Research Article

Backpropagation Neural Network Artificial Intelligence Algorithm-Based Magnetic Resonance Imaging Image Feature Analysis in the General Anesthesia Hip Arthroplasty

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Objective. This study aimed to present an investigation of the clinical significance of magnetic resonance imaging (MRI) images obtained based on the backpropagation neural network (BPNN) artificial intelligence algorithm for hip arthroplasty under general anesthesia. **Methods.** In this study, a case-review method was used to collect 100 patients requiring total hip replacement. They were then randomly divided into an observation group and a control group. Based on the neural network algorithm, the images of the two groups of patients were analyzed to judge their accuracy. Then the sensitivity, specificity, and accuracy of MRI images based on neural algorithms were compared with those processed by radiologists. **Results.** It was found that MRI processed by BP neural network had good accuracy in the diagnosis of hip joint diseases compared with CT. Meanwhile, the images processed by BP neural network had good specificity and accuracy compared with the images processed by radiologists. **Conclusion.** Imaging images obtained by BPNN artificial intelligence algorithm were more accurate than CT images, which had more guiding value for surgeons in operation.

1. Introduction

Hip arthroplasty is one type of artificial joint replacement. The indications for hip arthroplasty are mainly osteoarthritis, aseptic necrosis of the bone, certain hip fractures, rheumatoid arthritis, traumatic arthritis, benign and malignant bone tumors, ankylosing spondylitis, etc. [1]. Clinical data have shown that the incidence of osteoarthritis in 45–65-year-olds is up to 30% and in 65-year-olds can reach 60% [2–4]. The main purpose of an artificial joint replacement is to relieve joint pain, correct deformity, and restore and improve joint motor function [5, 6]. In summary, there are indications for joint arthroplasty whenever there are X-ray signs of joint destruction, accompanied by moderate to severe persistent joint pain and dysfunction that cannot be relieved by various other nonsurgical treatments [7]. General anesthesia has better anesthesia and analgesia

effect on elderly patients undergoing hip arthroplasty and has little effect on postoperative cognitive function [8].

Magnetic resonance imaging (MRI) has been applied in the imaging diagnosis of various systems in the whole body, and the best results are the brain, spinal cord, cardiac vessels, joint bones, soft tissue, and pelvic cavity [9]. Compared with other imaging examinations, MRI has many advantages, such as no ionizing radiation damage to the human body, the ability to obtain primary three-dimensional cross-sectional imaging, and the clear display of soft tissue structure [10, 11]. Clinical data have suggested that MRI can more specifically reflect the early necrosis of the femoral head, which has a great role in the preoperative diagnosis of hip arthroplasty [12]. With the development of artificial intelligence algorithms in the field of medical imaging, the backpropagation neural network (BPNN) artificial intelligence algorithm is integrated with MRI image feature analysis [13]. As early as

2016, Chinese scholars proposed the application of BP neural network algorithm in brain tumor MRI image segmentation. His research results showed that BP neural network could effectively segment brain MRI containing fuzzy regions after strengthened training for fuzzy regions. The boundaries of the brain tumor areas were very obvious. The fuzzy areas in the lower left and right corners were mostly clustered as normal tissues, and the segmentation was relatively accurate on the whole. Artificial neural network has the ability of large-scale parallel processing and distributed information storage, good adaptive, self-organization, strong learning, association, and fault tolerance [14]. In the medical field, artificial neural network has been used in clinical diagnosis of diseases, disease screening, and auxiliary diagnosis, disease-related factors research, disease risk prediction, survival analysis, gene identification, DNA and RNA sequence analysis, protein structure analysis, etc. Artificial neural network has also been widely used in imaging, which can improve the diagnostic accuracy. In foreign countries, artificial neural network has been applied to MRI images to diagnose hip joint diseases.

To sum up, 100 patients needing total hip arthroplasty in the hospital were taken as the research objects to explore the application of MRI image feature analysis based on BPNN artificial intelligence algorithm in total hip arthroplasty under general anesthesia. They were divided into the observation group and the control group to analyze the different imaging examination results. Moreover, its effect on total hip arthroplasty was investigated in this study. The results of this study were intended to provide a reference for the application of an artificial intelligence algorithm based on BPNN in total hip arthroplasty.

2. Methods

2.1. Research Objects. 100 cases were selected as the research objects in this study, who were admitted to hospital during January 2018–January 2020, were diagnosed with femoral aseptic necrosis (such as femoral head necrosis), some hip fracture (such as femoral neck fractures), rheumatoid arthritis, traumatic arthritis, benign and malignant bone tumors, and ankylosing spondylitis, and required hip arthroplasty therapy. Then, they were grouped randomly into the control group and the observation group, with 50 cases in each. The general information and other conditions of patients from the two groups were compared and analyzed, and the difference was not statistically obvious ($P > 0.05$). This study was approved by the ethics committee of the hospital, and all the patients included in the study signed the informed consent forms.

The criteria for inclusion were defined to include patients who were older than 50 years old, who had the complete imaging data, whose lesions were reported, and who signed the surgical consent forms.

The criteria for exclusion were defined to include patients who were complicated with infection or other basic diseases of bone tissue, spinal cord injury, or hemodynamic instability and took part in other studies.

2.2. Examination Method. 50 patients from the control group underwent CT examinations, with the help of a CT/e-type spiral CT produced by GE in the United States for scanning. The patients were placed in the supine position, and the parameters were set with the help of the CT scanner. The voltage was set as 120 kV, the tube current was set as 300 mA, the layer thickness was set as 10 mm, and the layer spacing was set as 10 mm. Next, the patient's femur was scanned. Patients from the observation group were examined by MRI, and they were kept in supine position; and the femur of the patients was scanned through the MRI instrument. Using a Siemens MAGNETOM Skyra 3.0 T MRI scanner, all MRI examinations were performed prior to clinical treatment. High-resolution MRI T2 lipid-pressure sagittal scan parameters were as follows: repetition time (TR): 8500 ms, echo time (TE): 97 ms, field of view (FOV): 200 mm × 200 mm, and layer thickness: 3.5 mm. The transverse scanning parameters of T2 lipid pressure were as follows: TR: 4400 ms, TE: 62 ms, FOV: 200 mm × 200 mm, layer thickness: 4 mm; TR: 4300 ms, TE: 104 ms, FOV: 180 mm × 180 mm, and thickness: 4 mm. Conventional MRI T2WI lipogenic sagittal scan parameters were as follows: TR: 5000 ms, TE: 50 ms, FOV: 350 mm × 284.4 mm, and thickness: 4 mm. After the examinations of the patients from the two groups, surgical exploration was conducted for all patients, and the diagnostic accuracy between the groups was compared and analyzed. Its accuracy was judged by pathological biopsy results during the operation. Then, 50 patients in the observation group were divided into two groups, namely, the BP neural network group and the physician group. MRI images of patients in the former group were processed by BP algorithm, while MRI images of patients in the latter group were only diagnosed by radiologists. Finally, the sensitivity, specificity, and accuracy of the two groups of images were compared.

2.3. BP Neural Network Design. BP is a multilayer network for weight training of nonlinear differentiable functions. BPNN is a special type of BP network. BPNN consists of three layers: an input layer, a hidden layer, and an output layer. The input layer receives data and outputs data. The neurons of the previous layer connect to the neurons of the next layer to collect the information from the neurons of the previous layer and transfer the value to the next layer through “activation.” The structural pattern is shown in Figure 1.

In the design of BP network, the number of grid layers, the number of neurons in each layer, the activation function, and the initial value should be considered. In this study, a three-layer BP grid with a hidden layer was adopted, and its topology was 2-3-1. The activation function of the network adopts the Sigmoid function, which is expressed as follows:

$$f(x) = \text{logsig}x = \frac{1}{1 + e^{-x}}. \quad (1)$$

2.4. Training of BP Network and Simulation Test of Predictive Neural Network Model. In this study, BP neural network with forward additional momentum was adopted, and its

FIGURE 1: Three-layer structure pattern diagram of BPNN.

topological structure consisted of three layers: input layer, hidden layer, and output layer. There were 26 neural nodes in the input layer, including 21 neural nodes in the hidden layer with clinical parameters and above radiological features, and 6 neural nodes in the output layer using transfer function and Sigmoid linear transfer function. The steps were as follows. The input data were pre-processed. 40 groups of 50 pieces of experimental data were selected as training samples. In order to make the input data fall on the gradient with the fastest change of transfer function, preprocessing of training samples was carried out by dividing the value of each indicator by the maximum value of the indicator. The normalization equation was as follows:

$$\chi = \frac{Xi}{\max \chi}. \quad (2)$$

Xi refers to the experimental data, and $\max(x)$ is the maximum value of each index. In order to observe the reliability of the prediction neural network model, the simulation test was carried out on the model. The remaining 10 groups of experimental data were taken as training samples, and the training samples were preprocessed. The value of each indicator was divided by the maximum value of the indicator, and the normalized equation was shown in the following:

$$\omega = \frac{\chi}{\max(x)}, \quad (3)$$

where x refers to the number of training samples and $\max(x)$ refers to the maximum value of each index. The trained MRI image feature prediction neural network model was applied to predict the above data and the error value was calculated. The calculation equations were as follows:

- (i) Absolute error = actual lesion number – predicted lesion number
- (ii) Relative error = absolute error/number of actual lesions $\times 100\%$

2.5. Image Processing of BP Neural Network Algorithm. MRI images of patients' hip joint were processed using BP neural network algorithm. In order to make the input data more in line with the requirements of artificial neural network Sigmoid transfer function, linear eucalyptus tree was transformed into normalized processing, and the expression was as follows:

$$y = \frac{(x - \text{MinValue})}{(\text{MaxValue} - \text{MinValue})}, \quad (4)$$

where x and y are the values before and after conversion, respectively, and MaxValue and MinValue are the maximum and minimum values of samples, respectively. The converted input parameters are all distributed within the range of $[0, 1]$.

2.6. Staging Criteria. With the help of MRI examination, four diagnostic criteria of stage I necrosis, stage II necrosis, stage III necrosis, and stage IV necrosis were adopted for the diagnosis of patients with femoral head necrosis. Stage I necrosis: pain is in the hip, gradually forming uninterrupted hip pain that worsens as the hip is walking. Stage II necrosis: pain is usually needle-like, dull, or sore, radiating to the groin area, the inner thighs, the back of the buttocks, and the inner knee, and there will be numbness in this area. Besides, the pain will be obvious when patients are in activity, but it will be reduced after the rest. Stage III necrosis is manifested as more intense and persistent hip pain with severe joint pain while standing. Stage IV necrosis: the morphology and structure of the femoral head of the patient are significantly changed, with large areas of irregular collapse or flattening and structural variation of the trabecular bone.

2.7. Surgical Methods. The procedures of joint arthroplasty surgery were as follows: first, before the operation, the patients were under general anesthesia, and the femoral head was removed. The hip joint was successfully dislocated by flexion, adduction, and internal rotation. The femoral neck was cut off 1–1.5 cm above the lesser trochanter, and the round ligament and the surrounding joint capsule were cut off, so that the femoral head was removed. Second, the acetabulum was treated. Acetabular cartilage was repaired with acetabular grinding until blood oozed from subchondral bone, so as to ensure that all around the acetabulum were crushed. Acetabular prosthesis was implanted at an extroverting angle of 45° , and antebrachial angle of $12\text{--}15^\circ$ was given. Third, the femur was processed. After reaming, the medullary cavity drill from small size to large size was employed to penetrate the medullary cavity with the medullary cavity file from small size to large size. Then, reduction was tried, lining was installed, and the femoral prosthesis was implanted. Fourth, the bone cement was used for fixation and the surgical incision was closed.

2.8. Statistical Methods. Statistical software SPSS20.0 was used for statistical processing and the X^2 test was used to detect the count data. In addition, $P < 0.05$ indicated a statistically significant difference.

3. Results

3.1. Basic Information of Patients from the Two Groups. In this study, 100 patients needing hip arthroplasty were included in the control group ($n = 50$) and the observation group ($n = 50$), and there was no statistical difference in the basic information between the two groups ($P > 0.05$). In the control group, there were 33 male patients, accounting for 66%, and 17 female patients, accounting for 34%. There were 31 males (62%) and 19 females (38%) in the observation group. In the control group, 43 cases were more than 65 years old, accounting for 86% of the total number of patients in the control group; in the observation group, 40 cases were older than 65 years old (80.0%). In the control group, 29 (58.0%) had smoked, and 27 (54%) had smoked in the observation group. There were 23 patients with a history of diabetes in the control group, accounting for 46.0%, and 25 patients in the observation group, accounting for 50%. In the control group, there were 17 patients with a history of heavy use of antibiotics, accounting for 34.0%. The data of the two groups were not statistically significant (Table 1).

3.2. Comparison of Features of CT and MRI Images Processed by Neural Network Algorithm. CT and MRI images based on BP neural network algorithm were analyzed to judge the accuracy of these two examination methods in the diagnosis of hip diseases. The gold standard of these diseases was the result of pathological biopsy during the operation, as shown in Figure 2.

3.3. Analysis of CT and MRI Examination Results of 100 Patients. In the control group, CT examination results showed a total of 7 diseases, of which the most suggestive disease was osteoarthritis (23 cases and 46.0%). Then, there were 17 cases of bone aseptic necrosis (necrosis of femoral head), accounting for 34.0%, and 3 cases of sacrum fracture and rheumatoid arthritis, accounting for 6.0%. The number of patients diagnosed with benign tumor and compulsory spondylitis was the least, 1 case each. In the observation group, MRI examination results indicated that osteoarthritis was still the most common disease (21 cases, accounting for 42.0%), followed by aseptic necrosis of bone, sacral fracture, rheumatoid arthritis, etc. (Figures 3(a) and 3(b)).

3.4. Comparison of Misdiagnosis Rates between CT and MRI Examination Results of 100 Patients. The total misdiagnosis rate was 12% in the control group, including 3 cases of osteoarthritis, 2 cases of necrosis of the femoral head, and 1 case of rheumatoid arthritis, as shown in Table 2. The patients from the observation group underwent MRI examinations, and the total misdiagnosis rate was 4%, including 2 patients with misdiagnosis, including osteoarthritis and aseptic necrosis of bone, as shown in Table 3.

3.5. The Comparison of the BP Neural Network Group and the Physician Group. The MRI image of hip joint after BP neural network processing is shown in Figure 4. In Table 4, MRI

images processed by radiologists had higher sensitivity (%), while images processed by BP neural network algorithm had higher specificity.

3.6. BP Network Training Results of MRI Image of Hip Joint. According to the design of neural network and the requirements of this study, the parameters were set as follows. The maximum training step epochs were 10,000; the deviation goal was 0.00001; the interval display during training show was 25; the maximum number of differences max-fail was 5; the number of rows and columns mem-reduc was le-010; the reduction rate of characteristic function mu-dec was 0.1; the increase rate of characteristic function mu-inc was 10; the u upper limit mu-max was 100,000,000,000. Moreover, the designed neural network was trained with parameters, and the error recording curve obtained is shown in Figure 5.

3.7. Simulation Test Results of the Prediction Neural Network Model. The data obtained after normalization of the remaining 10 groups of data were as follows: 0.89, 1.01, 0.45, 0.34, 1.24, 0.32, 1.12, 0.67, 0.78, 0.56; 0.21, 0.37, 0.48, 0.87, 0.49, 0.73, 0.98, 0.98, 0.76, 0.68; 0.81, 0.76, 0.74, 0.23, 0.57, 0.76, 0.35, 0.85, 0.26, 0.83; 0.24, 0.64, 0.73, 0.37, 0.82, 0.72, 0.73, 2.47, 0.25, 0.25.

Comparison of test results with target samples is shown in Table 5.

3.8. Staging Criteria of Femoral Head Necrosis. In the process of surgical exploration, there were 17 cases of femoral head necrosis in the control group, including 7 cases of stage II femoral head necrosis (41.2%), 6 cases of stage I femoral head necrosis (35.3%), 3 cases of stage III femoral head necrosis (11.8%), and 1 case of stage IV femoral head necrosis (5.9%). In the observation group, there were a total of 18 cases of femoral head necrosis, of which the largest proportion was stage I (8 patients) (50.0%), followed by stage II (5 cases), stage III (2 cases), and stage IV (2 cases). The accuracy of stage I diagnosis of femoral head in patients from the observation group was higher than that of the control group, and the difference was statistically substantial ($P < 0.05$) (Figures 6(a) and 6(b)).

4. Discussion

In clinical work, imaging methods are mainly used to diagnose bone tissue-related diseases, which mainly include X-ray plain film examination, CT examination, and MRI examination [15]. Compared with other imaging examinations, MRI examination can obtain the native 3-dimensional section imaging, which also can give clear display of soft tissue and no ionizing radiation damage to human body; the MRI examination of soft tissue such as central nervous system, bladder, rectum, and uterus is better than CT, multisequence imaging, and multiple image types, providing more abundant image information for defining the nature of lesions [16]. Clinical data

TABLE 1: Comparison of basic information of 100 patients in the control group and the observation group.

Basic information		The number of cases in the control group	Proportion (%)	The number of cases in the observation group	Proportion (%)	<i>p</i>
Gender	Male	33	66.0	31	62.0	0.001
	Female	17	34.0	19	38.0	0.000
Age	More than 65 years old	43	86.0	40	80.0	0.002
	Less than 65 years old	7	14.0	10	20.0	0.019
A history of smoking	Yes	29	58.0	27	54.0	0.011
	No	21	42.0	23	46.0	0.003
A history of diabetes	Yes	23	46.0	25	50.0	0.001
	No	27	54.0	25	50.0	0.001
A history of the heavy use of antibiotics	Yes	17	54.0	16	32.0	0.000
	No	33	66.0	34	68.0	0.000

FIGURE 2: Comparison of diagnostic accuracy of different examination methods. *Note.* A: osteoarthritis; B: aseptic osteonecrosis; C: sacral fracture; D: rheumatoid arthritis; E: traumatic fracture. FIGURE 3: CT examination results of 50 patients in the control group (a) and 50 patients in the observation group (b). *Note.* A: osteoarthritis; B: aseptic necrosis of bone; C: sacral fracture; D: rheumatoid arthritis; E: traumatic fracture; F: benign or malignant tumors; G: compulsory spondylitis.

TABLE 2: Misdiagnosis rate of CT examinations in patients from the control group.

Control group	Actual number of cases	Number of cases diagnosed by CT	Misdiagnosis rate (%)
Osteoarthritis	23	20	6
Aseptic necrosis of bone	17	15	4
Sacral fracture	3	3	0
Rheumatoid arthritis	3	2	2
Traumatic fracture	2	2	0
Benign or malignant tumors	1	1	0
Compulsory spondylitis	1	1	0
Total	50	44	12

TABLE 3: Misdiagnosis rate of MRI examinations in patients from the control group.

Control group	Actual number of cases	Number of cases diagnosed by CT	Misdiagnosis rate (%)
Osteoarthritis	21	20	2
Aseptic necrosis of bone	18	17	2
Sacral fracture	4	4	0
Rheumatoid arthritis	3	3	0
Traumatic fracture	1	1	0
Benign or malignant tumors	1	1	0
Compulsory spondylitis	1	1	0
Total	50	48	4%

FIGURE 4: MRI image of hip joint. (a) Original MRI image and (b) image processed by BP neural network algorithm.

TABLE 4: The comparison of the BP neural network group and the physician group.

The pathologic result	Results of BP treatment		Results of radiologist handled	
	Malignant	Benign	Malignant	Benign
Malignant	19	6	20	5
Benign	2	23	3	22
Sensitivity (%)	84.0 (21/25)		92.0 (23/25)	
Specificity (%)	92.0 (23/25)		88.0 (22/25)	
Accuracy (%)	96.0 (24/25)		92.0 (23/25)

FIGURE 5: Training results of BP network.

TABLE 5: Comparison of MRI image prediction results with actual results.

No.	Output value	Prediction of MRI image features	Actual MRI image features	Absolute error	Relative error (%)
1	0.8638	78.25	73.36	-4.89	6.37
2	0.2789	39.66	36.36	-3.3	3.25
3	0.2566	39.36	35.29	-4.07	2.36
4	0.3672	63.36	69.35	5.99	7.34
5	0.9735	29.47	32.53	3.06	2.56
6	0.9857	29.53	25.46	-4.07	4.36
7	0.2978	58.46	57.36	-1.1	3.56
8	0.2256	37.58	39.45	1.87	8.56
9	0.2789	43.74	42.54	-1.2	8.46
10	0.6583	27.58	30.52	2.94	9.45
Average value	0.5186	55.897	44.22	0.11	5.73
Standard deviation	0.2532	11.34	10.87	3.97	8.68

FIGURE 6: Staging of femoral head necrosis in the control group (a) and the observation group (b).

suggest that MRI can more specifically and clearly reflect the early necrosis of the femoral head, which has a great role in the preoperative diagnosis of hip arthroplasty [17]. The results of this study also indicated that the overall misdiagnosis rate was 12% in the control group with CT

examinations and 4% in the observation group with MRI examinations, including 2 patients with misdiagnosis (osteoarthritis and aseptic necrosis of the bone), suggesting that the accuracy of MRI was higher than that of CT.

The BPNN is adopted to analyze MRI image features, so the diagnostic rate of images can be improved. In recent years, the BPNN artificial intelligence algorithm has been integrated with MRI image feature analysis. BPNN is an artificial neural network using radial basis function as an activation function [18]. The latest research reports that BPNN, as a kind of artificial neural network using radial basis function as an activation function, has been gradually applied in the field of medicine. BP neural network contains three layers of structure: input layer, hidden layer, and output layer [19–21]. The results of this study showed that there were absolute errors and relative errors between the predicted MRI image features and the actual MRI features. The average value of absolute error was 0.11, and the standard deviation was 3.97, while the average value of relative error was 5.73, and the standard deviation was 8.68. After using BPNN to analyze and process the features of MRI images, the accuracy of MRI images was improved.

In clinical practice, due to osteoporosis in the elderly, trochanteric and intertrochanteric fractures of the femoral head are prone to occur, especially unstable fractures accompanied by severe osteoporosis, which eventually lead to ischemic necrosis of the femoral head [17]. Studies have shown that aseptic necrosis of the bone (necrosis of the femoral head) occurs in 23–30% of the population, and the main causes are alcohol and heavy antibiotic use. In clinical work, patients with femoral head necrosis are staged, including stages I–IV, in order to provide better surgical treatment for patients. A large number of studies have pointed out that more than 50% of the patients are in stages I and II [22, 23]. In this study, the patients with necrosis of the femoral head in the control group and the observation group were classified. The results revealed that 41.2% of the patients from the control group were in stage II, and nearly 50% of the patients in the observation group were in stage I, which was roughly the same as the results reported in domestic and foreign literature studies.

In this study, the BPNN artificial intelligence algorithm was applied to process the features of MRI images. The results disclosed that the misdiagnosis rate and missed diagnosis rate of MRI images processed by the BPNN algorithm were reduced, and the accuracy of MRI images was improved, thus greatly promoting the success rate of total hip arthroplasty under general anesthesia.

5. Conclusion

This study aimed to explore the application of MRI image feature analysis based on BPNN artificial intelligence algorithm in hip arthroplasty under general anesthesia. In this study, 100 patients who were treated in the Orthopedics Department of our hospital and needed total hip arthroplasty were selected as the research objects. Besides, they were enrolled randomly into the observation group and the control group. There was no statistical difference among the groups. It was found that MRI imaging analysis based on neural algorithm was more specific and accurate than radiologists in diagnosing MRI images. BP neural network algorithm can effectively improve the success rate of surgery

in MRI diagnosis of hip diseases and reduce postoperative complications of patients. The sample size selected in this study is from a third-class A hospital, which had a small sample size. It could not accurately reflect the advantages of BP neural network algorithm in MRI. Meanwhile, this study only focuses on total hip arthroplasty. Therefore, it is necessary to explore the application of BNPP artificial intelligence algorithm in MRI image feature analysis for more surgeries. In conclusion, the results of this study can provide reference for the application value of BPNN artificial intelligence algorithm in MRI image features in surgery.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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