Bone and Arthrosurgery Science, 2025, Volume 3, Issue 3
http://ojs.bbwpublisher.com/index.php/BAS
Online ISSN: 2981-8222

Clinical Application of "Three-in-One" Bone Repair Strategy in the Perioperative Period of Elderly Intertrochanteric Femoral Fractures

Xihua Zhang[1,2], Zhongyu Peng[1,2], Hongchi Yi[1,2], Zhuoqian Dong[1,2], Huzhen Liu[1,2], Chengzheng Zhou[1,2], Wentao Zhao[1,2], Tao Chen[1,2]*

[1]Yunnan University of Traditional Chinese Medicine First Affiliated Hospital/Yunnan Provincial Hospital of Traditional Chinese Medicine Bone Injury Center Third Ward, Kunming 650021, Yunnan, China
[2]Yunnan University of Traditional Chinese Medicine, Kunming 650500, Yunnan, China

***Corresponding author:** Tao Chen, henpao@126.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: *Objective:* To investigate the clinical value of the "three-in-one" bone repair strategy (perioperative anti-osteoporosis therapy, optimization of minimally invasive intramedullary fixation technology, and postoperative intervention of Shenqi Hexue Decoction) in the treatment of elderly intertrochanteric femoral fractures. *Methods:* We retrospectively analyzed the elderly patients with intertrochanteric femoral fracture and intramedullary nail fixation admitted from January 2022 to December 2024, and divided the patients into two groups according to the method of this study: control group (63 cases, routine intramedullary fixation and basic anti-osteoporosis therapy) and trinity group (63 cases, using the "three-in-one" strategy). The perioperative indexes, bone metabolism indexes (BALP, BGP, PICP, PINP), Harris hip score, complications, and 1-year survival rate were compared between the two groups. *Results:* The intraoperative blood loss (95.3 ± 15.2 mL) and hospital stay (9.8 ± 2.1 days) in the trinity group were significantly lower than those in the control group (128.7 ± 20.1 mL and 14.5 ± 3.6 days, respectively) ($P < 0.01$). Six weeks after surgery, the levels of bone formation markers BALP (25.1 ± 3.8 U/L) and PICP (125.6 ± 18.3 μg/L) in the trinity group were significantly higher than those in the control group ($P < 0.05$). At 12 weeks after operation, the Harris score (86.7 ± 6.4) was significantly better than that of the control group (78.2 ± 7.1) ($P < 0.01$). Compared with the control group (14.7 ± 2.3 weeks), the fracture healing time in the trinity group (11.2 ± 1.8 weeks) was shortened by 23.8%, and the incidence of deep vein thrombosis (4.8% vs 15.9%) was significantly reduced ($P < 0.05$). *Conclusion:* The "three-in-one" strategy optimizes perioperative management, promotes bone metabolism and fracture healing, rapidly improves hip joint function, and reduces complications through multi-target intervention. It is a safe and effective solution for intertrochanteric fractures in the elderly, and is worthy of clinical application.

Keywords: Three-in-one; Bone repair strategies; Intertrochanteric fractures; Perioperative; Shenqi Hexue Decoction

Online publication: July 11, 2025

1. Introduction

Intertrochanteric femoral fracture (IFF) is a common trauma among elderly patients with osteoporosis, accounting for 45–50% of hip fractures [1]. With the intensifying aging of the population, there are over 200,000 new cases in China every year, with a disability rate of 30% and a mortality rate of 15–30% within one year, earning it the nickname "the last fracture of life" [2]. Traditional treatment faces three major difficulties: (1) Deteriorating bone metabolism environment: Osteoporosis leads to a high failure rate of internal fixation, reaching 10–15%, and increases the risk of postoperative refracture by three times [3]; (2) Surgical technique limitations: Even with minimally invasive intramedullary nail fixation (such as PFNA), there are still risks of loss of reduction and cutting for comminuted fractures above Evans-Jensen type III [4,5]; (3) Delayed recovery process: Long-term bed rest can lead to complications such as hypostatic pneumonia and deep vein thrombosis, with 30% of patients suffering from permanent dysfunction [6].

The "three-in-one" bone repair strategy, first proposed by Chen *et al.*, focuses on integrating anti-osteoporosis treatment, reasonable bone implant technology, and accelerated bone healing measures [7]. The innovations of this study lie in: (1) Incorporating preoperative anti-osteoporosis pretreatment into the ERAS process; (2) Refining the technical operation specifications of intramedullary nails based on fracture classification; (3) Introducing Shenqi Hexue Decoction to replace traditional prescriptions for promoting blood circulation and removing blood stasis. Shenqi Hexue Decoction, originating from the Yao's gynecology school, has proven effective in improving microcirculation and promoting callus formation in postoperative orthopedic recovery [8]. This study aims to verify the clinical application value of this strategy in the perioperative period of intertrochanteric femoral fractures.

2. Materials and methods

A retrospective analysis was conducted on elderly patients with intertrochanteric femoral fractures treated with intramedullary fixation from January 2022 to December 2024. Patients were divided into a control group and a trinity group based on the study methodology and inclusion criteria. The control group received conventional intramedullary fixation and basic anti-osteoporosis treatment, while the trinity group underwent a comprehensive intervention program incorporating preoperative anti-osteoporosis pretreatment, refined intramedullary nail techniques based on fracture typing, and the introduction of Shenqi Hexue Decoction.

2.1. Subjects

A retrospective analysis was conducted on elderly patients with intertrochanteric femoral fractures who underwent intramedullary fixation from January 2022 to December 2024. Based on the study methodology and inclusion criteria, the patients were divided into two groups after retrieving their medical records: the control group (63 cases) and the trinity group (63 cases). The control group consisted of 29 males and 34 females, aged between 70 and 94 years, with a mean age of 78.4 ± 6.2 years. According to the Evans-Jensen classification of fractures, there were 38 cases of Type III and 25 cases of Type IV. The mean bone mineral density T-score was -3.1 ± 0.4. The trinity group comprised 27 males and 36 females, aged from 72 to 96 years old, with an average age of 79.2 ± 6.8 years. There were 36 cases of Type III and 27 cases of Type IV fractures based on the Evans-Jensen classification. The mean bone mineral density T-score was -3.0 ± 0.5. Inclusion criteria for the study were: (1) age ≥70 years old, (2) bone mineral density T-score ≤-2.5, (3) fresh closed fracture (time from injury to surgery <72 hours), and (4) surgical treatment required for Evans-Jensen Type III-IV fractures. Exclusion criteria included: (1) pathological fractures, (2) severe cardiac insufficiency (NYHA Class III-IV), (3) cognitive impairment preventing cooperation

with rehabilitation, and (4) coagulation disorders. There were no statistically significant differences in baseline characteristics between the two groups ($P > 0.05$), indicating comparability. This study followed the relevant guidelines of the hospital's ethics committee, and the patient and medical record data were objective, authentic, and complete.

2.2. Treatment methods

2.2.1. Control group

Adopting conventional intramedullary fixation + basic anti-osteoporosis regimen:

(1) Surgical treatment: Patients underwent proximal femoral nail anti-rotation (PFNA) fixation under anesthesia.

(2) Postoperative management: Included prophylactic antibiotics, anticoagulation, and a gradual rehabilitation program.

(3) Anti-osteoporosis therapy: Oral administration of calcium carbonate D3 tablets and alendronate sodium.

2.2.2. Trinity group

The trinity group received a perioperative comprehensive intervention program (**Table 1**), which integrated anti-osteoporosis therapy, refined surgical techniques based on fracture typing, and the introduction of Shenqi Hexue Decoction.

Table 1. Perioperative comprehensive intervention program in the trinity group

Phase	Core intervention	Implementation details
Preoperative	Antiresorptive pretreatment	Initiated upon admission: - Correct hypocalcemia - Menatetrenone Soft Capsules 15 mg TID PO - Elcatonin Injection 20 U QD SC (1 week total)
	Multidisciplinary risk assessment	Consultations with Anesthesiology, Cardiology & Endocrinology: - Maintain blood glucose <8.3 mmol/L - Control systolic BP <160 mmHg
Intraoperative	Optimized intramedullary fixation	1. Tip-Apex Distance (TAD) control: <20 mm on AP/lateral views 2. Blade fixation + Bone cement augmentation 3. Arthrocentesis to prevent myositis ossificans
Postoperative	Shenqi Hexue Decoction	Initiated 8h post-op: -Composition: Astragalus 30 g, Ginseng 15 g, Angelica 15 g, Atractylodes 30 g, Poria 30 g, Chuanxiong 15 g, Peach Kernel 10 g, Dipsacus 15 g, Amomum 10 g, Honey-fried Licorice 10 g - Decoction: 300 mL BID ×8 weeks
	Phased rehabilitation protocol	- 8h post-op: Ankle pumps & lower extremity exercises - 24h post-op: Bedside sitting - 72h post-op: Standing with walker - 2 weeks: 50% weight-bearing ambulation
	Maintenance antiresorptive therapy	- Calcium Carbonate + D3 Tablets (600 mg/d) + sequential Calcitriol - Zoledronic Acid 5 mg IV infusion (within 1–3 days post-op; repeated annually ×5 years)

Strategy description:

(1) Pre-treatment for osteoporosis resistance: Tetrahydroxymenadione promotes bone formation; Elcatonin

inhibits acute bone loss, reduces inflammation, and alleviates pain caused by osteoporosis and fractures [9]; Postoperative zoledronic acid rapidly inhibits osteoclast activity, sequential basic calcium and vitamin D supplementation promote bone metabolism and improve bone healing.

(2) Optimization of intramedullary fixation technique: For Evans-IV type fractures, a spiral blade and bone cement reinforcement technique (bone cement injection volume ≤3 mL) is used to enhance the holding force; intraoperative C-arm monitoring ensures that the tip-apex distance is less than 20 mm in both planes.

(3) Application of Shenqi Hexue Decoction: In the prescription, *Astragalus* and Ginseng tonify qi and consolidate the constitution; *Angelica* and Chuanxiong promote blood circulation and remove blood stasis; *Dipsacus* root strengthens muscles and bones; *Amomum villosum* regulates qi and harmonizes the stomach, reducing gastrointestinal reactions [8].

2.3. Observation indicators

(1) Perioperative indicators: Operation time, intraoperative blood loss, hospital stay, and complications (deep vein thrombosis, lung infection, incision infection, etc.).

(2) Bone metabolism indicators: Serum bone alkaline phosphatase (BALP), osteocalcin (BGP), procollagen type I carboxy-terminal propeptide (PICP), and procollagen type I amino-terminal propeptide (PINP) were measured before surgery and at 6 weeks postoperatively.

(3) Imaging evaluation: Hip joint X-rays were taken at 1, 6, and 12 weeks postoperatively to observe fracture healing (criterion: continuous callus passing through the fracture line), internal fixation position, and tip-apex distance changes.

(4) Functional score: Harris hip score (including pain, function, range of motion, and deformity, with a total score of 100) was used to evaluate the function at 12 weeks postoperatively.

(5) Quality of life: SF-36 score at 6 months postoperatively and 1-year survival rate were recorded.

2.4. Statistical methods

Data were analyzed using SPSS 25.0. Measurement data were expressed as mean ± standard deviation (SD) and compared between groups using the *t*-test. Count data were expressed as a rate (%) and compared using the χ^2 test. Survival analysis was performed using the Kaplan-Meier curve. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of perioperative indicators

The trinity group significantly outperformed the control group in terms of intraoperative blood loss, time to weight-bearing, and hospital stay ($P < 0.01$). Regarding complications, the trinity group had significantly lower rates of deep vein thrombosis (4.8% vs 15.9%) and lung infection (6.3% vs 15.9%) ($P < 0.05$). See **Table 2** for details.

Table 2. Comparison of perioperative indicators between the two groups (mean ± SD)

Indicator	Control group (n = 63)	Trinity group (n = 63)	Statistic	P
Operation time (min)	68.5 ± 12.3	65.2 ± 11.6	t = 1.612	> 0.05
Intraoperative blood loss (mL)	128.7 ± 20.1	95.3 ± 15.2*	t = 10.387	< 0.01
Time to weight-bearing (d)	6.2 ± 1.5	3.1 ± 0.8*	t = 15.239	< 0.01
Hospital stay (d)	14.5 ± 3.6	9.8 ± 2.1*	t = 9.213	< 0.01
Complications [n (%)]			χ^2 = 6.714	< 0.05
Deep vein thrombosis	10 (15.9%)	3 (4.8%)*		
Pulmonary infection	10 (15.9%)	4 (6.3%)*		
Surgical site infection	3 (4.8%)	2 (3.2%)		

Note: Compared with the control group, *P < 0.05

3.2. Changes in bone metabolism indicators

At 6 weeks postoperatively, bone metabolism indicators improved in both groups, but the trinity group showed a more significant increase in bone formation markers: BALP (25.1 ± 3.8 U/L vs 19.3 ± 3.1 U/L) and PICP (125.6 ± 18.3 μg/L vs 98.7 ± 15.2 μg/L) (P < 0.05). PINP levels in the trinity group reached 58.9 ± 7.8 μg/L, which was 38.6% higher than the control group (42.5 ± 6.3 μg/L) (P < 0.01).

3.3. Fracture healing and functional recovery

The fracture healing time in the trinity group (11.2 ± 1.8 weeks) was 23.8% shorter than that in the control group (14.7 ± 2.3 weeks) (P < 0.01). At 12 weeks postoperatively, the Harris score showed that the trinity group had significant advantages in pain relief (38.5 ± 3.2 vs 32.1 ± 4.1) and walking ability (24.3 ± 2.8 vs 20.1 ± 3.2) (P < 0.01), and the overall excellent and good rate (88.9% vs 73.0%) was significantly improved (P < 0.05). At 6 months postoperatively, the SF-36 score indicated that the trinity group performed better in physiological function (75.6 ± 8.3 vs 68.2 ± 9.1) and mental health (72.4 ± 7.5 vs 65.3 ± 8.2) dimensions compared to the control group (P < 0.05).

3.4. Survival analysis

After 1 year of follow-up, the survival rate of the trinity group (93.7%) was higher than that of the control group (85.7%), but the difference was not statistically significant (P > 0.05). The deaths were mainly due to cardiopulmonary failure (5 cases in the control group and 2 cases in the trinity group).

4. Discussion

4.1. Theoretical basis and innovation of the “three-in-one” strategy

There are many difficulties in the treatment of osteoporotic fractures, such as complex fracture comminution, a vicious cycle of bone loss, and delayed fracture healing. There are also misconceptions in diagnosis and treatment processes, including cognitive, conceptual, and technical misunderstandings. Within 1 year after hip fracture, 21–30% of patients die from various complications, up to 50% of survivors have disabilities, and only about 30% of patients can return to their pre-injury status [10].

This study is the first to integrate "anti-osteoporosis pretreatment–intramedullary fixation optimization–accelerated healing with traditional Chinese medicine" into the perioperative management of intertrochanteric hip fractures in the elderly. The main innovations include the following.

4.1.1. Rapid bone metabolism regulation starting before surgery

Dual-channel bone metabolism regulation is achieved through the combination of tetracycline (activates osteocalcin, promotes bone formation; inhibits osteoclast release) and zoledronic acid (inhibits osteoclast activity; induces osteoclast apoptosis). Upon admission, patients are administered elcatonin injection (a calcium homeostasis agent) to inhibit acute bone loss caused by immobilization and bed rest after fracture, and to reduce inflammation and relieve pain caused by fractures and osteoporosis [9]. Data from this study showed that the PICP level in the trinity group increased by 27.3% at 6 weeks postoperatively, verifying the bone formation effect of this protocol.

4.1.2. Standardization of intramedullary nailing technique

For unstable Evans-IV fractures, a dual-plane control method for tip-apex distance (both anteroposterior and lateral views are <20 mm) and a bone cement augmentation technique are proposed. Biomechanical studies have confirmed that bone cement can increase the holding force of spiral blades by 30–50%, especially suitable for patients with severe osteoporosis with a Singh index ≤ III. No cases of cutting or loss of reduction occurred in this group, confirming the reliability of this technique.

4.1.3. Multi-target regulation of Shenqi Hexue Decoction

Based on traditional qi-invigorating and blood-activating herbs, this prescription adds *Dipsacus asper* to strengthen tendons and bones, and *Amomum villosum* to invigorate the spleen and stomach, which not only promotes bone healing but also reduces gastrointestinal reactions to medications [8]. Modern pharmacology has confirmed that *Astragalus* polysaccharides can increase serum TGF-β1 levels and promote osteoblastic differentiation [11,12]; *Angelica sinensis* ferulic acid inhibits the release of TNF-α and reduces inflammatory responses [13]; *Dipsacus* saponin VII increases callus calcium salt deposition. In this study, the average healing time of the integrated treatment group was reduced to 11.2 weeks, and the Harris score increased by 11.1%, reflecting the synergistic advantages of integrated Chinese and Western medicine.

4.2. Optimization of perioperative management and prevention and control of complications

Surgery within 48 hours for hip fractures in the elderly can significantly reduce mortality [14,15]. Through a multidisciplinary team (MDT) approach, this study achieved a reduction in the average time from admission to surgery to 28.5 hours and a decrease in the incidence of deep vein thrombosis to 4.8% in the integrated treatment group. This was mainly attributed to: (1) advance anticoagulation: initiating low molecular weight heparin 12 hours before surgery combined with postoperative pneumatic compression therapy, coupled with the blood rheology improvement effect of Shenqi Hexue Decoction (reducing whole blood viscosity and fibrinogen); (2) graded rehabilitation: starting ankle pump exercises 6 hours postoperatively and seated training at 24 hours, significantly reducing the risk of hypostatic pneumonia; (3) nutritional support: the postoperative serum albumin level in the integrated treatment group (35.2 ± 3.1 g/L) was higher than that in the control group (32.5 ± 2.8 g/L) (*P*

< 0.05), benefiting from the gastrointestinal function regulation of Shenqi Hexue Decoction and high-protein diet guidance.

4.3. Mechanism of Shenqi Hexue Decoction in bone repair

Osteoporotic fractures have a high incidence and are harmful, being a significant cause of disability and death in the elderly population [16,17]. The integrated treatment of Chinese and Western medicine highlights its advantages in China. This study reveals that Shenqi Hexue Decoction accelerates fracture healing through a triple predictive mechanism:

(1) Improving microcirculation: The ligustrazine in Chuanxiong and polysaccharides in *Angelica sinensis* dilate microvessels, increase local blood flow to the fracture site, and alleviate ischemia-reperfusion injury.

(2) Regulating bone metabolism: Ginsenoside Rg1 upregulates the BMP-2/Runx2 pathway [18], promotes osteoblast differentiation, and synergistically enhances BALP and PINP levels with zoledronic acid [19].

(3) Inhibiting inflammatory response: *Astragalus* flavonoids reduce IL-6 and TNF-α expression [20], alleviate pain, and create conditions for early functional exercise.

Compared to anti-osteoporosis drugs alone, the multi-target characteristics of Chinese medicine intervention are more aligned with the pathogenesis of "qi and blood deficiency, blood stasis blocking meridians" in elderly fractures. The results of this study are consistent with reports on the treatment of hip fractures with Shenqi Bushen Huoxue Decoction [8], but Shenqi Hexue Decoction has more advantages in improving gastrointestinal tolerance.

4.4. Research limitations and prospects

This study has the following limitations: (1) No control subgroup using different Chinese medicine prescriptions was set up; (2) The medication costs in the integrated treatment group are relatively high, requiring pharmacoeconomic evaluation; (3) There is a lack of dynamic monitoring data on postoperative bone density. Future research directions include: (1) Developing formula granules of Shenqi Hexue Decoction to improve medication compliance; (2) Exploring individualized responses to bone metabolism interventions based on gene polymorphism; (3) Extending the follow-up period to 2 years to evaluate the prevention effect of secondary fractures.

5. Conclusion

The "three-in-one" bone repair strategy significantly optimizes perioperative management for intertrochanteric hip fractures in the elderly: preoperative anti-osteoporosis pretreatment improves the basis of bone metabolism; individualized intramedullary fixation techniques ensure mechanical stability; Shenqi Hexue Decoction intervention synergistically promotes bone healing. This strategy reduces fracture healing time to 11.2 ±1.8 weeks, achieves a Harris score of 86.7 ± 6.4, and lowers the incidence of deep vein thrombosis to 4.8%, effectively promoting rapid patient recovery. It is a safe and effective comprehensive treatment plan worthy of clinical promotion.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Che SH, Cho MR, Quinn PM, et al., 2023, Risk Factors Affecting Hip Fracture Patterns in an Elderly Korean Patient Population. Medicine (Baltimore), 102(33): e34573.

[2] Whitehead K, Spaner D, 2018, Management of Traumatic Hip Fracture in the Palliative Care Unit. J Palliat Care, 33(3): 175–177.

[3] Hu Q, Wang Q, Liu F, et al., 2022, Combination of Calcitriol and Zoledronic Acid on PINP and β-CTX in Postoperative Patients with Diabetic Osteoporosis: A Randomized Controlled Trial. Disease markers, 2022: 6053410.

[4] Miller ND, Cho T, Gokula L, et al., 2025, Intertrochanteric Fractures in the Elderly Treated with Different Intramedullary Devices: A Systematic Review and Meta-Analysis Based on Comparison Studies. JBJS Rev, 13(3).

[5] Youth Osteoporosis Study Group of Chinese Orthopaedic Association, Trauma Orthopedics and Multiple Injuries Study Group of Emergency Resuscitation Professional Committee of Chinese Medical Doctor Association, Osteoporosis Professional Committee of Shanghai Association of Integrative Medicine, 2018, Chinese Expert Consensus on Perioperative Management of osteoporotic Fractures (2018). Chinese Journal of Clinical Medicine, 25(5): 860–866.

[6] Hagen MS, Allahabadi S, Zhang AL, et al., 2020, A Randomized Single-Blinded Trial of Early Rehabilitation Versus Immobilization After Reverse Total Shoulder Arthroplasty. J Shoulder Elbow Surg, 29(3): 442–450.

[7] Chen X, Hu Y, Su J, 2024, Application of the "Trinity" Bone Repair Strategy in Osteoporotic Fractures. Chinese Journal of Trauma, 39(06): 494–499.

[8] Wan Q, Zou C, Yi H, et al., 2022, Application of Shenqi Hexue Decoction in Postoperative Rehabilitation of Orthopedic Diseases. Chinese Ethnic Medicine and Ethnomedicine, 31(19): 82–84.

[9] Desai SM, Bernhard WN, McAlary B, 1990, Regional Anesthesia: Management Considerations in the Trauma Patient. Crit Care Clin, 6(1): 85–101.

[10] US Preventive Services Task Force, Curry SJ, Krist AH, et al., 2018, Screening for Osteoporosis to Prevent Fractures: US Preventive Services Task Force Recommendation Statement. JAMA, 319(24): 2521–2531.

[11] Hamid M, Liu D, Abdulrahim Y, et al., 2017, Amelioration of CCl4-Induced Liver Injury in Rats by Selenizing Astragalus Polysaccharides: Role of Proinflammatory Cytokines, Oxidative Stress and Hepatic Stellate Cells. Research in Veterinary Science, 114: 202–211.

[12] Erseckin V, Mert H, Irak K, et al., 2022, Nephroprotective Effect of Ferulic Acid on Gentamicin-Induced Nephrotoxicity in Female Rats. Drug Chem Toxicol, 45(2): 663–669.

[13] Ekhtiar M, Ghasemi-Dehnoo M, Azadegan-Dehkordi F, et al., 2025, Evaluation of Anti-Inflammatory and Antioxidant Effects of Ferulic Acid and Quinic Acid on Acetic Acid-Induced Ulcerative Colitis in Rats. J Biochem Mol Toxicol, 39(2): e70169.

[14] Kukla C, Heinz T, Gabler C, 1995, Acute Management of Para-Articular Hip Fractures in Geriatric Patients. Wien Klin Wochenschr, 107(5): 169–174.

[15] Verbeek DO, Ponsen KJ, Goslings JC, et al., 2008, Effect of Surgical Delay on Outcome in Hip Fracture Patients: A Retrospective Multivariate Analysis of 192 Patients. Int Orthop, 32(1): 13–18.

[16] Cao L, Chen X, Weng W, et al., 2017, Surgical Treatment Strategy Selection for Hip Fracture Patients Over 80 Years Old: A Report of 915 Cases. Academic Journal of Second Military Medical University, 38(04): 409–414.

[17] Liu Z, Lv X, Liu J, et al., 2020, Epidemiological Characteristics of 2342 Hip Fracture Cases: A Single-Center Analysis. Chinese Journal of Tissue Engineering Research, 24(32): 5085–5091.

[18] Ye J, Wei D, Peng L, et al., 2019, Ginsenoside Rb1 Prevents SteroidInduced Avascular Necrosis of the Femoral Head

Through the Bone Morphogenetic Protein2 and Vascular Endothelial Growth Factor Pathway. Mol Med Rep, 20(4): 3175–3181.

[19] Chen F, Dai Z, Kang Y, et al., 2016, Effects of Zoledronic Acid on Bone Fusion in Osteoporotic Patients After Lumbar Fusion. Osteoporos Int, 27(4): 1469–1476.

[20] Zhang J, Zhao R, Hou G, et al., 2023, Stereoscopic Differences in the Identification, Bioactivity, and Metabolism of C-20 and C-24 Epimeric Ginseng Saponins. Mini Rev Med Chem, 23(7): 804–820.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.