar is inserted under fluoroscopic visualization and directed towards the Anterior Inferior Iliac Spine (AIIS), allowing for gravity-assisted marrow flow and access to a thicker part of the ilium while maintaining a safe distance from the sciatic notch. This approach offers real-time visualization of the trochar, enhancing precision and safety. The lateral positioning also facilitates easier transition to supine position for concurrent surgical procedures. We have performed this technique on 47 patients with a minimum 2-year follow-up, observing no complications such as vascular or nerve injury, persistent pain, or hematoma formation. The procedure requires no activity restrictions post-operation and presents a versatile solution for harvesting bone marrow aspirate.

Introduction

Outline of the clinical problem

As many tissues, such as cartilage, tendon, ligament, bone, muscle, and meniscus have little intrinsic healing, orthobiologics are increasingly being used to improve the chances of healing [1]. Orthobiologics can utilize the body's natural healing mechanisms through growth factors and stem cells to improve healing and reduce recovery time [2].

Indications

Bone marrow aspirate is a commonly used orthobiologic to stimulate healing of tissues and bone. It contains two types of adult stem cells with proliferative potential: Hematopoietic and mesenchymal stem cells (MSC's) [3]. Bone marrow can be aspirated from various anatomical locations, including the anterior iliac crest, posterior iliac crest, distal femur, proximal or distal tibia, and calcaneus. In order to enhance therapeutic potential, bone marrow aspirate is concentrated (cBMA), which significantly increases the number of progenitor cells and growth factors for treating various musculoskeletal injuries. Typically, aspirated bone marrow contains around 600 progenitor cells per cc, while cBMA can contain approximately 2500 progenitor cells per cc [3,4]. This concentration process not only increases the number of mesenchymal stem cells (MSCs) but also concentrates various growth factors and cytokines, which stimulate healing through their anti-inflammatory and anabolic effects [5].

Contraindications

Contraindications for bone marrow aspiration include:

1. Active infection.
2. Blood disorders.
3. Uncontrolled diabetes mellitus.
4. Cancer not in remission for at least 5 years.
5. Patients on anticoagulants should discontinue their medication before the procedure: Patients on Warfarin should wait at least 5 days, while patients on Eliquis or other non-vitamin K-dependent anticoagulants should wait at least 3 days.

***Corresponding author:** Anand Saluja, BA, Midwest Orthopedic Specialty Hospital, Franklin, Wisconsin, USA

Accepted: December 20, 2024

Published online: December 22, 2024

Citation: Saluja A, Saluja A, Saluja R (2024) Fluoroscopically Guided Aspiration of Bone Marrow from the Posterior Superior Iliac Spine: A Novel Technique. J Orthop Surg Tech 7(1):572-578

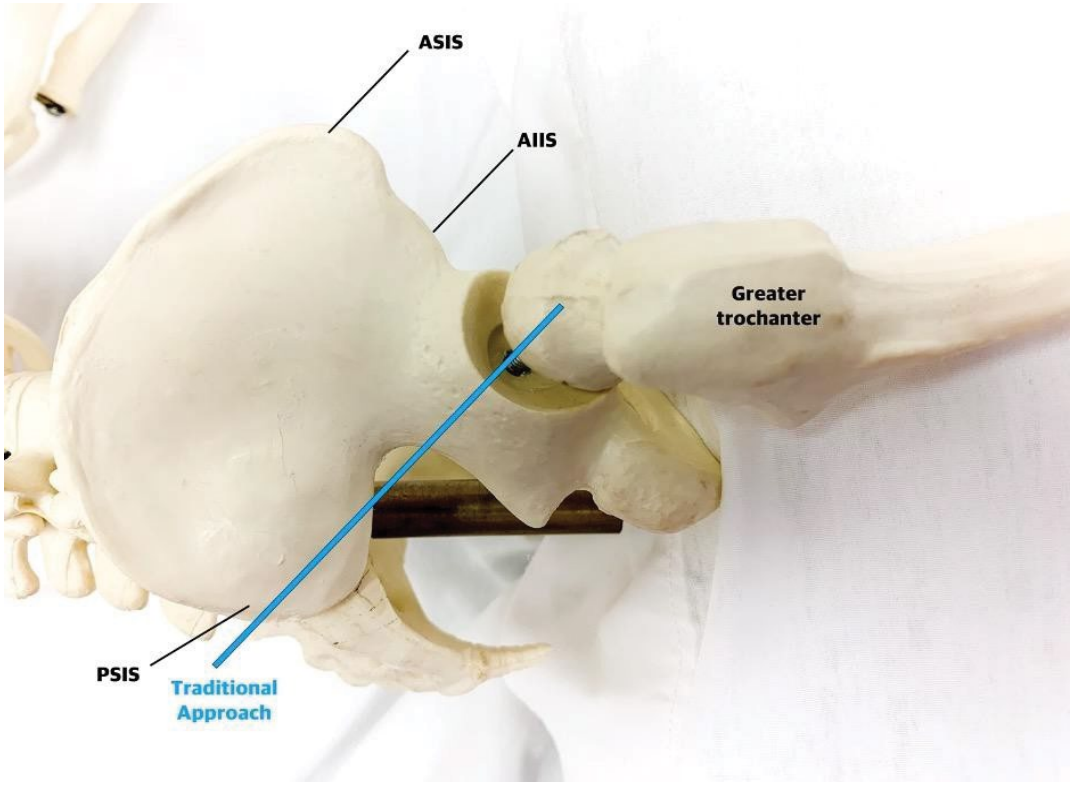

Figure 1: The traditional approach proposed by Hernigou, et al. for bone marrow aspiration.
PSIS: Posterior Superior Iliac Spine; ASIS: Anterior Superior Iliac Spine; AIIS: Anterior Inferior Iliac Spine

Current Surgical Techniques

The Posterior Superior Iliac Spine (PSIS) has been favorable due to its large area of bone, sufficient depth for needle insertion, and access to a high concentration of mesenchymal stem cells (MSCs) in the posterior iliac crest [6]. There are two common techniques described for aspiration from the PSIS, both performed with the patient in the prone position.

Hernigou's Technique: The aspiration cannula is directed either caudally 20-45 degrees and 30-45 degrees laterally from the entry point towards the greater trochanter (Figure 1) [7]. This approach aims to access a larger area of cancellous bone but carries a risk of penetrating the sciatic notch if the trocar is advanced too deep.

Hirahara's Technique: Aspiration cannula is directed laterally at a 25-degree angle by dropping the hand medially towards the midline, without any cephalad or caudad angulation (Figure 2) [8].

While this technique may reduce the risk of sciatic notch penetration, it poses a risk of penetrating the thinner portion of the ilium if the trocar is advanced beyond 5 centimeters [7].

Both techniques have limitations regarding the depth of penetration of the cannula and trocar, potentially leading to complications such as nerve or vascular injury. These risks highlight the need for a safer and more reliable approach to bone marrow aspiration.

Novelty of the New Technique

We present a technique which adds real-time fluoroscopy to the technique proposed by D'Souza, et al. based on 3D CT-Scans to establish a safer needle trajectory from the PSIS to the Anterior Inferior Iliac Spine (AIIS). This approach offers a wider safety margin from the greater sciatic notch and encounters a higher area of cancellous bone, potentially increasing the yield of progenitor cells. Our fluoroscopic technique allows real-time visualization, enhancing precision and safety, and is performed with the patient in the lateral decubitus position where blood flows readily by gravity (Figure 3).

The night before the procedure, it is recommended for patients to take some type of simethicone to reduce intestinal gas, which could obscure fluoroscopic visualization.

The patient is positioned in the lateral decubitus position. An axillary roll is not used due to the short length of the procedure. Pillows are placed between the legs. The fluoroscopy machine is positioned to obtain an AP view. The PSIS is easily visualized and the entry point is then provisionally marked with a surgical marker (Figure 4a and Figure 4b).

Once surgical preparation is completed, the area is draped with four towels. A spinal needle is used to confirm the angle of entry into the curved prominence of the PSIS under fluoroscopic guidance (Figure 5a and Figure 5b). After making a small nick in the skin with an 11 blade, the trocar and cannula are inserted into the bone. The hand is dropped 25 degrees medially and angling about 25 degrees caudad towards the AIIS, with fluoroscopic visualization (Figure 6). A mallet is used to initially penetrate the cortex of the PSIS, and the trocar is advanced towards the AIIS. Due to the lateral positioning, gravity allows for immediate blood flow (Figure 7).

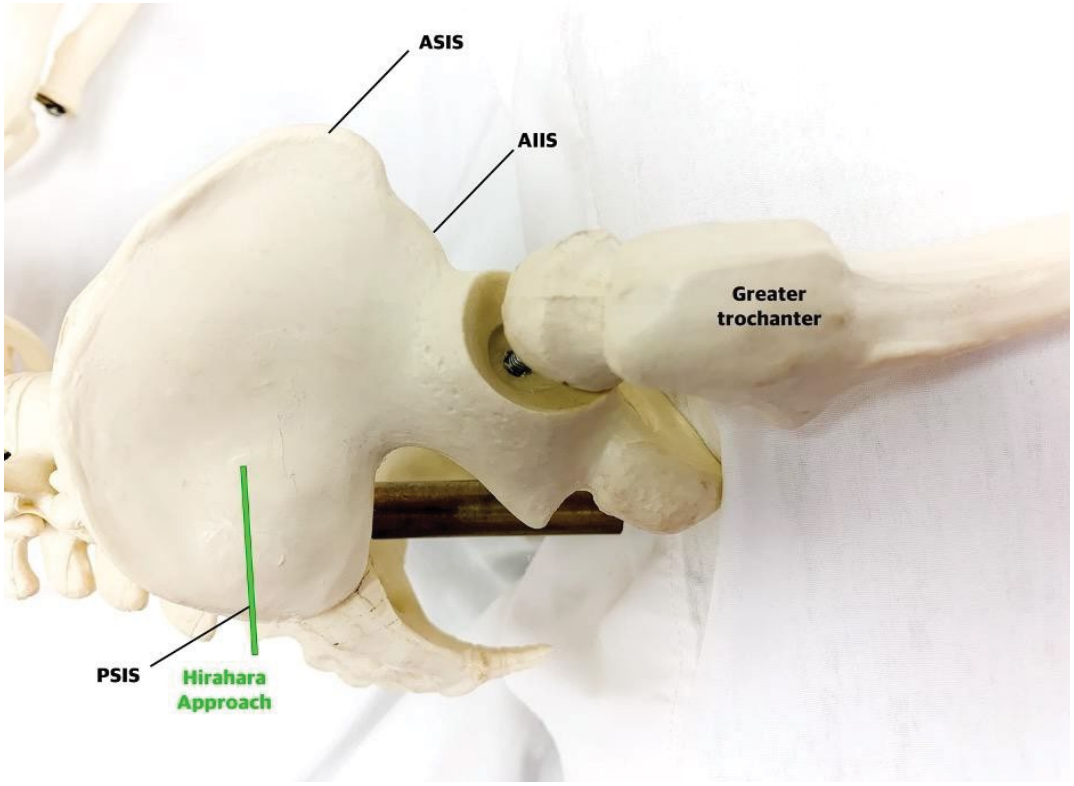

Figure 2: The approach proposed by Hirahara, et al. for bone marrow aspiration.

PSIS: Posterior Superior Iliac Spine; ASIS: Anterior Superior Iliac Spine; AIIS: Anterior Inferior Iliac Spine

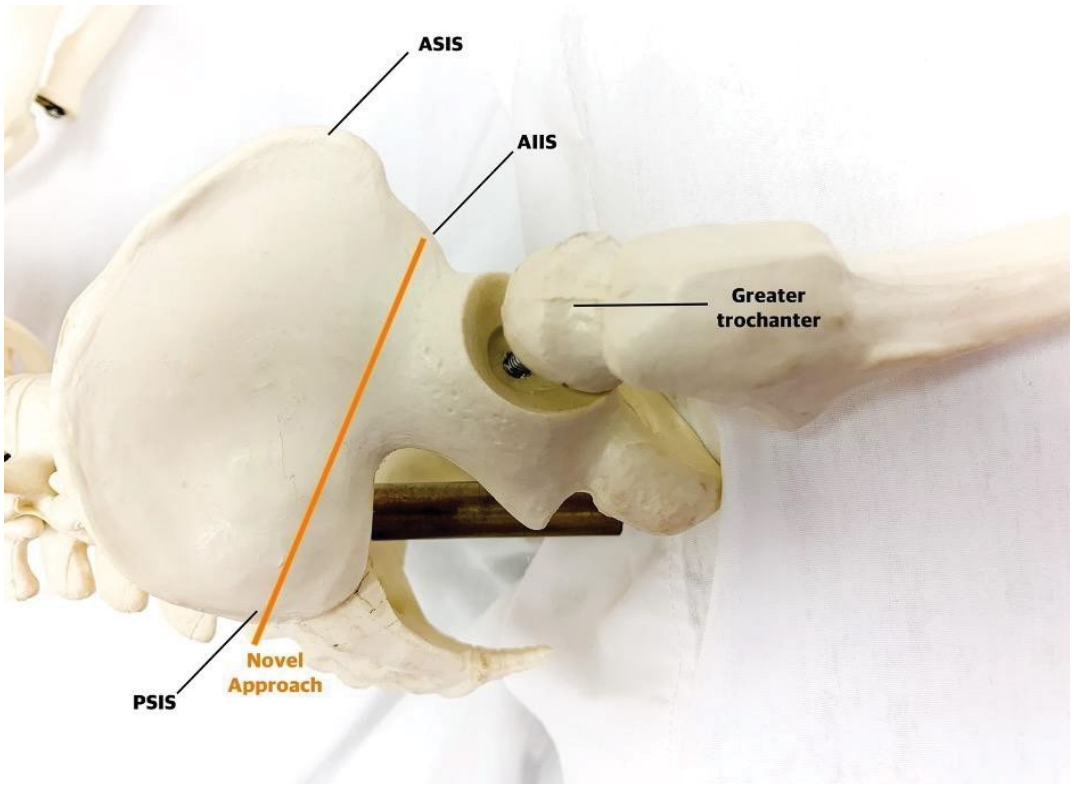

Figure 3: The novel approach proposed by D'Souza, et al. for bone marrow aspiration.

PSIS: Posterior Superior Iliac Spine; ASIS: Anterior Superior Iliac Spine; AIIS: Anterior Inferior Iliac Spine

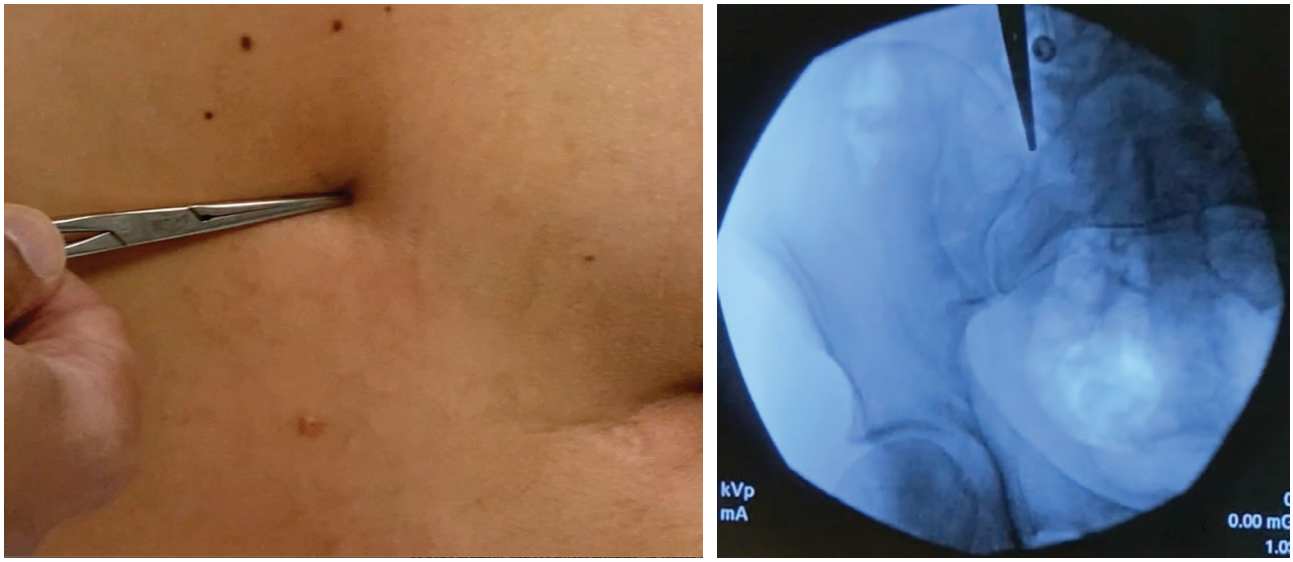

Figure 4: (a) The PSIS is marked using fluoroscopic guidance; (b) The PSIS is marked using fluoroscopic guidance.
PSIS: Posterior Superior Iliac Spine

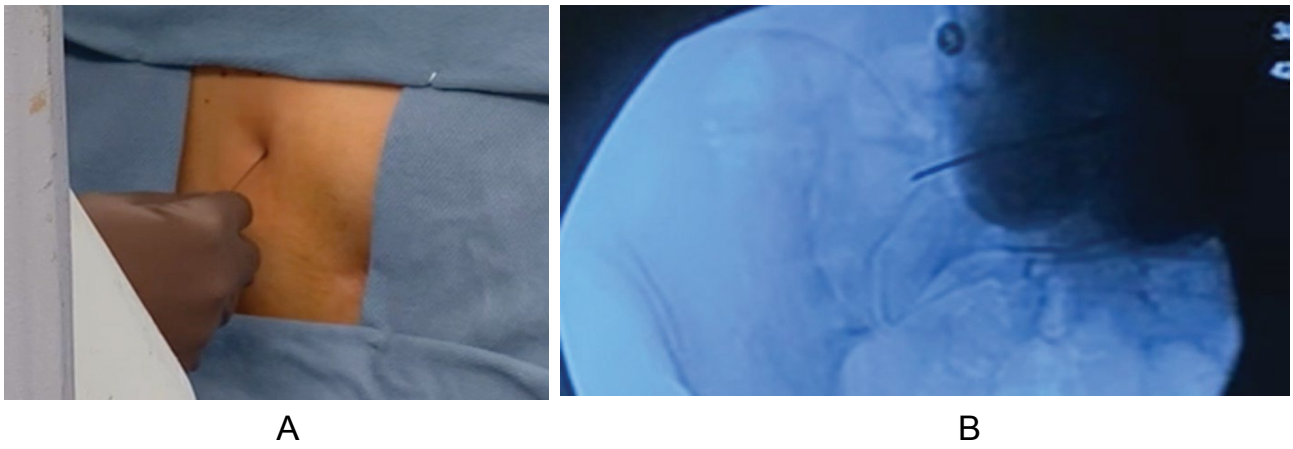

Figure 5: (a) The spinal needle is pictured on the PSIS; (b) The spinal needle is pictured on the PSIS.
PSIS: Posterior Superior Iliac Spine

The cannula and trocar are advanced several centimeters to the desired depth, and aspiration begins with a syringe containing an anticoagulant. To maximize yield, the cannula is withdrawn half a turn after every 5 cc - 10 cc of bone marrow aspiration. We typically use two 30 cc syringes, each containing 5 cc of the anticoagulant, filling a total of 60 cc of bone marrow-anticoagulant mixture. In cases requiring larger volumes, we have aspirated up to 120 cc of marrow (Figure 8).

The aspirate is then processed to form a concentrate at a desired hematocrit to maximize the MSC cell count. After applying pressure over the site for approximately one minute, the entry point is closed with steri-strips and covered with a small, sealed bandage.

Technique Advantages

While the anterior iliac crest is anatomically an easily accessible source of bone marrow, it carries a risk of nerve injury. Although aspiration can be performed with the patient in the supine position, marrow does not flow readily and must be actively aspirated. In contrast, Pierini, et al. have demonstrated that aspirate from the posterior crest contains a greater number of connective tissue progenitor cells [9], making it a more desirable harvest site.

Hernigou and associates have described six sectors in the pelvis in their process of developing safe techniques for bone marrow aspiration [10,11]. Sector 6, which contains the PSIS, appeared to have the largest thickness of spongiosus bone, making it favorable for bone marrow aspiration. However,

Figure 6: Fluoroscopic visualization is utilized while inserting the cannula and trocar into the PSIS.

Figure 7: The cannula and trocar enter the PSIS.
PSIS: Posterior Superior Iliac Spine

Figure 8: Bone Marrow aspirated in 30 cc syringes premixed with anticoagulant.
CC: Cubic Centimeters

if the trocar is introduced beyond 6 cm or at an incorrect angle, there is a risk of injuring the sciatic nerve and superior gluteal vessels, which corroborates the 3D-CT scan findings by D'Souza, et al. [7].

Hirahara's approach can also provide good bone marrow aspirate from the posterior crest, but caution must be exercised to avoid penetrating beyond a depth of 5 cm where the pelvis becomes too thin, risking intrapelvic penetration. Both Hernigou and Hirahara's techniques are traditionally performed with the patient in the prone position. As a result, upon entry of the PSIS, marrow does not flow readily but can be obtained through active aspiration.

Our novel technique addresses these limitations. We generally harvest bone marrow for injections during surgical procedures, and it is more convenient to start with the patient in the lateral decubitus position. This positioning requires less protective padding of the patient under anesthesia and allows for easier transition from lateral to supine position compared to transitioning from prone to supine. Additionally, with entry into the PSIS cortex in the lateral position, bone marrow flows more readily due to gravity.

D'Souza, et al. have used 3D CT Scan data to validate a safe path from PSIS to AIIS where greater cancellous bone is encountered and there is less risk of neurovascular injury [7]. We have adapted this technique using fluoroscopy, allowing for real-time visualization of both the PSIS entry point and the AIIS. This approach enables bone marrow to be aspirated safely and efficiently, minimizing the risk of complications while maximizing the yield of progenitor cells.

The usage of fluoroscopy allows for precise identification of the PSIS entry point. Real-time visualization allows for meticulous control of the needle's depth and direction, guiding it towards the safe zone of the pelvis for optimal bone marrow aspiration. The entry point is only a small nick in the skin approximated with steri-strips and covered with gauze and Tegaderm, allowing for seamless wound closure. Notably, the lateral decubitus positioning of the patient harnesses gravity, promoting more efficient blood flow during aspiration compared to alternative positions that necessitate active, slower aspiration. Postoperatively, patients face no specific activity restrictions related to the aspiration itself. However, when this technique is employed in conjunction with other surgical interventions, additional activity limitations may apply based on the nature of the concurrent procedures.

There are possible limitations for this novel approach to bone marrow extraction. Firstly, additional time is required to reposition to the supine position for concomitant procedures from the lateral decubitus position used in the aspiration. However, relative to other techniques requiring repositioning

from the prone position to the supine position, switching from the lateral decubitus position requires less effort, which becomes noticeable especially in patients with higher BMIs. Secondly, intestinal gas may impede fluoroscopic visualization of the PSIS. While preoperative administration of simethicone is recommended, it may not entirely eliminate this issue, potentially requiring heightened scrutiny of the PSIS and surrounding anatomy during the procedure. Lastly, the presence of a large abdominal pannus in the patient may also obscure visualization of the PSIS. In such cases, mobilization and taping of the pannus may be necessary to ensure unobstructed access and visualization for the extraction process.

Outcomes

We have performed this procedure on 47 patients with minimum 2-year follow-up, in which bone marrow was aspirated and injected both into the joint space of the knee and the subchondral bone of the proximal tibia and distal femur. There have been no complications, such as vascular injury, nerve injury, persistent pain, or hematoma formation. There have also been no activity restrictions following this procedure.

Conclusion

Fluoroscopically guided bone marrow aspiration via the PSIS to the AIIS is a safe and reliable option for harvesting bone marrow.

Ethical Approval

No ethical approval is required as our presented technique is a modification of an established technique.

Declaration of Competing Interests

The senior author has a consulting agreement with Arthrex (Naples, FL) but the technique was developed independently of any support.

Author Contributions

Anand Saluja: Original Draft, Visualization, Data Curation, Visualization; Akshay Saluja: Visualization, Data Curation; Rajit Saluja: Conceptualization, Methodology, Writing- Reviewing and Editing, Supervision, Validation.

References

1. Moreno-Garcia A, Rodriguez-Merchan EC (2022) Orthobiologics: Current role in orthopedic surgery and traumatology. Arch Bone Jt Surg 10: 536-542.
2. Sezgin EA, Atik OŞ (2018) Are orthobiologics the next chapter in clinical orthopedics? A literature review. Eklem Hastalik Cerrahisi 29: 110-116.
3. Calcei JG, Rodeo SA (2019) Orthobiologics for bone healing. Clin Sports Med 38: 79-95.
4. Bray CC, Walker CM, Spence DD (2017) Orthobiologics in pediatric sports medicine. Orthop Clin North Am 48: 333-342.
5. Brozovich A, Sinicrope BJ, Bauza G, et al. (2021) High variability of mesenchymal stem cells obtained via bone marrow aspirate concentrate compared with traditional bone marrow aspiration technique. Orthop J Sports Med 9: 23259671211058459.
6. Konda B, Pathak S, Edwin I, et al. (2014) Safe and successful bone marrow biopsy: An anatomical and CT-based cadaver study. Am J Hematol 89: 943-946.
7. D'Souza RS, Li L, Leng S, et al. (2021) A three-dimensional computed tomography study to determine the ideal method for fluoroscopically-guided bone marrow aspiration from the iliac crest. Bosn J Basic Med Sci 21: 370-377.
8. Hirahara AM, Panero A, Andersen WJ (2018) An MRI analysis of the pelvis to determine the ideal method for ultrasound-guided bone marrow aspiration from the iliac crest. Am J Orthop (Belle Mead NJ) 47.
9. Pierini M, Di Bella C, Dozza B, et al. (2013) The posterior iliac crest outperforms the anterior iliac crest when obtaining mesenchymal stem cells from bone marrow. J Bone Joint Surg Am 95: 1101-1107.
10. Hernigou J, Alves A, Homma Y, et al. (2014) Anatomy of the ilium for bone marrow aspiration: Map of sectors and implication for safe trocar placement. Int Orthop 38: 2585-2590.
11. Hernigou J, Picard L, Alves A, et al. (2014) Understanding bone safety zones during bone marrow aspiration from the iliac crest: The sector rule. Int Orthop 38: 2377-2384.

DOI: 10.36959/453/613