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Therapeutic effect of bone decompression needle on the knee osteoarthritis in rabbit.

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Abstract

Objective: Osteoarthritis is a progressive disease of the joints which often cause increased intraosseous pressure in the tibia bones and reduced blood flow. Bone decompression needle is a newly developed osteoarthritis treatment device.

Methods: To investigate the effectiveness of bone decompression needle on osteoarthritis, we constructed an osteoarthritis model with Japan white rabbits, and used bone decompression needle for decompression treatment.

Results: It showed that the decompression treatment reduced the intraosseous pressure in tibia bones. In hemorheology measurement, the decompression also dropped all the hemorheology indexed including whole blood viscosity, plasma viscosity, hematocrit, and erythrocyte sedimentation rate, therefore the blood flow was greatly increased. We also showed that two needle decompression treatments could almost bring all these indicators back to the level as in the normal condition.

Conclusion: Therefore the decompression with bone decompression needle has clear protection and therapeutic effect on knee osteoarthritis.

Keywords: Osteoarthritis, Bone decompression needle, Rabbits, Hemorheology.

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Introduction

Millions of people around the world are affected with arthritis [1]. Most common arthritis is the Osteoarthritis (OA) or degenerative arthritis which is defined by deterioration of articular cartilage, pain in joints and tenderness, and dysfunction among old people [2]. Largest part of the body weight affects the knee joints leading to the risk of OA. The occurrence of OA is high and it is progressive and global economy is adversely affected due to this [3]. Factors which trigger OA in people are age, weight, Body Mass Index (BMI), genetics, occupational activities, history of trauma, and physical work activities [4,5]. The triggering factors and mechanism for OA quiet remains unclear.

Report states that in OA patient's bone-related cause of pain because the blood flow is decreased and intraosseous pressure gets elevated [6]. OA has early vascular components that modify the primary bone perfusion in the affected bone [7]. Though phlebographic studies in OA reveals that pain is due to impaired vascular clearance from bone and raised intraosseous pressure in the bone marrow near the painful joint. But the detailed change of pathophysiology remains unclear [6-8]. These preceding studies demonstrates higher intraosseous pressure in hip and knee in OA patients compared to people without OA or pain consists of a normal intraosseous pressure. Osteotomy of the proximal femur reduces both intraosseous pressure and the consequent pain with hip OA [6-8].

Investigations are carried out on animal OA models. In October, 2010, Osteoarthritis and Cartilage published the OAC histopathology supplement, [9] published models and guidelines for histopathologic assessment of osteoarthritis progression in the mouse, rat, guinea pig, rabbit, dog, sheep, goat, and horse. Rabbit model of OA consists of ACL tear, meniscectomy and chemically tempted. Even some limitations were identified; e rabbit model has been used to evaluate the efficacy of various compounds. Efficacy mechanisms are studied which would be impossible in humans.

Bone decompression needle is a newly developed device to reduce the intraosseous pressure in OA patients. Despite its wide application in clinics, there are very few systematic studies on the mechanism and application of this new technique. Here we used Keen Osteo Arthritis (KOA) model with Japanese white rabbit to study the effect of needle decompression. We found that needle decompression can reduce the intraosseous pressure in tibia bones, and increase the blood flow. These studies suggest that bone needle decompression is a very effective treatment for OA.

Materials and Methods

Materials and animals

From experimental Animal Center of Shandong Luye Pharmaceutical Co., Ltd, 40 healthy adult Japanese white rabbit, weighing 2-2.5 kg, (Yantai, China) were collected. Animals were housed in specific pathogen-free animal house facility at Qilu Hospital of Shandong University, which was controlled under 22-24°C with 50% to 60% humidity. The accessed food and water before being used in experiments. Protocol used by animal was appraised and sanctioned by the Institutional Animal Care and Use Committee of Qilu Hospital of Shandong University.

Animal grouping and KOA model construction

40 healthy adult Japanese white rabbits were randomly divided into 4 groups, 10 rabbits in each group. The control group, rabbits were not subjected to any surgery and treatment. The model group, rabbits underwent a surgery procedure to induce OA. The treatment group A, rabbits were given decompression treatment at 8^{th} week after model construction; and the treatment group B, rabbits were given two decompression treatments, once at 8^{th} week and another at 10^{th} week after model construction.

After being purchased and kept for one week, except the control group, the rabbits in all the other 3 groups underwent the OA modelling surgery procedure. Only the right knees of the study animals were operated upon. 3% pentobarbital sodium with a dose of 30 mg/kg was used to tranquilize the rabbit through ear vein injection. The animal was fixed on the operation table, facing up, with knees open and a 30 degree bent. A 1 cm cut was opened near the right groin and the vein was separated and exposed for ligation at two positions, followed by a cut in between the two ligation positions. Then, another cut was opened near the right side hip joint, and the vein was separated out for the same ligation process. After this, the skin and undercover was re-joined and cleaned with 70% alcohol. After surgery, the animals were given injection of penicillin (5×10^4 U/kg) and streptomycin (1×10^5 U/kg), for 3 d. All animals were kept in different cages and provided with food and water.

Intraosseous pressure measurement

At the 8^{th}, 10^{th} and 12^{th} weeks after the model construction, the intraosseous pressure in the upper end of tibia bone of the rabbits in all the four groups were measured, using a digital ZMZ intraosseous pressure monitor (Guangdong, China), which has a pressure transducer connected with a digital recorder. The procedures were following the manufactory's instructions.

Hemorheology measurement

After the intraosseous pressure had been measured, 5 ml bone marrow blood was taken from the rabbits in each group for hemorheology measurement on a MVIS-2035 Automatic Hemorheology Analyzer (Chongqing, China). The parameters to measure included High Shear rate of Whole Blood Viscosity (HSWBV), Low Shear rate of Whole Blood Viscosity (LSWBV), plasma viscosity, hematocrit and Erythrocyte Sedimentation Rate (ESR). The procedures were following the manufactory's instructions with default settings.

Statistical data analysis

This analysis was performed with the program SPSS statistical software, version 19.0 (IBM Corp., Armonk, NY). By means of mean ± standard deviation (SD), data was expressed. By one way Analysis of Variance (ANOVA) a statistical used for multiple group comparison, and two tailed student t-test (T-test) for two groups comparison. Assumed the statistical significance at $P<0.05$.

Results

Changes in the intraosseous pressure in upper tibia bone

At 8^{th}, 10^{th} and 12^{th} week after model construction, the intraosseous pressure of rabbits in each group were measured in Figure 1. It showed that the intraosseous pressure of rabbits in the model group, as well as in the groups A and B, was much higher than that in the control group ($p<0.05$), verifying that our OA model construction was successful.

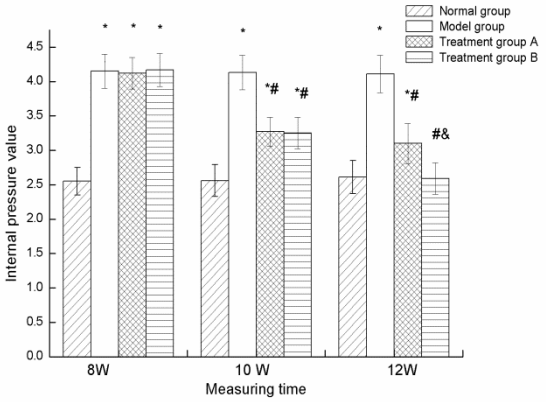

Figure 1. *The intraosseous pressure of rabbits in different groups.*

Intraosseous pressure in upper tibias before and after decompression

The intraosseous pressure was measured at 8^{th}, 10^{th} and 12^{th} weeks after model construction. At 8^{th} week, intraosseous pressure in all three O Group A's was much higher than the control group. At 10th week, intraosseous pressure in both group's A and B was significantly reduced compared to the model group. At 12^{th} week, intraosseous pressure in group B was further significantly reduced, and in group A it also decreased but to a less extent than group B.

The decompression treatment was given on 8^{th} week (for Group A) and another at 10^{th} week (for Group B). At 10^{th}

week, the intraosseous pressure of rabbit's in both the group's A and B was much lower than that the control group ($p<0.05$), as well their same groups at the 8th week ($p<0.05$), showing that the decompression treatment with bone decompression needle reduced the intraosseous pressure. At 12th week, comparing to the group A, the intraosseous pressure in group B rabbit's was further significantly reduced after another decompression treatment ($p<0.05$), suggesting that repeated decompression treatment has much better effect than single treatment. In this study, after two treatments, the intraosseous pressure in group B rabbit's was dropped to the normal range, showing no difference with the control group.

Changes in hemorheology in tibia bone

At 8th, 10th and 12th week after model construction, some important biomarkers of hemorheology of rabbit's in each group were measured, including HSWBV, LSWBV, Plasma viscosity, Hematocrit and Erythrocyte Sedimentation Rate (ESR). The results were summarized in Figures 2-6.

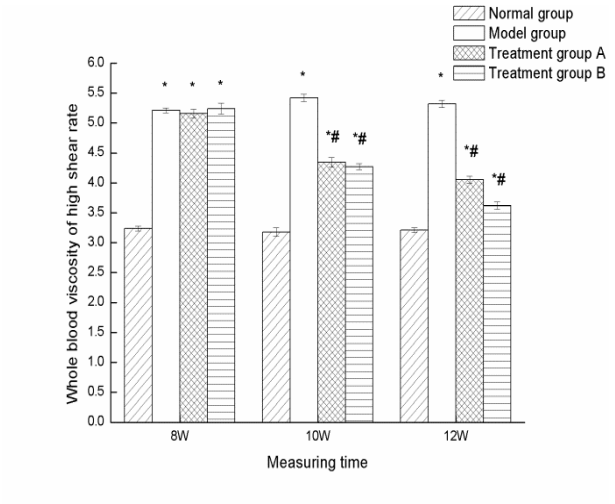

Figure 2. *High shear rate of whole blood viscosity (HSWBV).*

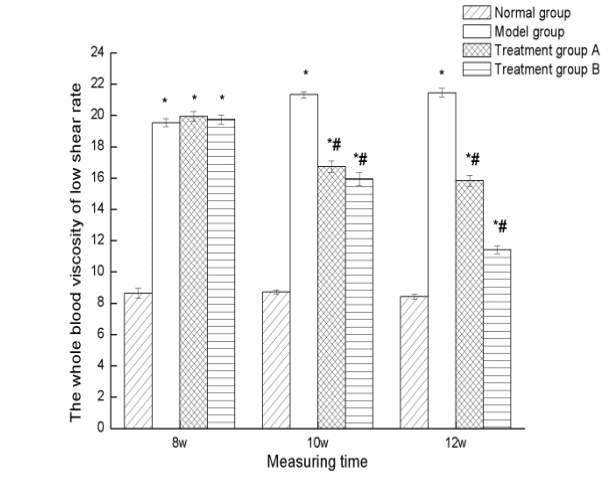

Figure 3. *Low shear rate of whole blood viscosity (LSWBV).*

Changes of high shear rate of whole blood viscosity (HSWBV) at different time in each group

At 8th week, HSWBV in all three O Group A's was much higher than the control group. At 10th week, HSWBV in both group's A and B was considerably lesser than the model group. In the 12th week, HSWBV in group B was considerably lower, and in group A it also decreased but to a less extent than group B.

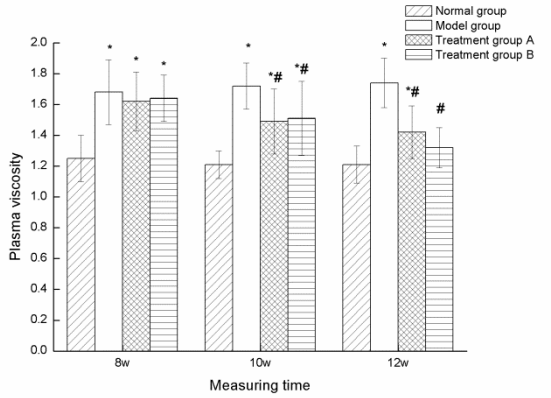

Figure 4. *Plasma viscosity.*

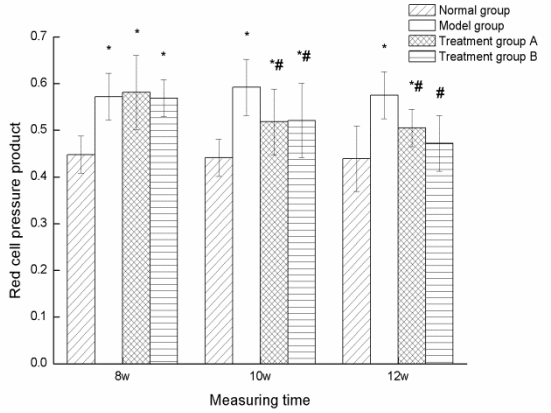

Figure 5. *Hematocrit.*

Changes of low shear rate of whole blood viscosity (LSWBV) at different time in each group

At 8th week, LSWBV in all three O Group A's was much higher than the control group. At 10th week, LSWBV in both group's A and B was considerably less than the model group. In the 12th week, LSWBV in group B was further considerably lower, and in group A it also decreased but to a less extent than group B.

Changes of plasma viscosity at different time in each group

At 8th week, plasma viscosity in all three O Group A's was much higher than the control group. At 10th week, plasma viscosity in both group's A and B was considerably less than

the model group. In the 12th week, plasma viscosity in group B was further considerably lower, and in group A it also decreased but to a less extent than group B.

Changes of hematocrit at different time in each group

At 8th week, plasma viscosity in all three O Group A's was much higher than the control group. At 10th week, plasma viscosity in both group's A and B was considerably less than the model group. In the 12th week, plasma viscosity in group B was further significantly lowered, and in group A it also decreased but to a less extent than group B.

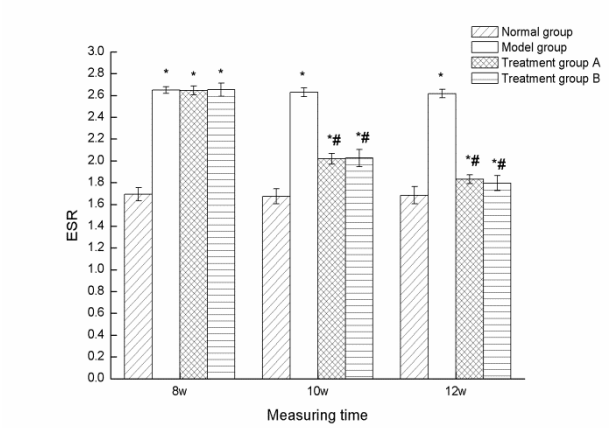

Figure 6. Erythrocyte sedimentation rate (ESR).

Changes of erythrocyte sedimentation rate (ESR) at different time in each group:

At 8th week, ESR in all three O Group A's were much higher than the control group. At 10th week, ESR in both A and Group B were reduced compared to the model group. At 12th week, ESR in both A and Group B were further reduced. However, two treatment (group B) only showed a little bit better than one treatment (group A), without much difference.

At 8th week, comparing to the values from the control group, all the 4 biomarkers in the model group as well as in group's A and B were significantly higher ($p<0.05$), confirming the model construction was successful.

At 10th week, comparing to the model group, all the 4 biomarkers in groups A and B were significantly lowered ($p<0.05$), demonstrating the effect of the decompression treatment at 8th week in increasing blood flow. And at 12th week, comparing to the group A, all the 4 biomarkers in group B were further significantly lowered ($p<0.05$), suggesting that repeated treatment has much better effect than single treatment.

Discussion

It is well known that OA patients usually have raised intraosseous pressure which contributed significantly to the pain associated with OA [6,8,10]. Bone decompression model is a newly developed device aiming to reduce the intraosseous pressure, and this study clearly showed its effectiveness in reducing the intraosseous pressure in the tibia bones, therefore it is very useful in reduce OA caused pain and OA treatment.

The property of blood flow is reflected by hemorheological parameters with bigger hemorheological parameters that indicates the higher blood viscosity and higher risks of thrombosis formation [11]. Both the whole blood viscosity and plasma viscosity is used to determine the blood viscosity. The erythrocyte deformability is decreased when the whole blood viscosity is increased with high shear rate. The erythrocyte aggregation is increased if the whole blood viscosity is increased with the low shear rate [12].

Proposed study shows that the whole blood high shear rate, low shear rate, plasma viscosity, and hematocrit level were increased in OA model animals, and after needle decompression, they were all reduced, and therefore the blood flow can be increased. This proves the effectiveness of needle decompression in increase blood flow in OA treatment.

Conclusion

In worldwide, maximum persons are affected by chronic problem and few treatments are existing to treat this. Pathophysiology of OA has been studied and new treatments are enhanced to control OA symptoms and disease progression by improving animal models of OA. Our current report showed that decompression treatment with bone decompression needle on rabbits in the osteoarthritis model could reduce the intraosseous pressure in the tibia bones, and could improve the blood flow in bone marrow, and also recover the ultrastructure of bone marrow microcirculation. Therefore the decompression with bone decompression needle has clear protection and therapeutic effect on knee osteoarthritis.

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None

Author's contributions

Wanli Yan, Xiaofang Chi and Huadao Li designed the research, performed the experiments, interpreted the data and wrote the manuscript.

All authors read and approved the final manuscript.

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