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Original Research Article

Therapeutic efficacy of intra-articular betamethasone injection and comparative assessment of temporomandibular joint pathologies using cone-beam computed tomography and magnetic resonance imaging

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Abstract

Purpose: *To investigate the radiographic characteristics of temporomandibular joint (TMJ) disorders using cone-beam computed tomography (CBCT) and magnetic resonance imaging (MRI), and to examine the therapeutic effectiveness of intra-articular betamethasone injection in the management of TMJ pathologies.*

Methods: *A total of forty (40) patients diagnosed with suspected TMJ disorders (study group) and 40 healthy volunteers (control group) who underwent comprehensive examinations in the Department of Stomatology and Rehabilitation Medicine, Qiqihar City, Heilongjiang Province, China were enrolled in this study. All participants underwent CBCT and MRI imaging to assess structural characteristics of TMJ, evaluate changes in condylar morphology, presence of disc displacement, and detection of joint effusion.*

Results: *There was no statistically significant difference in image quality between CBCT and MRI modalities ($p > 0.05$). There was significant difference in posterior joint space, condylar dimensions (internal and external), and anterior/posterior condylar dimensions in both CBCT and MRI assessments between study and control groups ($p < 0.05$). There was also significant difference in condylar bone morphology using CBCT and MRI scans between the study and control groups ($p < 0.05$). Furthermore, visual analog scale (VAS) scores of patients in the study group were significantly lower than those of control group ($p < 0.05$).*

Conclusion: *Magnetic resonance imaging provides superior visualization of the articular disc and surrounding soft tissues, while CBCT offers better delineation of bony structures. Intra-articular betamethasone injection therapy significantly improves efficacy, reduces pain, improves joint function, and increases mouth opening in the management of TMJ disorders. Further studies should include comprehensive outcome measures and assessment tools to provide a more robust evaluation of treatment effects and overall patient well-being.*

Keywords: *Temporomandibular joint disorders, Cone-beam computed tomography (CBCT), Magnetic resonance imaging (MRI), Intra-articular injection, Betamethasone*

INTRODUCTION

Temporomandibular disorders (TMDs) are a group of common oro-maxillofacial conditions characterized by functional abnormalities of the temporomandibular joint (TMJ) and its associated structures. These disorders may lead to pain, discomfort, and impaired function, significantly affecting basic activities such as chewing, speaking, and facial expressions [1-3]. The etiology of TMDs is multifactorial, and the similarity of symptoms among different pathologies makes diagnosis challenging. Imaging plays a crucial role in the objective assessment of TMJ structure and function.

Magnetic resonance imaging (MRI) is considered the gold standard for evaluating soft tissues, including TMJ discs. Magnetic resonance imaging (MRI) provides detailed images of the disc's position, morphology, and displacement, as well as any surrounding soft tissue inflammation or injury [4]. However, other modalities, such as cone-beam computed tomography (CBCT), have also been employed to further examine the skeletal components of TMJ [5]. Management of TMDs has been an area of consistent investigation. One widely used non-surgical treatment approach is intra-articular injection therapy, which involves the direct administration of medications, such as corticosteroids and local anesthetics, into the TMJ space. This approach serves to alleviate pain, reduce inflammation, improve joint function, and restore normal oral activities [6].

The present study was aimed at investigating imaging features of TMDs, measuring and analyzing the differences and changes in TMJ disc and joint space between CBCT and MRI. Furthermore, this study also investigated the therapeutic efficacy of intra-articular betamethasone injection (widely used corticosteroid with anti-inflammatory and immunosuppressive properties), in the management of TMDs. The findings from this study will provide valuable reference data for the development of TMD examination protocols, as well as contribute to the basic understanding and management of TMDs.

METHODS

Study population

A total of 80 participants who underwent examinations at the Department of Dentistry and Rehabilitation Medicine of The Second Affiliated Hospital of Qiqihaer Medical University, Qiqihar City, Heilongjiang Province, China between May 2020 and November 2022 were enrolled. Cone-beam computed tomography (CBCT) and MRI imaging were performed on all subjects, with 40 individuals suspected of TMDs assigned to study group and 40 healthy volunteers serving as control group. All diagnosed patients were thoroughly screened, and only those who received treatment at the hospital and had no contraindications for the relevant therapies were included in the study. The study group was further divided into two subgroups: Group A received intra-articular betamethasone injection therapy, while Group B received conventional injection therapy. This study was approved by the Ethics Committee of The Second Affiliated Hospital of Qiqihaer Medical University (approval no. 78432) and conducted in accordance with the principles outlined in the Helsinki Declaration [7]. Written informed consent was obtained from all participants prior to commencement of the study.

Inclusion criteria

Patients who presented with at least one symptom of temporomandibular dysfunction (temporomandibular joint pain, clicking or popping sounds in the joint, limited mouth opening, deviation during mouth opening, and joint locking); patients with no contraindications for the required examinations or treatments, conscious, able to communicate effectively, cooperative with imaging examinations, and able to complete the prescribed treatment.

Exclusion criteria

Incomplete clinical data, presence of severe organ disorders, temporomandibular joint tumors, trauma, or specific inflammation, history of otitis media, ear surgery, facial bone fractures, or other related abnormalities [8].

Image acquisition

Cone-beam computed tomography (CBCT)

Prior to CBCT imaging, all participants were required to remove any metallic objects in the temporomandibular joint region. Patients were positioned upright, with the Frankfurt plane maintained parallel to the ground, to ensure the head and temporomandibular joint area were within scanning range. The CBCT imaging was performed using a tube voltage of 80 kV and a tube current of 5 mA. A chin rest and head immobilization device were utilized to stabilize patient's head position. The crosshair was adjusted to align the vertical scanning baseline with the sagittal midline, and the horizontal scanning baseline was parallel to the Frankfurt plane. The scanning range extended from the forehead to the chin. The acquired two-dimensional projections were then reconstructed into three-dimensional images using specialized computer software. The reconstruction parameters were set to a slice thickness of 0.5 mm, an interslice distance of 0.125 mm, a grayscale of 256 levels, and an image size of 30 mm × 40 mm. The pixel size was 125 μm × 125 μm. Cone-beam computed tomography (CBCT) scan data of the temporomandibular joint for each participant were subsequently reconstructed into coronal images using standard CBCT image processing software.

Magnetic resonance imaging (MRI) examination

Prior to MRI scanning, all participants were required to remove any metallic objects related to the temporomandibular joint area. A 1.5T MRI scanner (Philips) was utilized for image acquisition. Patients were positioned on the MRI scanning bed and instructed to remain relatively still. An 8-channel phased-array head coil was used for imaging the temporomandibular joint. Positioning line was placed at centerline of the coil. For the closed-mouth position, axial sequences were initially obtained, followed by oblique sagittal and oblique coronal sequences based on the axial images for positioning. The oblique sagittal scan was performed with the positioning line perpendicular to long axis of the condyle (level showing condyle on the axial plane). An oblique coronal scan was performed with the positioning line parallel to the long axis of the condyle (level showing condyle on the axial plane). For the open-mouth position, a plastic bite plate was placed between the patient's upper and lower anterior teeth to achieve maximum comfortable opening, following the same scanning methods as the closed-mouth position. After image acquisition, data were reconstructed by the computer to generate high-resolution temporomandibular joint images.

Image measurements

To minimize the potential for operator bias and enhance the standardization and reliability of measurements, the team followed a rigorous protocol for image data acquisition and analysis. Only the highest quality temporomandibular joint (TMJ) imaging studies, as determined by predefined quality criteria, were selected for inclusion in the analysis. Selected professional researchers utilized the measurement tools provided by the imaging workstation software to assess TMJ structures in the axial, oblique sagittal, and oblique coronal planes. Measurements were done in triplicate and the average was recorded.

Treatments

Patients in Group A received intra-articular injections of betamethasone into the TMJ. Prior to injection, anesthesia was induced locally using lidocaine to alleviate any discomfort or pains. After joint lavage, betamethasone injectable suspension (Depo-Medrol, National Drug Approval Number J20080062, Shanghai Xianlingbaoya Pharmaceutical Co., Ltd.) was injected into the TMJ cavity using a needle with 25-27 gauge.

The injection site was located superior or lateral to the TMJ, and image guidance techniques, such as ultrasound or fluoroscopy, were employed to ensure accurate delivery of the medication into the joint space. The dosage ranged from 0.25 to 0.5 mL per injection, with the specific amount determined based on severity of the patient's symptoms and the degree of joint inflammation. The injections were repeated once every 10 days, with a total of 3 injections considered as one complete treatment course. Following injection, compression or cold press was done to help alleviate potential discomfort and swelling at the injection site. Control group (Group B) received conventional injections for management of TMJ disorders.

Evaluation of parameters/indices

Image quality assessment

A panel of four expert radiologists, including two board-certified radiologists and two oral and maxillofacial radiologists, were invited to evaluate and grade the generated MRI and CBCT images. Evaluation primarily focused on assessing tissue contrast and spatial resolution. Grading criteria were classified as poor image quality (0 – 4 points) characterized by insufficient visualization of anatomical structures and fine details, fair image quality (5 – 6 points) characterized by recognizable depiction of tissue layers of anatomical structures, although with blurred margins, good image quality (7 – 8 points) characterized by clear delineation of tissue layers and relatively sharp margins, but with some irregularities in tissue details and signal/density, and excellent image quality (9 – 10 points) characterized by precise and detailed visualization of anatomical structures, uniform signal/density, and distinct tissue layers.

Evaluation of articular disc morphology and position

The evaluation comprised of size, shape, and changes in density/signal characteristics of the articular disc in the temporomandibular joint (TMJ). Normal disc morphology was defined based on the positional relationship between the disc and specific bony landmarks, while other conditions were considered as disc deformation. In the closed-mouth oblique sagittal T1-weighted MRI, position of the posterior disc band in relation to the condylar head was observed. If the posterior disc band was located superior to the condylar apex, it indicated a normal disc-condyle relationship. Conversely, if the posterior disc band extended anteriorly beyond the condyle, it was referred to as anterior disc displacement. In the open-mouth oblique sagittal T1-weighted MRI, if the disc-condyle position relationship returned to normal, it was defined as reducible anterior disc displacement. However, if the disc remained anterior to the condyle and did not return to its normal position, it was classified as irreducible anterior disc displacement.

Condylar bone morphological changes

The evaluation involved assessing the relationship between the condyle and glenoid fossa, including the presence of bone erosion, sclerosis, and flattening or reduction of the cortical bone and surrounding osseous regions of the condyle.

Treatment indices

Pain perception

The level of pain experienced by patients was assessed using the visual analog scale (VAS). The VAS scores ranged from 0 to 10 and classified as mild pain (≤ 3) characterized by slight discomfort without significant impact on daily activities, moderate pain (4 – 6) signifying noticeable but manageable discomfort, and severe pain (≥ 7) indicating intolerable levels of discomfort. Scores were directly proportional to the intensity of pain, and comparisons between different groups were performed before and after treatment.

Joint function

The mandibular function impairment questionnaire (MFIQ) was utilized to evaluate jaw function in patients before and after treatment. This questionnaire consisted of 16 items related to functional performance and jaw mobility. Scoring ranged from 0 to 4, with higher scores indicating greater difficulty and inversely correlating with joint function.

Maximum mouth opening

Maximum mouth opening was measured before and after treatment. Maximum mouth opening was defined as the distance between the upper and lower central incisors without any pain or discomfort when the patient achieved their full mouth opening capacity. A measurement of ≥ 35 mm was considered within normal range.

Statistical analysis

Data was analyzed using GraphPad Prism 8 software (GraphPad Software, San Diego, USA). Statistical analysis was performed using Statistical Packages for Social Sciences version 26.0 software (SPSS, IBM Corp, Armonk, NY, USA). Measurement data were presented in mean ± standard deviation (SD), and independent sample t-tests were used for comparisons. Categorical data were presented in frequencies and percentages (%) and analyzed using chi-square test. $P < 0.05$ was considered statistically significant.

RESULTS

Baseline characteristics

Study group comprised 40 patients diagnosed with temporomandibular joint (TMJ) disorders. This group included 26 males and 14 females, mean age of 31.22 ± 15.14 years (range, 16 – 66 years) and, mean duration of the condition was 16.21 ± 3.22 days (range, 3 – 129 days). Control group comprised 40 healthy volunteers, including 22 males and 18 females, average age of 33.44 ± 13.10 years (range, 20 – 56 years). There was no significant difference in gender and characteristics between the study and control groups (Table 1).

Image quality

The CBCT images achieved an image quality score of 9.17 ± 0.94, whereas MRI images scored 9.09 ± 0.98, reflecting a very remarkable clarity. Furthermore, there was no significant difference in image quality between CBCT and MRI ($p > 0.05$). This indicates that both imaging modalities exhibit comparable levels of visual fidelity, ensuring reliable diagnostic information for medical professionals.

Table 1: Baseline characteristics (n = 40)

Characteristic		Study group	Control group	x^2/t	*P*-value
Gender	Male	26 (65%)	22 (55%)	0.833	0.361
	Female	14 (35%)	18 (45%)		
Age (years)	Average (range)	31.22±15.14 (16-66)	33.44±13.10 (20-56)	0.701	0.485
Duration (days)	Average	16.21±3.22 (3-129)			
Affected Side	Left Side	25 (62.5%)			
	Right Side	15 (37.5%)			
Symptoms	TMJ Pain	40 (100%)			
	Restricted Mouth Opening	32 (80%)			
	TMJ crepitus	23 (57.5%)			

Table 2: Articular disc and condylar bone morphology changes (%)

Parameter	CBCT	MRI	χ^2	*P*-value
Number of cases	80	80		
Articular disc		37		
Normal		25		
Reducible anterior disc displacement				
Irreducible anterior disc displacement		18		
Medial disc displacement		7		
Lateral disc displacement		4		
Joint effusion		14		
Condylar bone morphology changes	65	49	7.811	0.005

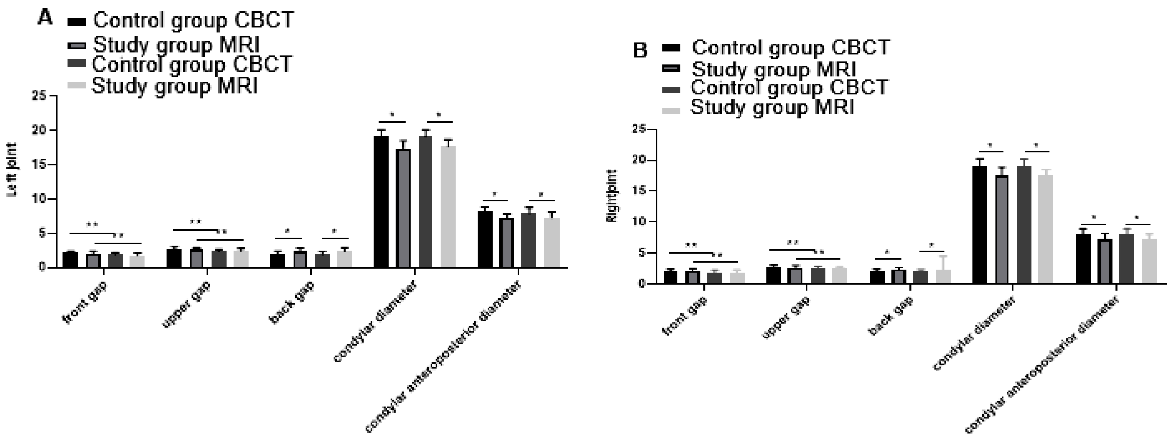

Figure 1: Condyle and joint space measurements using different imaging modalities between the two groups (A) Left joint (B) Right joint. **P* < 0.05 vs control group using the same imaging modality, ***p* < 0.05 vs different imaging modalities

Condyle and joint space

There was a significant difference in posterior joint space, condylar diameter, and condylar anteroposterior diameter between study and control groups ($p < 0.05$). Furthermore, there was a significant difference in anterior joint space and superior joint space between CBCT and MRI scans ($p < 0.05$; Figure 1).

Articular disc and condyle morphology

Magnetic resonance imaging (MRI) provided clear depiction of articular disc and joint cavity effusion, which were not readily discernible on CBCT imaging. Both modalities, however, effectively detected alterations in condylar morphology (Table 2).

Pain perception

There was significant reduction in VAS score of group A at 1 and 3 months compared to group B ($p < 0.05$).

Joint function

The mandibular functional impairment questionnaire (MFIQ) scores were significantly lower in Group A compared to Group B ($p < 0.05$).

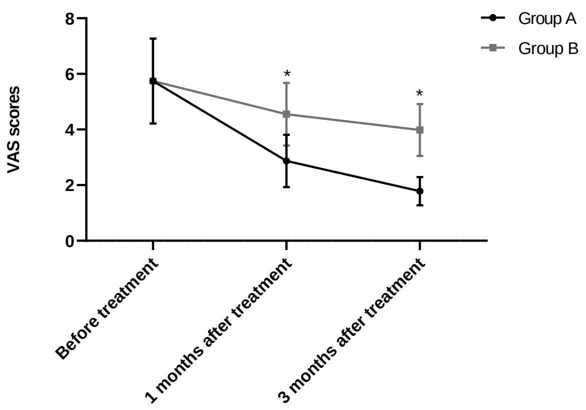

Figure 2: The VAS scores before and after treatment in both study groups. *$P < 0.05$ vs both groups

Maximum mouth opening

Maximum mouth opening values for Group A were significantly greater compared to Group B following treatment ($p < 0.05$; Figure 4).

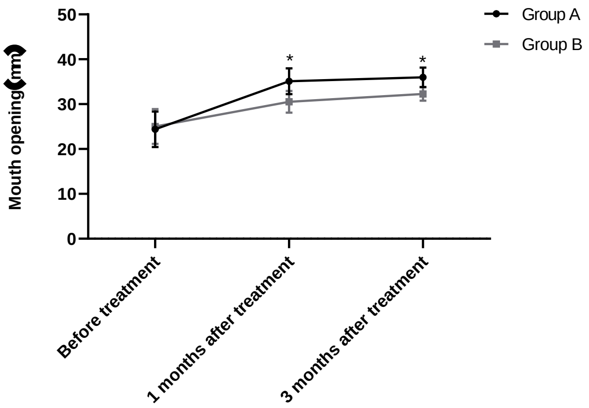

Figure 3: Maximum mouth opening before and after treatment in the two groups. *$P < 0.05$ vs group B

DISCUSSION

The temporomandibular joint (TMJ) comprises the joint connecting the mandible (jawbone) and temporal bone, situated in front of the ear. It is located between the temporal bone and the mandible. This joint consists of a cartilaginous disc, known as the articular disc, which separates the temporal bone and the mandible. The articular disc provides cushioning to withstand the pressure generated during chewing and mouth opening. Disruption of the TMJ leads to displacement, injury, or deformation of this disc-shaped cartilage. Temporomandibular joint (TMJ) disorders emanate from various causes, including abnormal TMJ structure, TMJ trauma, incorrect bite and occlusal force, TMJ overuse, inflammation, muscle disorders, and others [9,10]. Due to complexity of TMJ disorders, additional imaging techniques may be necessary to accurately diagnose and plan effective treatment. Therefore, this study analyzed and compared the characteristics of CBCT and MRI in diagnosing TMJ disorders. The findings revealed minimal differences in image quality between CBCT and MRI, with each modality possessing its advantages in diagnosing TMJ disorders.

Magnetic resonance imaging (MRI) offers clearer visualization of the disc and surrounding tissues, while CBCT provides better visualization of bone structures. The advantages of MRI in diagnosing TMJ disorders lie in its capacity to provide high-contrast and detailed images of soft tissue anatomy, enabling a more accurate assessment of TMJ structure and abnormalities [11]. Furthermore, MRI is a radiation-free imaging technique considered the gold standard for analyzing the position and morphology of TMJ discs. It is relatively safe and offers excellent soft tissue visualization [12]. On the other hand, CBCT excels in providing high-resolution three-dimensional images, which aid clinicians in understanding the structure and abnormal changes in TMJ. It helps in developing individualized treatment plans and assessing the need for surgical intervention. Previous literature suggests that CBCT has become an indispensable tool in dentistry due to its cost-effectiveness, lower equipment and scan costs compared to MRI, and superior accuracy and reliability compared to traditional tomography or panoramic X-rays [13]. Furthermore, CBCT enables high-resolution visualization of pathological changes such as condylar erosion, fractures, ankylosis, dislocation, and osteophytes in all dimensions.

Table 3: Mandibular functional impairment questionnaire (MFIQ) scores (n = 20; mean ± SD)

Treatment	Group A	Group B	*T-value*	*P*-value
Before	27.14±2.56	27.25±2.88	0.128	0.899
After	9.52±1.28	14.12±1.85	9.144	<0.001

Despite its economic advantages and ability to depict fine details of the human body, CBCT does not display the joint disc and has limited visualization of soft tissues, which are precisely the strengths of MRI [14]. Therefore, in practice, healthcare professionals may choose the appropriate imaging modality based on the patient's condition and specific circumstances related to temporomandibular disorders (TMD). Standardized protocols and diagnostic criteria for TMJ examinations should be established to provide a quantitative reference for basic studies, diagnosis and treatment of TMJ diseases. Furthermore, treatment of TMJ disorders is a significant concern. Intra-articular injection therapy is a non-invasive, simple, and safe treatment option that yields rapid effects. It alleviates pain, improves joint function, and eliminates the need for surgery or high-dose medication. Commonly used medications in intra-articular injection therapy include corticosteroids and local anesthetics [15,16].

This study also investigated the therapeutic effectiveness of intra-articular betamethasone injection in the management of TMJ pathologies. The results demonstrated that betamethasone significantly reduces VAS and MFIQ scores. Also, betamethasone significantly increases maximum mouth opening compared to conventional therapy. These findings suggest that intra-articular injection of betamethasone exhibits superior efficacy in rapidly and effectively relieving pain, improving joint function, and promoting patient recovery compared to conventional treatment. Intra-articular injection therapy is a commonly employed non-surgical treatment method. By directly injecting the medication into the joint cavity, intra-articular injection reduces inflammation, enhances joint function, and provides prompt pain relief. Previous studies have shown that glucocorticoids, a class of synthetic steroid hormones with effects similar to naturally produced adrenal cortex hormones, have significant non-specific anti-inflammatory effects when used for intra-articular injection [17,18].

Betamethasone (a glucocorticoid), possesses anti-inflammatory and immunosuppressive properties. It alleviates inflammation caused by arthritis, reduces pain and swelling, and stabilizes lysosomal membranes, thereby decreasing release of hydrolytic enzymes, and pro-inflammatory factors such as TNF and IL-1. Also, it mitigates symptoms by suppressing excessive release of local inflammatory factors through its anti-inflammatory and immunosuppressive effects [19], which is in agreement with this present study. However, some animal experimental studies conducted have suggested that repeated intra-articular injection of glucocorticoids may lead to severe degenerative changes in joint tissues [20,21].

Limitations of this study

The study utilized a specific treatment method, intra-articular injection of betamethasone, without comparing its effectiveness to other treatment approaches. Therefore, it could not be established if betamethasone is the optimal choice for treating TMJ disorders or if there are alternative therapies that may be more effective. Also, the sample size of this study was relatively small and included patients within a specific timeframe. Due to the limited sample size, results may not be generalizable to the entire population of individuals with TMJ disorders. Further large-scale studies may be needed to validate these findings.

The observation period in this study was relatively short, focusing only on early treatment effects. Since TMJ disorder is a chronic condition, long-term follow-up studies are necessary for assessing the durability and long-term effects of treatment, and this study did not provide comprehensive information on long-term effects of betamethasone treatment. Furthermore, this study was limited to the diagnostic imaging of TMJ disorders and evaluation of one treatment method, without considering other potential factors that may influence TMJ disorders, such as lifestyle, psychological factors, and temporomandibular joint functionality. Therefore, a study design that considers a more comprehensive set of factors may provide better understanding of the etiology of TMJ disorders and treatment strategies. This study lacked detailed assessment of patient quality of life, functional recovery, and adverse reactions. These factors are important for evaluating treatment outcomes and safety.

CONCLUSION

Magnetic resonance imaging (MRI) provides superior visualization of the TMJ disc and surrounding soft tissues, while cone-beam computed tomography (CBCT) provides better imaging of bone structures with exceptional clarity. Intra-articular injection of betamethasone promptly alleviates pain, enhances joint function, and improves mouth opening. Further studies should include more comprehensive outcome measures and assessment tools to provide a more enhanced evaluation of treatment effects and overall patient well-being.

DECLARATIONS

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Ethical approval

This study was approved by the Ethics Committee of The Second Affiliated Hospital of Qiqihaer Medical University (approval no. 78432).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest

No conflict of interest is associated with this work.

Contribution of Authors

We declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Sang J and Li G designed the study; Yang C and Liu H carried out the investigations; Zhang M and Xiao Y conducted the experiments. Li J analyzed the data. All authors read and approved the final manuscript for publication.

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