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Retrospective Study of Rehabilitation Exercise Combined with Extracorporeal Shock Wave Therapy for Knee Osteoarthritis

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Background: The aim of this study was to investigate the effect of rehabilitation exercise combined with extracorporeal shock wave therapy (ESWT) on knee osteoarthritis (KOA).

Material/Methods: The clinical data of 217 patients with KOA who underwent ESWT in our hospital from December 2017 to January 2020 were retrospectively analyzed. The patients were divided into a rehabilitation exercise (RE) group and a non-rehabilitation exercise (NRE) group according to whether they were given RE. The treatment course of the 2 groups was 5 weeks. Pain Visual Analog Scale (VSA), Western Ontario and McMaster Universities knee osteoarthritis index visualized scale (WOMAC), Lequesne index scores, Range of motion (ROM) score, and Japanese Orthopaedic Association (JOA) scores were used to evaluate the treatment effect of the 2 groups of patients.

Results: After 5 weeks of treatment, the VSA scores ($p<0.001$), WOMAC scores ($P<0.001$) and Lequesne index scores ($P<0.001$) of the RE group and NRE group were significantly lower than those before treatment, while ROM score ($P<0.001$) and JOA score ($p=0.006$) were significantly increased. Compared with the NRE group, the VAS score (3.14±0.64 *vs.* 4.78±0.85, $P=0.002$), WOMAC score (20.37±4.06 *vs.* 27.82±4.57, $P<0.001$) and Lequesne index score (6.13±1.83 *vs.* 7.35±2.21, $P=0.019$) in the RE group were significantly lower than those in the NHE group; however, the ROM score (89.13±9.83 *vs.* 79.15±6.25, $P=0.021$) and JOA score (79.53±7.59 *vs.* 67.85±8.27, $P=0.016$) were significantly higher than those in the NRE group.

Conclusions: RE combined with ESWT has a positive effect on KOA, which may more significantly relieve the patient's clinical symptoms and improve joint function and quality of life.

MeSH Keywords: Acute Pain • Osteoarthritis, Knee • Physical and Rehabilitation Medicine

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Background

Knee osteoarthritis (KOA) is a chronic joint disease characterized by articular cartilage degeneration and secondary bone changes. The prevalence of KOA is as high as 50% in people over age 60 years [1–4]. In the United States, more than 10 million people suffer from KOA each year, and the annual treatment of this disease costs up to 420 million US dollars [5,6]. The clinical manifestations of KOA include pain, joint swelling, and limited mobility. In the later stages of progression, joint deformation and functional limitation may occur and can be disabling in severe cases [7]. The high prevalence of KOA and the high cost of treatment are serious problems. To delay the development of knee osteoarthritis in early and mid-term KOA patients, the currently commonly used conservative treatment options include oral non-steroidal anti-inflammatory drugs, intra-articular injection of hyaluronic acid, physical therapy, and functional exercise, but the effects are not satisfactory [8,9]. Therefore, exploring effective treatment of KOA is of great significance for improving the quality of life and joint function of patients.

Extracorporeal shock wave therapy (ESWT) is a non-surgical, non-invasive treatment that is safe and effective for treating musculoskeletal diseases [10,11]. ESWT has become an important treatment for chronic tenopathy, nonunion of long bone fracture, and early avascular necrosis of the femoral head [10,11]. In recent years, further studies have found that for early and mid-term KOA, ESWT can effectively relieve pain and improve clinical symptoms of patients [12,13]. Patients with KOA in the early and middle stages usually need to be immobilized for a long time, which easily induces knee joint adhesion, stiffness, and other adverse conditions, which affects the recovery of knee joint function, decreasing self-care ability and leading to a poor prognosis. Therefore, it is necessary to improve rehabilitation exercises for patients and to improve knee joint function through early muscle strength training of the lower limbs. At present, there are few reports about the effect of ESWT combined with rehabilitation exercise on the treatment of KOA. The present study retrospectively collected the clinical data of 217 cases of KOA to observe the clinical efficacy of rehabilitation exercise combined with ESWT on KOA, and provides a reference for clinical treatment of KOA.

Material and Methods

Inclusion and exclusion criteria

The clinical data of 217 early- and mid-stage KOA patients who underwent ESWT in our hospital from December 2017 to January 2020 were retrospectively collected for analysis. Inclusion criteria: 1) The patient's age ranged from 45 to 70 years; 2) subjects diagnosed with knee OA according to the clinical criteria of the American College of Rheumatology [14]; 3) subjects diagnosed with grade II or III OA during radiological examination as defined by the radiological classification of Kellgren and Lawrence (K-L) scale for knee OA [15]; 4) subjects who had pain on 1 side of the knee. Exclusion criteria: 1) Kellgren and Lawrence (K-L) scale stage 0 and stage IV; 2) Rheumatoid arthritis, rheumatoid arthritis, traumatic arthritis, gouty arthritis; 3) The knee has tuberculosis, infection, osteomyelitis, tumor; 4) The affected limb has vascular and nervous system diseases; 5) The knee has a severe varus deformity; 6) With serious primary diseases such as liver, kidney, cardiovascular, or hematopoietic disease; 7) With severe osteoporosis; 8) Women who are breastfeeding or pregnant; 9) Those who cannot tolerate ESWT due to pain and other factors. According to whether the patients were performing rehabilitation exercises, they were divided into a rehabilitation exercise (RE) group and a non-rehabilitation exercise (NRE) group. The study was performed in accordance with the ethics standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethics standards. This study was approved by the Ethics Committee of the Traditional Chinese Medicine Hospital in Chongqing.

Interventions

Both groups were treated with ESWT, and the treatment methods of extracorporeal shock wave were administered as described previously [16,17]. The local tenderness points around the affected knee joint, the pain points during joint flexion and extension activities, and the pain points during passive traction of the ligaments were used as impact points. ESWT with 2000 pulses of 0.18 mJ/mm^2 at a frequency of 15 Hz was administered using the Masterpuls MP100 extracorporeal shock wave therapeutic instrument (manufactured by Stormedical AG, Switzerland). ESWT was given 3 times a week for 5 weeks. The RE group received rehabilitation exercise on the basis of ESWT. Rehabilitation treatment was carried out in the hospital after extracorporeal shock wave therapy. The rehabilitation treatment was supervised and implemented by 2 professional rehabilitation doctors. The number of rehabilitation treatment was 3 times a week for 5 weeks. The specific methods of rehabilitation exercise including: 1) Range of motion training: from 0° to over 90° gradually, 10 min/time, 3 times/d. 2) Cycling exercise for air riding: take a supine position, bend hips and knees at 90°, then slowly straighten, alternate lower limbs as if pedaling a bicycle, 10 min/time, 3 times/d; 3) Straight leg raising exercise: take the supine position, straighten the knee joints naturally, raise the lower limbs alternately to 50–60°, keep it down for 10 s, repeat it, 10 min/time, 3 times/d; 4) Quadriceps isometric contraction exercise: Take a sitting position and perform isometric contraction at 0 and 90°

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Table 1. Patients characteristics.

Variable	RE group (n=104)	NRE group (n=113)	P value
Gender (Male/Female	71/36	82/33	0.471
Age (years)	58.17±5.66	57.93±6.21	0.718
BMI (kg/m^2)	22.38±1.34	22.72±1.36	0.127
Course of disease (month)	18.38±3.34	17.43±5.96	0.094
K-L grade (grade I/II/III)	17/64/13	21/74/18	0.531
VAS score	6.47±1.03	6.31±1.32	0.629
WOMAC score	38.24±7.17	38.87±6.32	0.871
Lequesne index score	12.17±3.27	12.45±3.62	0.226

RE – rehabilitation exercise; NRE – non rehabilitation exercise; BMI : Body Mass Index; K-L grade – Kellgren and Lawrence (K-L) grade; VSA – Visual Analog Scale, WOMAC – Western Ontario and McMaster Universities knee osteoarthritis index visualized scale.

of the knee joint. First contract for 10 s and then relax for 10 s, 10 min/time, 3 times/d. 5) Isometric contraction of the adductor muscle group: take the sitting position, bend the hips and knees 90°, place both fists between the legs, clamp the lower limbs, hold for 10 s, relax for 5 s, repeat the above process, 10 min/time, 3 times/d. 6) Standing position knee bending training: take the standing position, do knee bending exercises, and transfer the center of gravity between the legs alternately, such as Bagua palm and Taiji step, 10 min/time, 3 times/d. Patients in both groups were treated with oral celecoxib capsule (produced by Pfizer Pharmaceutical Co., Ltd., national drug standard j20120063, once a day, 200 mg each time). In addition, there were no other auxiliary treatment measures in the 2 groups.

Clinical assessments

Pain Visual Analog Scale (VSA), Western Ontario and McMaster Universities knee osteoarthritis index visualized scale (WOMAC), and Lequesne index scores were used to assess the knee joint pain and function of the 2 groups of patients before and after treatment [16–19].

The higher the VAS score, WOMAC score, and Lequesne score, the more severe the KOA. The range of motion (ROM) score was used to evaluate the improvement of the knee joint range of motion before and after treatment. The highest possible score is 100 points. The higher the score, the higher the knee joint range of motion [20]. The Japanese Orthopedic Association (JOA) score was used to evaluate the knee joint function and swelling before and after treatment. The highest possible score is 100 points. The higher the score, the better the recovery of knee joint function [21].

Statistical analysis

SPSS 20.0 software (IBM Corporation, Armonk, New York, USA) was used for statistical analysis. The data are expressed as mean±SD. For measurement data conforming to the normal distribution, the paired *t* test was used for comparison within groups, and the 2 independent-samples *t* test was used for comparison between groups. The Wilcoxon test was used for the measurement data that did not conform to the normal distribution. The chi-square test was used for enumeration data, and $P<0.05$ was considered as statistically significant for all tests.

Results

Patient characteristics

As shown in Table 1, there was no significant difference ($P<0.05$) in sex, age, BMI, disease course, K-L classification, VAS score, WOMAC score, and Lequesne index score before treatment between the 2 groups, which suggests that the clinical baseline data of the 2 groups were similar.

Comparison of VAS scores between the 2 groups before and after treatment

As shown in Table 2, there was no statistically significant difference in VAS scores between the 2 groups before treatment. After 5 weeks of treatment, the VAS scores of patients in the RE group (6.47±1.03 *vs.* 3.14±0.64, $P<0.001$) and NRE group (6.31±1.32 *vs.* 4.78±0.85, $P<0.001$) were significantly lower than before treatment. However, compared with the NRE group, the VAS score (3.14±0.64 *vs.* 4.78±0.85, $P=0.002$) of the RE group was significantly lower than that of the NRE group.

Comparison of WOMAC scores between the 2 groups before and after treatment

As shown in Table 3, there was no statistically significant difference in WOMAC scores between the 2 groups of patients

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Table 2. Comparison of VAS scores between the two groups before and after treatment.

Groups	Before treatment	After treatment	P value
RE group (n=104)	6.47±1.03	3.14±0.64#*	<0.001
NRE (n=113)	6.31±1.32	4.78±0.85#	<0.001
P value	0.629	0.002	

VSA – Pain Visual Analog Scale; RE – rehabilitation exercise; NRE – non rehabilitation exercise; # represents P<0.05 after treatment compared with before treatment; * represents P<0.05 compared with the non-rehabilitation group after treatment.

Table 3. Comparison of WOMAC scores between the two groups before and after treatment.

Groups	Before treatment	After treatment	P value
RE group (n=104)	38.24±7.17	20.37±4.06#*	<0.001
NRE (n=113)	38.87±6.32	27.82±4.57#	<0.001
P value	0.871	<0.001	

WOMAC – Western Ontario and McMaster Universities knee osteoarthritis index visualized scale; RE – rehabilitation exercise; NRE – non rehabilitation exercise; # represents P<0.05 after treatment compared with before treatment; * represents P<0.05 compared with the non-rehabilitation group after treatment.

Table 4. Comparison of Lequesne index scores between the two groups before and after treatment.

Groups	Before treatment	After treatment	P value
RE group (n=104)	12.17±3.27	6.13±1.83#*	<0.001
NRE (n=113)	12.45±3.62	7.35±2.21#	<0.001
P value	0.226	0.019	

RE – rehabilitation exercise; NRE – non rehabilitation exercise; # represents P<0.05 after treatment compared with before treatment; * represents P<0.05 compared with the non-rehabilitation group after treatment.

before treatment. After 5 weeks of treatment, the WOMAC scores of patients in the RE group (38.24±7.17 *vs.* 20.37±4.06, *P*<0.001) and NRE group (38.87±6.32 *vs.* 27.82±4.57, *P*<0.001) were significantly lower than before treatment. However, compared with the NRE group, the WOMAC score (20.37±4.06 *vs.* 27.82±4.57, *P*<0.001) of the RE group was significantly lower than that of the NRE group.

Comparison of Lequesne index scores between the 2 groups before and after treatment

As shown in Table 4, there was no statistically significant difference in Lequesne index scores between the 2 groups of patients before treatment. After 5 weeks of treatment, the WOMAC scores of patients in the RE group (12.17±3.27 *vs.* 6.13±1.83, *P*<0.001) and NRE group (12.45±3.62 *vs.* 7.35±2.21, *P*<0.001) were significantly lower than before treatment. However, compared with the NRE group, the RE group Lequesne index score (6.13±1.83 *vs.* 7.35±2.21, *P*=0.019) was significantly lower than that of the NRE group.

Comparison of ROM and JOA scores between the 2 groups before and after treatment

As shown in Table 5, there was no significant difference in ROM scores and JOA scores between the 2 groups of patients before treatment. After 5 weeks of treatment, the ROM scores (*P*<0.001) and JOA scores (*P*<0.05) of patients in the RE group and NRE group were significantly higher than before treatment. However, compared with the NRE group, the RE group's ROM scores (89.13±9.83 *vs.* 79.15±6.25, *P*=0.021) and JOA scores (79.53±7.59 *vs.* 67.85±8.27, *P*=0.016) were significantly better than in the NRE group.

Discussion

KOA is one of the most common progressive and degenerative bone and joint diseases. At present, the etiology and pathogenesis are unknown, and its occurrence and development are related to factors such as weight, lifestyle, age, sex, and genetics [22,23]. Due to the long course of KOA and serious symptoms, there is no effective treatment. The International Society for the

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Table 5. Comparison of ROM and JOA scores between the two groups before and after treatment.

Groups	ROM scores		P value	JOA scores		P value
RE group (n=104)	Before treatment	After treatment		Before treatment	After treatment	
NRE (n=113)	45.24±6.27	89.13±9.83#*	<0.001	60.07±8.28	79.53±7.59#*	0.006
P value	44.76±7.62	79.15±6.25#	<0.001	61.45±6.92	67.85±8.27#	0.011
	0.846	0.021		0.761	0.016	

ROM – range of motion score; JOA – Japanese Orthopaedic Association Scores; RE – rehabilitation exercise; NRE – non rehabilitation exercise; # represents P<0.05 after treatment compared with before treatment; * represents P<0.05 compared with the non-rehabilitation group after treatment.

Study of Osteoarthritis (IAA) guidelines suggest that relieving joint pain and stiffness should be the primary goal of KOA treatment [22,23]. Therefore, the main challenge faced by clinicians is finding effective treatments to reduce joint pain and stiffness.

Extracorporeal shock wave (ESW) is a non-invasive treatment method. It was originally used to treat urinary stones, and then expanded to the treatment of musculoskeletal diseases [24]. In 2005, Revenaugh et al. applied ESW to the horse osteoarthritis model and found that pain and joint function of horses were significantly improved, creating a precedent for ESW to treat osteoarthritis in humans [25]. In recent years, people have conducted in-depth research on ESW and found that ESW can reduce the sensitivity of peripheral nerves, increase the pain threshold, reduce the release of substance P and calcitonin gene-related peptide and other pain factors, inhibit the transmission of pain information, and exert a good analgesic effect [26,27]. In addition, ESW can improve cartilage metabolism, can promote the proliferation and differentiation of chondrocytes, and is beneficial to cartilage repair and bone tissue remodeling [28,29]. Finally, ESW can also promote local blood circulation and reduce calcium deposition, thereby reducing soft tissue adhesion, restoring muscle strength, and improving knee joint range of motion [30,31]. In this study, compared with before treatment, after 5 weeks of treatment, the VAS score, WOMAC score, and Lequesne index score of the RE group and NRE group were significantly decreased, while ROM score and JOA score were significantly increased. The results of this study are similar to those of previous reports, and indicate that ESWT can reduce the clinical symptoms of KOA patients and improve knee joint function and quality of life of patients [28–32].

KOA patients generally need to be immobilized for a long time, which easily induces adhesions, stiffness, and other adverse conditions. This affects the recovery of knee joint function to some extent, resulting in a decline in the patient's ability to take care of themselves and contributing to a worse prognosis. Therefore, it is necessary to strengthen the rehabilitation care of patients and improve knee joint function through early muscle strength training of the lower limbs. Previous studies have suggested that moderate exercise in KOA patients can promote blood circulation in the affected limbs, absorb articular cartilage nutrition, prevent knee joint adhesions, stiffness, and other complications, improve patient control of joints and muscles, and promote rapid knee function recovery [33,34]. At present, there are few reports on the effect of ESWT combined with RE on the treatment of KOA. In this study, we used ESWT combined with RE to treat KOA patients and found that compared with ESWT alone, ESW combined with RE was significantly better at improving the ROM score and JOA score of KOA patients, and significantly reduced the VAS score, WOMAC score, and Lequesne index score of KOA patients. The results of this study suggest that RE combined with ESWT can better reduce the clinical symptoms of KOA patients, increase joint mobility, and improve the quality of life of patients.

This study has certain limitations. First, the sample size was relatively small, and it was a non-prospective randomized controlled trial, and the research results need to be further confirmed by a large-sample prospective study. Second, this was a single-center regression study, and a multi-center randomized controlled study is needed to obtain accurate clinical reference data. Third, due to the characteristics of equipment and population differences, the results of this study may have inherent errors. Fourth, this study had all the limitations and risks of bias inherent in the research design. Fifth, this study lacked subtypes of KOA research. Sixth, the extra time the RE group took could have caused stronger effects than in the NRE group, and contributed to lack of objective assessments.

Conclusions

Rehabilitation exercise combined with extracorporeal shock wave therapy has a positive effect on KOA, which may better reduce the patient's clinical symptoms and improve the patient's joint mobility and quality of life.

Conflict of interests

None.

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