Comparison of Radial Pressure Waves and Focused Extracorporeal Shock Waves in Treatment of Osteoarthritis of the Knee

Xichun Sun[1], Suoli Cheng[1], Xianghua Xiong[2], Zhengcheng Wang[1]

Abstract

Objective: The aim of this study is to investigate and compare the clinical efficacy of radial pressure waves and focused external shock wave therapy for knee osteoarthritis (KOA).

Materials and Methods: From October 2020, 90 patients aged 45–65 years old with Kellgren and Lawrence classification (K-L) stage I and II of KOA were selected in our hospital or randomly assigned to 3 groups with 30 cases in each group. One group was treated with antiinflamatory medication. The other two groups received one course of treatment (once a week, 4 times in total) performed by using radial focused shock waves respectively, and follow-up was conducted by telephone and outpatient review 3, 6, and 9 months after the treatment. Visual Analog Scale (VAS) and Western Ontario McMaster Osteoarthritis Index (WOMAC) osteoarthritis score were used before and after treatment.

Results: (1) VAS, WOMAC, and evaluation indexes of both treated groups were better than those of the control group (oral drug group); (3) The score of the radial group was significantly different from that of the focused group ($P > 0.05$).

Conclusion: (1) Focused and radial pressure waves (RPW) have good clinical therapeutic effect on early KOA (2) Comparison of long-term effect: focused shock waves are more significant than radial (3) Radial pressure waves area good indication in relatively young patients, short course of disease (within 1 year), and K-L stage I an II. (4) In older patients, with more than a year of symptoms and K-L stages II and III, focused waves are more effective than radial waves. (5) Patients with acute onset and night pain or accompanied by obvious effusion can first take non-steroidal drugs orally continuously for a week, and the treatment effect is better. During treatment, the drugs can be continued or stopped according to the specific conditions. When synovial edema and effusion of the joint decreased, the conventional parameters were used for treatment.

Keywords: Knee osteoarthritis, Extracorporeal shock wave therapy, Radial Pressure Waves

Introduction

Knee osteoarthritis (KOA) has now become the most common joint disease worldwide [1], with common symptoms such as pain, joint stiffness, and decreased range of motion, which affects patients' quality of life [2]. The total prevalence of osteoarthritis in China is about 15%, 10–17% above 40 years of age, 50% above 60 years of age, and up to 80% above 75 years of age [3]. The prevalence of the presence of knee pain according to the Kellgren-Lawrence (K-L) grading of the knee joint is 8.1%. Currently, the treatment of end-stage KOA is relatively clear, but there is no clear method for the non-surgical treatment of early osteoarthritis [4,5]. In recent years, the extracorporeal shock wave has become a new hotspot in the treatment of osteoarthritis due to its advantages of safety, noninvasiveness, low pain, and rapid onset of action [6,7], and is known as the "bloodless scalpel." Currently, the extracorporeal shock waves used in the treatment of KOA can be divided into two categories according to the different output energy waveforms [8]: radial pressure waves (RPW) and focused extracorporeal shock waves therapy (fESWT), and the clinical efficacy of the two modalities is still controversial. For example, scholars compared the two types of waves in the treatment of osteoarthritis of the knee joints and found that there is no significant difference in the efficacy of the two modalities [9], but there is a slight discrepancy between the results obtained from the present study. The aim of this study is to investigate and compare the clinical efficacy of radial and focused external shock waves therapy for knee osteoarthritis (KOA).

Materials And Methods

General information

Patients aged between 45 and 65 years with Kellgren–Lawrence stages I and II KOA in

[1]Department of Orthopedics, People's Hospital of Ningxia Hui Autonomous Region, Yinchuan, Ningxia, China,
[2]Department of Orthopedics, People's Hospital of Liangping District, Chongqing, China.

Address of Correspondence
Dr. Suoli Cheng,
Department of Orthopedics, People's Hospital of Ningxia Hui Autonomous Region, Yinchuan, Ningxia, China.
E-mail: chengsuoli@126.com


Dr. Xichun Sun


Dr. Suoli Cheng


Dr. Xianghua Xiong


Dr. Zhengcheng Wang

Submitted Date: 12 Jul 2023, Review Date: 05 Sep 2023, Accepted Date: 22 Oct 2023 & Published: 30 Dec 2023

Figure 1: Gymna radial equipment.

Figure 2: Dornier focused equipment.

our hospital since October 2020 were selected, and after completing the screening and assessment of the basic characteristics, the qualified 90 patients were randomly divided into three groups: The control group (medication), the RPW group and the fESWT group (Table 1).

Inclusion criteria

(1) Age between 45 and 65 years old; (2) To meet the diagnostic criteria for KOA proposed by the Chinese Medical Association in 2018 [10]; (3) Arthritis staged at stage I/II; (4) Patients that can avoid strenuous activities for the time being during treatment.

Exclusion criteria

(1) Rheumatoid arthritis, traumatic arthritis; (2) patients with infectious arthropathy, Charcot-type arthritis, etc.; (3) patients with sensory disorders of the lower limbs caused by lumbar spine pathology or other reasons; (4) patients with contraindications to shock wave therapy.

Methods

(1) Control group: Simple oral Diclofenac sodium tablets; (2) Experimental groups: Two kind of waves were applied, (Figs. 1 and 2), all patients are treated by the same orthopedic surgeon. Dosage was for radial pressure waves: 1.8-2.8 Bar, for focused waves: 0.18-0.24 mJ/mm2), frecuency 6-8 Hz and 2000-2500 pulses per point. The treatment was carried out with the patient's knee flexed at 90°. lying flat on the treatment bed. The probe was moved along the peripatellar area of the affected knee, the medial-lateral joint space, and the area where the pain points were most obvious to observe the patient's tolerance to the treatment, and the patient was given the treatment once a week for a total of 4 times (Fig. 3).

Postoperative follow-up

The two groups of patients were treated with RPW and focused shockwave for one course of treatment (once a week, 4 times in total). At the end of one course of treatment, Visual Analog Scale (VAS) and Western Ontario Mcmaster Osteoarthritis Index (WOMAC) scores were carried out and health manuals were issued for the patients to guide them to carry out the corresponding functional exercises. The patients were instructed to go to the shockwave clinic for regular review in the 3rd, 6th, and 9th months after the end of the treatment to carry out the follow-up visits, and the follow-up visits were made up to October 30, 2022.

Observation index

(1) WOMAC osteoarthritis index score: This score is based on the clinical symptoms and signs of the patients to assess the severity of KOA and the degree of relief of the patient's condition by different therapies. The score includes three aspects of pain, stiffness, and joint function, with a total of 24 items, covering the basic symptoms and signs of KOA. Each item has a score of 0–4 points, with a total score of 96 points, and the higher the score, the more serious the disease. (2) VAS: 0–10 points, with 0 being no pain, 2–4 points representing mild pain, 5–7 points representing moderate pain, 8–9 points representing severe pain, and

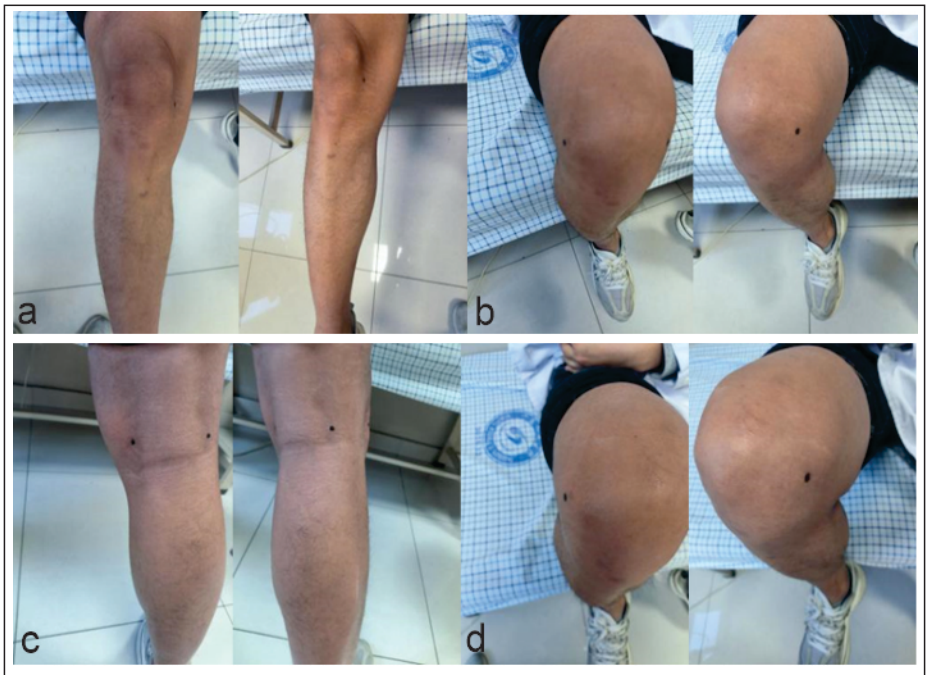

Figure 3: Selection of knee treatment points.

Table 1: Comparison of baseline patient data between the 3 groups

Characteristic	Focused group (*n* =30) Mean±SD	Radial group (*n* =30) Mean±SD	Drug group (n=30) Mean±SD	*P*-value
Age	59.3±9.78	60.7±8.43	59.9±8.97	0.69
Sex (M)	33.67%	43.33%	40%	0.59
BMI	25.8±1.89	24.9±1.43	25.4±1.61	0.47
Disease duration(M)	16.7±7.21	18.2±5.38	16.2±7.26	0.53
WOMAC	83.71±9.13	75.36±8.28	78.86±9.02	0.31
VAS	4.82±1.51	5.03±1.67	4.99±1.61	0.44

BMI: Body mass index, VAS: Visual Analog Scale, WOMAC: Western Ontario Mcmaster Osteoarthritis Index

Table 2: Between-group comparison of VAS scores of the three groups of patients before treatment and at the end of treatment at months 3, 6, and 9

Variable	Focused group	Radial group	Drug group	*P*-value
VAS before	4.82±1.51	5.03±1.67	4.99±1.74	0.44
After	2.36±1.03	2.30±0.91	2.39±1.09	0.58
Follow(3)	2.41±1.21	2.38±1.33	2.44±1.15	0.66
Follow(6)	2.74±1.17	3.46±1.29	3.97±1.12	0.012
Follow(9)	3.02±1.29	4.08±1.53	4.62±1.35	0.007

VAS: Visual Analog Scale

10 points representing intolerable severe pain.

Statistical methods

SPSS 22.0 was used to analyze the data of this study, and the chi-square test was used for the count data in the basic characteristics data. Measured data were expressed as mean ± standard deviation (X ± S), one-way analysis of variance (ANOVA) was used, and one-way ANOVA was performed for inter-group comparisons, and for significant inter-group differences, two-by-two inter-group comparisons were performed by least significant difference (LSD) test, and the difference was considered statistically significant at P < 0.05.

Results

Comparison of baseline data of patients in the 3 groups

The differences in baseline data (age, gender, body mass indexBMI, disease duration, pre-treatment WOMAC score, and VAS score) of patients in the 3 groups before treatment were not statistically different (P > 0.05), and the two groups were comparable. (Table 1).

Comparison of therapeutic efficacy

At the end of treatment and at the 3-month follow-up after the end of treatment, there was no statistically significant difference between the VAS scores and WOMAC scores of the three groups (P > 0.05); while at the 6-month and 9-month follow-up after the end of treatment, there was a statistically significant difference between the VAS scores and WOMAC scores of the three groups (P < 0.05) as shown in Tables 2 and 3. Further two-by-two comparison was made. It was found that the VAS scores and WOMAC scores of the fESWT group were lower than those of the RPW group, and the differences were statistically significant (P < 0.05), as shown in Tables 4~-7.

Discussion

Knee osteoarthritis is a common and disabling disease in middle-aged and elderly people, and the number of patients with KOA is increasing year by year as China is gradually moving into an aging society. Reducing the intensity of pain and improving the physical function are the two main therapeutic goals [11]. Extracorporeal shock wave therapy (ESWT) is a noninvasive treatment modality that uses a series of high-energy acoustic waves to induce biological and physiological effects in tissues and cells in the treatment target area [12]. In recent years, ESWT has become an emerging technique for the treatment of various neurological and musculoskeletal disorders and has received extensive attention from scholars at home and abroad. ESWT is divided into two different types: focused extracorporeal shock wave therapy (fESWT) and RPWradial pressure waves therapy (RPW). To the best of our knowledge, at this stage, very few studies have gone on to directly compare the effects of fESWT and RPW in patients with OA of the knee joints, so this study aims to investigate and compare the radial pressure waves and focused shock wave therapy for knee osteoarthritis to provide theoretical support for the use of different types of mechanical wave therapy for the treatment of KOA, and to develop new ideas for the treatment of KOAknee osteoarthritis.

The results of the present study confirmed that both fESWT and RPW played a significant role in reducing the level of knee pain and improving WOMAC scores in patients with KOA, which is in line with the views of many scholars [13-16]. A recent systematic review and meta-analysis that included 14 studies totaling 782 subjects with knee KOA, showed that ESWT was an effective treatment for relieving pain and improving functional status in patients with knee KOA without any significant adverse effects [17]. The exact mechanism of ESWT for the treatment of osteomuscular disorders

Table 3: Between-group comparison of WOMAC scores of the three groups of patients before treatment and at the end of treatment at months 3, 6, and 9

Variable	Focused group	Radial group	Drug group	*P*-value
WOMAC Before	41.71±9.13	40.36±8.28	39.39±7.69	0.31
After	20.27±6.09	21.11±5.33	22.55±5.26	0.63
Follow (3)	22.81±5.91	23.73±6.74	23.98±6.28	0.47
Follow (6)	23.63±6.82	25.49±6.17	29.59±6.08	0.009
Follow (9)	24.95±6.29	26.40±7.52	30.78±6.69	<0.001

WOMAC: Western Ontario McMaster Osteoarthritis index

Table 4: Two-by-two comparison results of VAS scores at 6 months after the end of treatment in the three groups (LSD test)

Group	Group	MD	LSD	*P*-value
Focused group	Radial group	−0.875	2.903	0.003
	Drug group	−1.416	4.812	0
Radial group	Drug group	−0.403	1.258	0.04

VAS: Visual Analogue Scale, LSD: Least significant difference

Table 5: Results of two-by-two comparison of VAS scores at 9 months after the end of treatment in the three groups (LSD test)

Group	Group	MD	LSD	*P*-value
Focused group	Radial group	−1.125	3.545	0.002
	Drug group	−1.718	5.314	0
Radial group	Drug group	−0.576	2.108	0.009

VAS: Visual Analogue Scale, LSD: Least significant difference

Table 6: Two-by-two comparison results of WOMAC scores at 6 months after the end of treatment in the three groups (LSD test)

Group	Group	MD	LSD	*P*-value
Focused group	Radial group	−1.929	2.263	0.021
	Drug group	−6.156	6.23	0
Radial group	Drug group	−4.241	3.108	0.005

WOMAC: Western Ontario mcmaster Osteoarthritis Index, LSD: Least significant difference

is not fully understood, but several studies have elaborated on the rationale for ESWT on the pathogenesis of OA and pain reduction, which may help to explain the clinical pain relief after the application of ESWT. Studies have shown that ESWT can produce hyperstimulation of nerve terminal tissues, which reduces the sensitivity of nerve cells and inhibits the conduction of pain signals and can cause changes in pericellular free radicals to release pain-suppressing substances and raise the pain threshold, thus relieving pain. In addition, ESWT can promote neovascularization and growth factor secretion, which has great potential to improve chondrocyte viability and cartilage repair mechanisms [18]. The use of ESWT in the treatment of KOA patients can activate their osteoblasts, repair their broken cartilage tissues, alleviate their symptoms of knee pain, and improve the function of their knee joints [19]. Animal studies have reported that ESWT produces cartilage protection [20], anti-inflammation [21], neovascularization [22], anti-apoptosis [23], and tissue regeneration [24], which may be relevant to the treatment of KOA.

Although a large number of studies have confirmed that ESWT for knee KOA is a safe and effective treatment, in general, ESWT can be categorized into two types: fESWT and RPW, and there is still a difference of opinion at this stage as to whether they have the same efficacy. For example. Guan et al.[9] found that there was no significant difference in the efficacy of both treatments at the same dose. In contrast, KoNai-Yu et al. [25] found in a randomized controlled study that fESWT improved more than RPW in three parameters, namely, VAS score, WOMAC score, and 6-min walking test distance, at 4-week and 8-week postoperative follow-up, and the difference was statistically significant. In order to investigate whether there is a difference in the clinical efficacy of the two procedures, 90 patients with no statistical difference in basic characteristics were randomly divided into the medication group, the RPW group, and the fESWT group in the present study, and at the 6-month and 9-month follow-ups after the end of the treatment, statistically significant differences were found in the VAS scores and the WOMAC scores among the three groups, and we therefore concluded that shockwave therapy can significantly reduce the pain and improved knee function in patients with KOA. FESWT had better long-term efficacy than RPW in terms of pain reduction and improvement in WOMAC scores. We considered that this might be related to the differences in shock wave propagation, energy distribution, and the different physical properties of fESWT and RPW. fESWT is generated by electromagnetic, hydroelectric, or piezoelectric methods, and has a concentrated beam shape. Where as RPWs are generated by aerodynamic methods with a dispersed beam shape. Due to the difference in wave propagation modes, fESWTs have a larger coverage area compared to RPWs and are able to focus energy to on deeper lesion sites than RPWs [26]. Thus, the focusing mechanism can direct each shock to the osteochondral interface, which is the target site in knee KOA treatment, without losing any energy. In addition, RPWs lacks the characteristics of shock waves, such as short rise time, high peak pressure, and nonlinearity, which reduces its efficacy in knee KOA [27].

Conclusion

In summary, ESWTextracorporeal shock wave therapy can significantly reduce pain, improve joint function, and enhance the daily life ability of patients with KOA, and compared with the application of conventional medication alone, ESWTextracorporeal shock wave therapy has significant efficacy, easy operation, and high safety. By further comparing the efficacy of RPW with that of fESWT, we found that fESWT had better long-term efficacy than RPW in terms of pain reduction and improvement of WOMAC score.

Table 7: Two-by-two comparison results of WOMAC scores at 9 months after the end of treatment in the three groups (LSD test)

Group	Group	MD	LSD	*P*-value
Focused group	Radial group	−1.557	3.263	0.026
	Drug group	−5.996	6.23	0
Radial group	Drug group	−4.671	5.108	0.001

WOMAC: Western Ontario mcmaster Osteoarthritis index, LSD: Least significant difference

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflicts of Interest: Nil. **Source of Support:** This study was supported by the KeyResearch and Development program of Ningxia Hui Autonomous Region(Grant No.:2022BEG03164).

Authors contribution: Xichun Sun and Suoli Cheng contributed equally.

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Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Sun X, Xiong X, Cheng S, Wang Z | Comparison of Radial Pressure Waves and Focused Extracorporeal Shock Waves in Treatment of Osteoarthritis of the Knee. | Journal of Regenerative Science | Jul-Dec 2023; 3(2): 62-66.