

# Core decompression, lesion clearance and bone graft in combination with Tongluo Shenggu decoction for the treatment of osteonecrosis of the femoral head

## A retrospective cohort study

Yang-Quan Hao, MD<sup>a,\*</sup>, Hao Guo, MS<sup>a</sup>, Tian Zhu, MS<sup>b</sup>, Zhao-Chen Xu, MS<sup>b</sup>, Han-Deng Qi, MS<sup>b</sup>, Chao Lu, MD<sup>a</sup>, Pu-Wei Yuan, MD<sup>c,\*</sup>

### Abstract

The aim of this study was to evaluate the clinical effect of core decompression (CD), lesion clearance, and bone graft in combination with Tongluo Shenggu decoction for the treatment of osteonecrosis of the femoral head (ONFH).

A total of 75 patients (92 hips), with ONFH at Association Research Circulation Osseous (ARCO) stages II to IIIA, were studied and divided into treatment group and control group. In control group, patients were treated with the CD in combination with autologous or artificial ceramic bone graft. In treatment group, patients were treated with the above method combined with Tongluo Shenggu decoction. Patients were followed-up at 1 month, 6 months, and 24 months after surgery. The visual analogue scale (VAS) scores, Harris Hip Score (HSS), and total effective rates were measured and recorded.

The total effective rate of the treatment group was significantly higher than that of the control group (97.2% vs. 89.9%,  $P < .05$ ). Compared with preoperative, the VAS and HSS scores were both improved at final follow-up, and there was significant difference between 2 groups ( $P < .01$ ).

The combination of CD, lesion clearance, and the bone graft with Tongluo Shenggu decoction is safe and effective for the treatment of ONFH, owing to which it can provide higher postoperative functional outcomes, reduce pain, and achieve smaller osteonecrosis area and better bone changes.

**Abbreviations:** ARCO = Association Research Circulation Osseous, CD = core decompression, HSS = Harris Hip Score, ONFH = osteonecrosis of the femoral head, TCM = traditional Chinese medicine, VAS = visual analogue scale.

**Keywords:** core decompression, femoral head, osteonecrosis, tongluo shenggu decoction

Editor: Muhammad Shahzad Aslam.

Y-QH and P-WY equally contributed to this paper and shared the co-corresponding authorship.

**Funding:** The study was supported by the Xi'an Health and Family Planning Commission Foundation (No. J201803048).

The authors report no conflicts of interest.

<sup>a</sup> Department of osteonecrosis and joint reconstruction, Honghui Hospital, Xi'an Jiaotong University, Xi'an, <sup>b</sup> Graduate School, Shaanxi university of Chinese medicine, Shiji Ave, Xi'an-xianyang New Economic Zone, <sup>c</sup> Department of Orthopedics, Affiliated Hospital of Shaanxi University of Chinese Medicine, Xianyang, Shanxi Province, P.R. China.

\* Correspondence: Yang-Quan Hao, Department of osteonecrosis and joint reconstruction, Honghui Hospital, Xi'an Jiaotong University, No. 555 Youyi East Road, Shaanxi, 710054, Xi'an, P.R. China (e-mail: Haoyq2008@163.com); Pu-Wei Yuan, Department of Orthopedics, Affiliated Hospital of Shaanxi University of Chinese Medicine, No. 1. Weiyang West Road, Xianyang, Shanxi 712000, P.R. China (e-mail: yuanpuwei\_66@163.com).

Copyright © 2018 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

Medicine (2018) 97:41(e12674)

Received: 11 April 2018 / Accepted: 6 September 2018

<http://dx.doi.org/10.1097/MD.00000000000012674>

## 1. Introduction

Osteonecrosis of the femoral head (ONFH) is a progressive disease, which if left untreated it will lead to the femoral head collapsing and hip dysfunction that severely affect patients' life quality.<sup>[1,2]</sup> The disease occurs predominantly in 30- to 50 years' old patients,<sup>[3,4]</sup> among them total hip arthroplasty will be performed in 80%.<sup>[5]</sup> Preservation of the femoral head is the ultimate goal to the treatment of ONFH.<sup>[6]</sup> Several treatment methods have been proposed to preserve native joints, including core depression,<sup>[7]</sup> advanced core decompression (CD),<sup>[8]</sup> intertrochanteric rotational osteotomy,<sup>[9–13]</sup> pedicle-bone grafting,<sup>[14–16]</sup> intertrochanteric varus osteotomy,<sup>[17]</sup> and curved intertrochanteric varus osteotomy.<sup>[18–20]</sup> However, there has been no consensus on the uniform treatment algorithm for treatment of ONFH.<sup>[21]</sup>

ONFH belongs to the category of “bone erosion”, “heumatism”, “bone flag” in traditional Chinese medicine (TCM). TCM theories believe that this disease is mainly related to liver and kidney. Kidney stores the renal yin and renal yang as well as essence and affects the production of marrow in bone and the empty marrow will lead to the loss of nutrients in the bone. Liver governs tendons and blood; insufficient blood volume will lead to the blood stasis. The treatment should be promoting blood circulation and removing blood stasis, tonifying liver and kidney, and activating collaterals and regenerating marrow. Based on this

method, Tongluo Shenggu decoction has achieved good curative effect in clinical trials through comprehensive analysis by the 4 examination methods.<sup>[22]</sup> Tongluo Shenggu decoction, as the CTM,<sup>[23–25]</sup> is mainly composed of Huangqi/Astragalus, Jixueteng/Caulis Spatholobi, Lujiao/Deer horn glue, Zhechong/ Ground beetle, Sanqi/Panax notoginseng, Niuxi/Achyranthes bidentata, Danshen/Salvia Miltiorrhiza. The combination use of various drugs could promote blood circulation and remove blood stasis. Therefore, in this study we aimed to evaluate the clinical effect of CD, lesion clearance, and bone graft in combination with Tongluo Shenggu decoction for the treatment of ONFH.

## 2. Materials and methods

### 2.1. Patients

This study was approved by the ethics committee of Affiliated Hospital of Shaanxi university of Chinese medicine and conducted according to the Helsinki Declaration. The written informed consent was obtained from all patients. From January 2012 to January 2013, 75 patients (92 hips) with ONFH who underwent CD in combination with autologous or artificial ceramic bone graft at our department were enrolled in this study. The patients were divided into 2 groups according to different therapeutic approaches: in control group, patients were treated with the CD in combination with autologous or artificial ceramic bone graft; in treatment group, patients were treated with above method as well as with Tongluo Shenggu decoction.

The exclusion criteria for this study were as follows: Association Research Circulation Osseous (ARCO) stage III B or above; no use drugs according to stipulations, no effect on accept other therapy; patients with concomitant heart, liver and renal dysfunction, or psychosis.

### 2.2. CD

The puncture was on lateral femoral greater trochanter under 2 cm. Under the guidance of the C-arm x-ray, a 2.0-mm diameter Kirschner wire was drilled into the subchondral lamella of the femoral head along the femoral neck axis toward to ONFH. After entering the ONFH, a 2-cm incision was performed. The subcutaneous tissue, fascia, and bone cortex were separated by a blunt shape. A cannulated drill (5 mm) was inserted via a Kirschner wire to obtain an 8 mm diameter of canal, and the k-wire was removed. The necrotic bone in the necrotic area was debrided by a curette. Bone graft instrument was used to irrigate the hybrid ceramic bone (tricalcium phosphate ceramic porcelain bone) or autogenic iliac bone, compacted with layer and layer and guaranteed sufficient bone graft. During the process of bone graft, the instrument was gradually toward to the basal parts of the femoral neck, and normal cylindrical bone tissue would be filled back in the same place. After compaction, the wound was flushed, sutured, and fixed by aseptic dressing.

### 2.3. Autogenic iliac bone

After general anesthesia or combined spinal epidural anesthesia, patients were placed in the supine position. A 2-cm incision along the iliac wing was performed on the ipsilateral iliac spine on 1.5 cm, exposing the ilium. A 2 cm × 2 cm × 0.5 cm size of the iliac bone was taken out by osteotome, saved in the wet gauze. The wound was flushed, sutured, and fixed by aseptic dressing. The autogenic iliac bone was crunched by rongeur and set aside for using.

### 2.4. Postoperative management

Weight bearing was not allowed within the first month post-surgery, partial weight bearing crutch walking was allowed 3 months after surgery, and full weight bearing was allowed 6 months after surgery.

Tongluo Shenggu decoction includes Huangqi/Astragalus (30g), Jixueteng/Caulis Spatholobi (30g), Lujiao/Deer horn glue (30g), Zhechong/Ground beetle (20g), Sanqi/Panax notoginseng (15g), Niuxi/Achyranthes bidentata (15g) and Danshen/Salvia Miltiorrhiza (12g). It should be taken twice a day for 3 months.

### 2.5. Clinical evaluation standard and follow-up

Curative effects were evaluated at 12 months' follow-up according to the following criteria.

**2.5.1. Cure.** Clinical examination was normal, the pain completely disappeared even after movement, X-ray showed bone rejuvenation, and bone trabeculae was continuous and homogeneous.

**2.5.2. Markedly effective.** Pain completely disappeared after movement, X-ray showed bone rejuvenation and obvious repair, reduction of necrotic area and tidy arrangement of trabeculae.

**2.5.3. Effective.** The pain was significantly relieved or is slightly painful after activity, the clinical examination was well functional, and the necrotic had a sign to repair development.

**2.5.4. Ineffective.** Clinical examination showed none of the tests changed after operation or even worsened than earlier.

After surgery, x-ray and MRI were performed at 3, 6, and 24 months. The clinical outcomes were evaluated according to diagnosis of disease and curative effect of TCM.<sup>[26]</sup> Before and after operation 1, 6 and 24 months, hip joint pain was measured according to the visual analogue scale (VAS, range, 0–10) and function outcomes was measured according to the Harris Hip Score (HSS).

### 2.6. Statistical analysis

Data analysis was performed with SPSS for Windows 18.0 (SPSS Inc, Chicago, IL). Continuous variables were presented as the means ± standard deviation, whereas categorical variables were presented as a number and percentage.  $P < .05$  was considered as statistically different.

## 3. Results

### 3.1. Baseline data

A total of 75 cases (92 hips) were included in this study. Thirty-eight patients (46 hips) treated with CD in combination with autologous or artificial ceramic bone graft as well as Tongluo Shenggu decoction were assigned in the treatment group, and the remaining 37 patients (46 hips) treated with the CD in combination with autologous or artificial ceramic bone graft were assigned in the control group. The characteristics of patients in both groups are summarized in Table 1. There were no statistically significant differences in terms of age, sex, types of hips, etiology, clinical stage, preoperative VAS, and HSS scores in 2 groups (all  $P > .05$ ).

**Table 1**  
Demographics and baseline characteristics of each group.

Characteristics	Treatment group (38 cases/46 hips)	Control group (37 cases/46 hips)	P
Age, y	37.8±8.3	36.2±8.0	.35
Sex, n (%)			.53
Male	25 (65.8%)	22 (59.5%)	
Female	13 (34.2%)	15 (40.5%)	
Hips, n (%)			.52
Unilateral	30 (65.2%)	27 (57.5%)	
Bilateral	16 (34.8%)	20 (42.5%)	
Etiology			.77
Corticosteroid	13	9	
Alcohol	18	20	
Idiopathic	7	8	
Clinical stage			.91
ARCO II A	20	17	
ARCO II B	7	9	
ARCO II C	7	8	
ARCO III A	4	3	
Pre VAS	7.2±0.6	7.1±0.8	.78
Pre HSS	41.73±7.06	42.61±8.03	.58

ARCO=Association Research Circulation Osseous, HSS=Harris Hip Score, Pre=preoperative, VAS=visual analogue scale.

### 3.2. Postoperative

All patients fulfilled the follow-up. The mean follow-up period was 22.7 months (ranged, 16–24 months). At postoperative month 12, in the treatment group, there were 21 hips cured, 14 hips markedly effective, 6 hips effective, and 5 hips ineffective; in the control group, there were 10 hips cured, 14 hips markedly effective, 9 hips effective, and 13 hips ineffective, respectively. The treatment group had a significant higher total effective rate than the control group (89.1% vs. 71.7%,  $P=.005$ ) (Table 2).

There was a significant difference between the preoperative and final follow-up VAS in both groups ( $P<.01$ ). In addition, there was also a significant difference between the groups in term of the final follow-up VAS ( $P<.05$ ). Furthermore, the VAS improvement in the treatment group was significantly greater than that in the control group ( $1.1±0.2$  vs.  $2.3±0.3$ ,  $P<.05$ ) (Table 3).

There was a significant difference between the preoperation and last follow-up HSS in both groups, and a significant difference was observed between the groups in terms of the final follow-up HSS (both  $P<.05$ ). Furthermore, the HSS improvement in the treatment group was significantly greater than that in the control group ( $82.40±6.32$  vs.  $69.70±8.21$ ,  $P<.05$ ) (Table 4).

Seven months and 9 months postoperatively, 2 cases of the treatment group with ARCO II progressed into ARCO III. These

**Table 2**  
Curative effects in 2 groups at 12 months' follow-up.

	Treatment group (n=46 hips)	Control group (n=46 hips)	P
Cure	21 (45.7%)	10 (21.7%)	
Markedly effective	14 (30.4%)	14 (30.4%)	
Effective	6 (13.0%)	9 (19.6%)	
Ineffective	5 (10.9%)	13 (28.3%)	
Total effective rate	89.1%	71.7%	.005

**Table 3**  
VAS scores in 2 groups.

Group	Preoperative	Postoperative 1 mo	Postoperative 6 mo	Postoperative 24 mo
Treatment group (n=46 hips)	7.2±0.6	4.7±0.5	2.8±0.4	1.2±0.2
Control group (n=46 hips)	7.1±0.8	5.6±0.7	4.2±0.6	3.1±0.3
P	0.49936	<.01	<.01	<.01

VAS=visual analogue scale.

2 patients presented with femoral head collapse, obvious pain, and claudication and converted to total hip replacement at postoperative 12 months. In the control group, 6 patients with ARCO II progressed into ARCO IIIC (3 cases) and ARCO IV (3 cases) and converted to total hip replacement at postoperative 12 months. Preoperative and postoperative radiographs of 3 representative cases were shown in Figures 1 to 3.

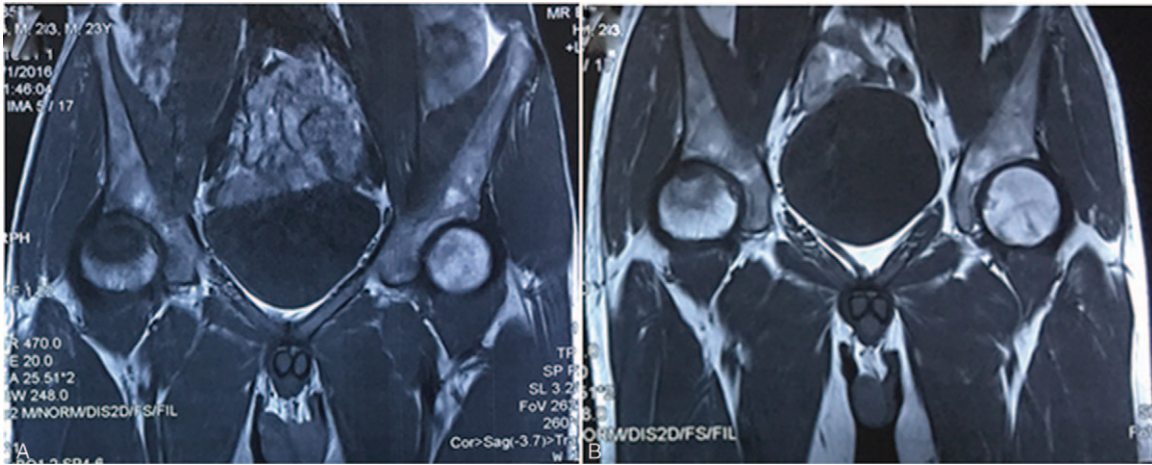
### 4. Discussion

The ONFH is mainly induced by ischemia;<sup>[27]</sup> the core of the treatment is to rebuild the blood supply of femoral head, the local blood vessels, and the osteogenesis processing.<sup>[28]</sup> The core mechanism of CD and bone grafting combined with Tongluo Shenggu decoction to promote blood circulation and strengthen bones is the targeted synergistic treatment of multiple targets for multiple pathogenesis of ONFH.<sup>[29,30]</sup> The aseptic necrosis of femoral head is a progressive disease with much etiologies;<sup>[31]</sup> the main pathological process relies on the apoptosis and repair of bone cells, bone marrow hematopoietic cells, and fat cell.<sup>[32]</sup> CD could release bone pressure and improve the local microcirculation. Under the similar environment to bone fractures, the implantation artificial bioceramic bone plays an early supporting role. Pure CD and bioceramics had good effects on AR-CO I to ARCO II A period patients,<sup>[33]</sup> whereas it had little effect on ACO II A to ARCO III A period patients. For ONFH patients at ARCO II B to ARCO III A period, focal lesions tend to form scleroses rather than the regeneration of bone and blood vessels. Especially for the older patients with low ability of osteogenesis differentiation, although to some extent, it alleviates the clinical symptoms, but it is uncertain for late treatment.

This study showed that the effectiveness of treatment group was superior to the control group. At follow-up, only 1 case of treatment group showed collapse of femoral head, whereas there were 4 cases in control group, which was superior to the curative effect of previous study. All patients achieved ideal and satisfied prognosis results after the lesions completely cleared and graft

**Table 4**  
Hip Harris score in 2 groups.

Group	Preoperative	Postoperative 1 mo	Postoperative 6 mo	Postoperative 24 mo
Treatment (n=46 hips)	41.73±7.06	61.42±8.53	72.52±8.04	83.41±6.42
Control (n=46 hips)	42.61±8.03	60.01±8.06	61.23±7.52	58.79±8.29
P	.58	.42	<.01	<.01



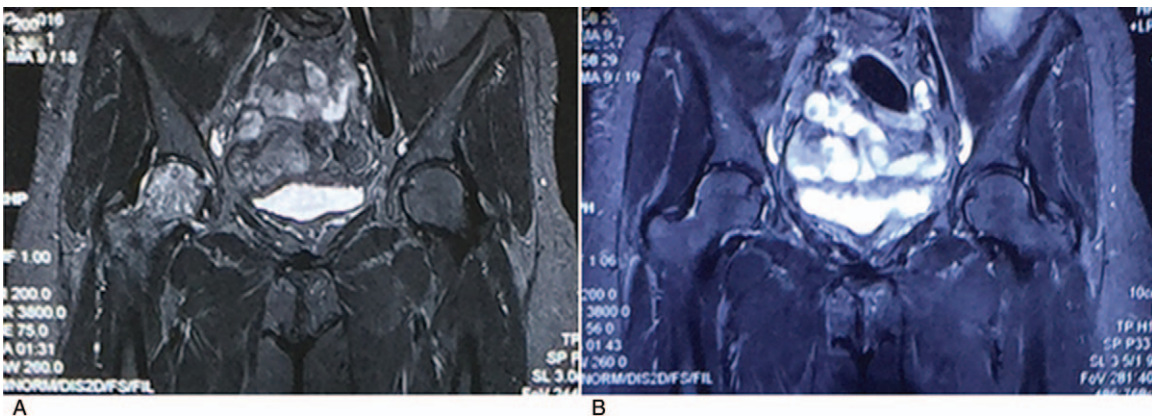
**Figure 1.** (A) Preoperative magnetic resonance imaging examination showed necrotic area >50%. (B) Post-operation with Tongluo Shenggu decoction, 9 months' follow-up showed significantly decreased necrotic area, new bone formation, and no occurrence of femoral head collapse.

fully decompressed. Some cases in treatment group presented the recovery of necrosis area, which suggested that Tongluo Shenggu decoction could promote local development into the vascularization. The results showed HSS after operation was obviously higher than before operation; the treatment group also had better HSS scores compared to the control group. All the results indicated that Tongluo Shenggu decoction could improve the function of hip bone. After operation, VAS score significantly lowers than before operation in treatment group; the curative effect was better than that of control group, which indicated the medicine could relieve the hip pain. In this study, it suggested that as long as the femoral head has not yet occurred deformation, Tongluo Shenggu decoction could get good curative effect on ARCO II C and III A patients.

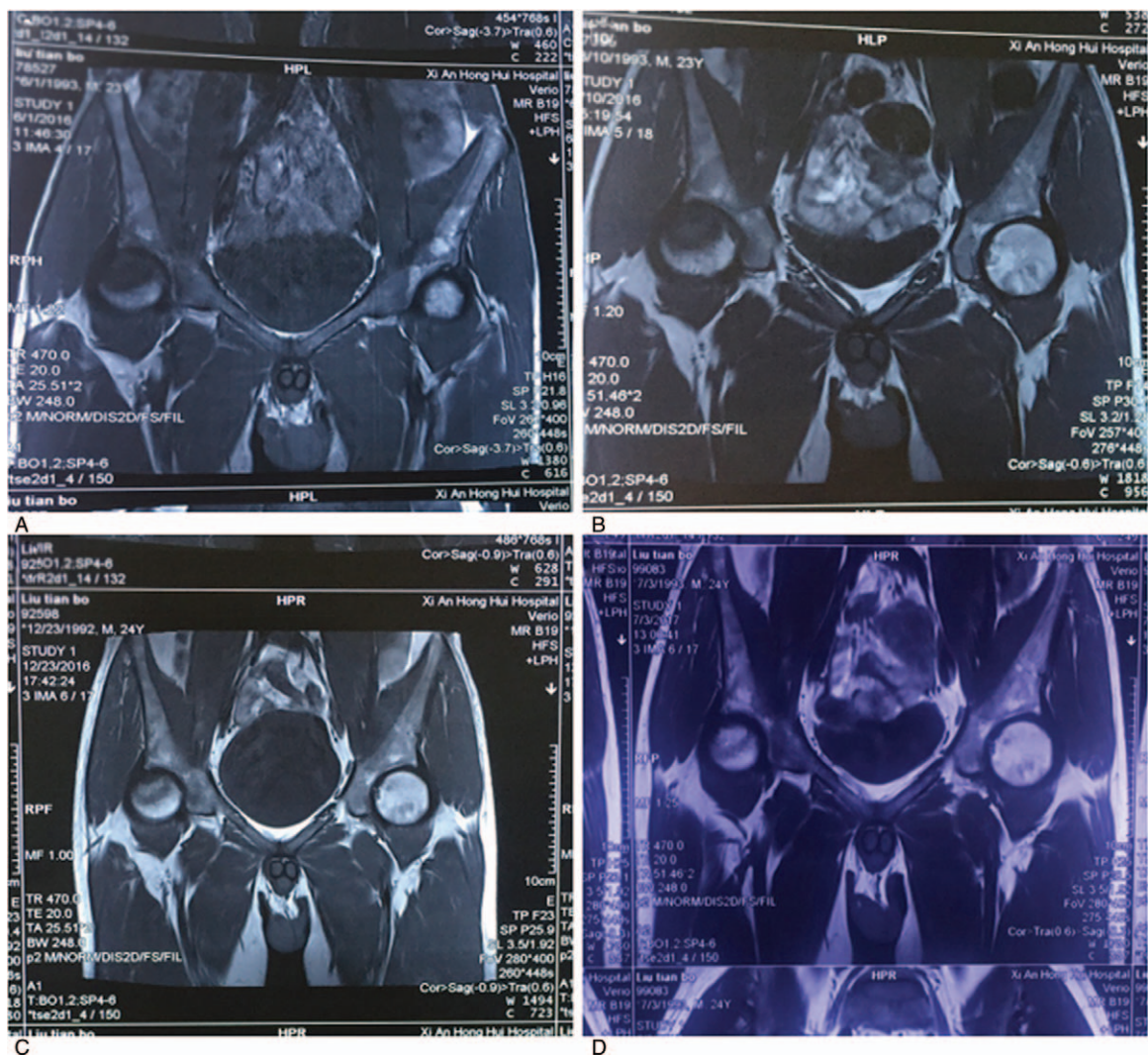
The limitations of this study include its single-center design and retrospective nature, with all of the inherent limitations of such investigations. A nonrandomized study with relatively short

duration of follow-up and small sample size may produce potential bias. Therefore, the results obtained can in no way be considered conclusive and should be confirmed by further studies. A prospective randomized controlled trial with a minimum follow-up of 24 months is our future direction. Nevertheless, our findings may help surgeons select an appropriate therapeutic method for ONFH.

In our study, the treatment via CD, lesion clearance, and bone graft in combination with Tongluo Shenggu decoction has obtained the good curative effect for femoral head necrosis. The study provided considerable postoperative outcomes with reducing pain, smaller osteonecrosis area, and better bone changes. TCM (Tongluo Shenggu decoction) may be worthy popularizing because of the less pain and injury. In addition, it also effectively improved the patient symptoms, which play roles on controlling the disease, relieving the clinical symptoms, and repairing the osteonecrosis area.



**Figure 2.** (A) Preoperative magnetic resonance imaging examination showed necrotic area >90%. (B) Post-operation with Tongluo Shenggu decoction, 12 months' follow-up showed significant decreased necrotic area, new bone formation, and no occurrence of femoral head collapse.



**Figure 3.** (A) Preoperative magnetic resonance imaging examination showed necrotic area >50%. (B) Post-operation with Tongluo Shenggu decoction, 10 months' follow-up showed significant decreased necrotic area to 30%. (C) Post-operation with Tongluo Shenggu decoction, 12 months' follow-up showed significant decreased necrotic area to 10%. (D) Post-operation with Tongluo Shenggu decoction, 14 months' follow-up showed disappearance of necrotic area.

**Author contributions**

**Conceptualization:** Pu-Wei Yuan and Yang-Quan Hao.

**Data curation:** Han-Deng Qi.

**Formal analysis:** Zhao-Chen Xu.

**Investigation:** Yang-Quan Hao, Hao Guo.

**Resources:** Chao Lu.

**Software:** Chao Lu.

**Supervision:** Pu-Wei Yuan and Yang-Quan Hao.

**Validation:** Tian Zhu.

**Visualization:** Chao Lu.

**Writing – original draft:** Yang-Quan Hao.

**Writing – review & editing:** Hao Guo.

**References**

[1] Malheiros CD, Lisle L, Castelar M, et al. Hip dysfunction and quality of life in patients with sickle cell disease. *Clin Pediatr* 2015;54:1354–8.  
 [2] Sugano N. Osteonecrosis of the Humeral Head[M]//Osteonecrosis. 2014;Springer, Berlin, Heidelberg:389-394.

[3] Razik F, Alexopoulos AS, El-Osta B, et al. Time to internal fixation of femoral neck fractures in patients under sixty years—does this matter in the development of osteonecrosis of femoral head? *Int Orthop* 2012;36:2127–32.  
 [4] Pauyo T, Drager J, Albers A, et al. Management of femoral neck fractures in the young patient: a critical analysis review. *World J Orthop* 2014;5:204–17.  
 [5] Martin JR, Houdek MT, Sierra RJ. Use of concentrated bone marrow aspirate and platelet rich plasma during minimally invasive decompression of the femoral head in the treatment of osteonecrosis. *Croat Med J* 2013;54:219–24.  
 [6] Markel DC, Miskovsky C, Sculco TP, et al. Core decompression for osteonecrosis of the femoral head. *Clin Orthop Relat Res* 1996;226–33.  
 [7] Mont MA, Hungerford DS. Non-traumatic avascular necrosis of the femoral head. *J Bone Joint Surg Am* 1995;77:459–74.  
 [8] Landgraeber S, Theysohn JM, Classen T, et al. Advanced core decompression, a new treatment option of avascular necrosis of the femoral head—a first follow-up. *J Tissue Eng Regen Med* 2013;7:893–900.  
 [9] Nakashima Y, Yamamoto T, Fukushi JI, et al. Transtrochanteric rotational osteotomy for avascular necrosis of the femoral head after unstable slipped capital femoral epiphysis: 10-year clinical results. *J Orthop Sci* 2016;21:831–5.

- [10] Morita D, Hasegawa Y, Okura T, et al. Long-term outcomes of transtrochanteric rotational osteotomy for non-traumatic osteonecrosis of the femoral head. *Bone Joint J* 2017;99-B:175–83.
- [11] Sonoda K, Yamamoto T, Motomura G, et al. Outcome of transtrochanteric rotational osteotomy for posttraumatic osteonecrosis of the femoral head with a mean follow-up of 12.3 years. *Arch Orthop Trauma Surg* 2015;135:1257–63.
- [12] Sugioka Y, Hotokebuchi T, Tsutsui H. Transtrochanteric anterior rotational osteotomy for idiopathic and steroid-induced necrosis of the femoral head. Indications and long-term results. *Clin Orthop Relat Res* 1992;111–20.
- [13] Iwasada S, Hasegawa Y, Iwase T, et al. Transtrochanteric rotational osteotomy for osteonecrosis of the femoral head. 43 patients followed for at least 3 years. *Arch Orthop Trauma Surg* 1997;116:447–53.
- [14] Hasegawa Y, Sakano S, Iwase T, et al. Pedicle bone grafting versus transtrochanteric rotational osteotomy for avascular necrosis of the femoral head. *J Bone Joint Surg Br* 2003;85:191–8.
- [15] Wang BL, Sun W, Shi ZC, et al. Treatment of nontraumatic osteonecrosis of the femoral head using bone impaction grafting through a femoral neck window. *Int Orthop* 2010;34:635–9.
- [16] Iwata H, Torii S, Hasegawa Y, et al. Indications and results of vascularized pedicle iliac bone graft in avascular necrosis of the femoral head. *Clin Orthop Relat Res* 1993;281–8.
- [17] Schneider W, Aigner N, Pinggera O, et al. Intertrochanteric osteotomy for avascular necrosis of the head of the femur. Survival probability of two different methods. *J Bone Joint Surg Br* 2002;84:817–24.
- [18] Sakano S, Hasegawa Y, Torii Y, et al. Curved intertrochanteric varus osteotomy for osteonecrosis of the femoral head. *J Bone Joint Surg Br* 2004;86:359–65.
- [19] Hamanishi M, Yasunaga Y, Yamasaki T, et al. The clinical and radiographic results of intertrochanteric curved varus osteotomy for idiopathic osteonecrosis of the femoral head. *Arch Orthop Trauma Surg* 2014;134:305–10.
- [20] Okura T, Hasegawa Y, Morita D, et al. What factors predict the failure of curved intertrochanteric varus osteotomy for the osteonecrosis of the femoral head? *Arch Orthop Trauma Surg* 2016;136:1647–55.
- [21] Moya-Angeler J, Gianakos AL, Villa JC, et al. Current concepts on osteonecrosis of the femoral head. *World J Orthop* 2015;6:590–601.
- [22] Juzan T, Baoju L, Bo S, et al. Influence of Panax Notoginseng Saponins on hemorrheology of rabbits with femoral head necrosis. *Journal of Liaoning University of Traditional Chinese Medicine* 2013;7:015.
- [23] Wang WL, Sheu SY, Chen YS, et al. Evaluating the bone tissue regeneration capability of the Chinese herbal decoction Danggui Buxue Tang from a molecular biology perspective. *Biomed Res Int* 2014;2014:853234.
- [24] Wang WL, Sheu SY, Chen YS, et al. Enhanced bone tissue regeneration by porous gelatin composites loaded with the Chinese herbal decoction Danggui Buxue Tang. *PLoS One* 2015;10:e0131999.
- [25] Yao CH, Yang H, Wen Q, et al. Alveolar bone regeneration potential of a traditional Chinese medicine, Bu-Shen-Gu-Chi-Wan, in experimental periodontitis. *Biomed Res Int* 2014;49:382–9.
- [26] G-p MA, Wang B, Li H-f. Application of western medicine diagnostic techniques in criteria of diagnosis and therapeutic effect of diseases and syndromes in TCM. *Chin Gen Pract* 2012;28:039.
- [27] Kimura T, Goto T, Hamada D, et al. Subchondral insufficiency fracture of the femoral head caused by excessive lateralization of the acetabular rim. *Case Rep Orthop* 2016;2016:4371679.
- [28] Pan ZM, Zhang Y, Cheng XG, et al. Treatment of femoral head necrosis with bone marrow mesenchymal stem cells expressing inducible hepatocyte growth factor. *Am J Ther* 2016;23:e1602–11.
- [29] Liu Y, Liu S, Su X. Core decompression and implantation of bone marrow mononuclear cells with porous hydroxylapatite composite filler for the treatment of osteonecrosis of the femoral head. *Arch Orthop Trauma Surg* 2013;133:125–33.
- [30] Pierce TP, Jauregui JJ, Elmallah RK, et al. A current review of core decompression in the treatment of osteonecrosis of the femoral head. *Curr Rev Musculoskelet Med* 2015;8:228–32.
- [31] Pouya F, Kerachian MA. Avascular necrosis of the femoral head: are any genes involved? *Arch Bone Jt Surg* 2015;3:149–55.
- [32] Li Z, Liao W, Zhao Q, et al. Angiogenesis and bone regeneration by allogeneic mesenchymal stem cell intravenous transplantation in rabbit model of avascular necrotic femoral head. *J Surg Res* 2013;183:193–203.
- [33] Drescher W, Knoke M, Wagner W, et al. New Therapies of Bone Necrosis[M]//Osteonecrosis. 2014;Springer, Berlin, Heidelberg: 273-275.