Anatomical changes in lumbosacral vertebrae and their correlation with facet joint-derived low back pain in patients with hip osteoarthritis after total hip arthroplasty: a cohort study

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Background: Little is known about the anatomical changes in lumbosacral vertebrae and their correlation with facet joint-derived low back pain in patients with hip osteoarthritis (HOA) after total hip arthroplasty.

Methods: Seventy-four HOA patients with low back pain who underwent initial total hip arthroplasty were included. Their Harris Hip Score (HHS), Oswestry Disability Index (ODI), Visual Analogue Scale (VAS) and anatomical parameters were analyzed. Paired *t*-tests were used to compare the various index scores before and after surgery, and independent sample *t*-tests were used for the between-group comparisons.

Results: The HHS and ODI significantly changed at 3 and 6 months postoperatively [HHS: preoperative (43.56±4.34) *vs.* 3 months (80.34±5.23) *vs.* 6 months (84.37±4.78); ODI: preoperative (36.26±5.34) *vs.* 3 months (26.44±3.23) *vs.* 6 months (19.34±3.27); P<0.001]. At the first 3 months after surgery, the VAS low back pain score decreased from 5.24±1.21 to 2.89±1.03 (P<0.001), and the VAS hip pain score decreased from 7.45±1.32 to 2.34±1.12 (P<0.001). There was also a statistically significant difference between the preoperative and 1-month postoperative anatomical indices: lumbar lordosis (LL) increased significantly after surgery [preoperative (43.46°±13.89°) *vs.* 1 month (48.27°±14.42°), P=0.001], while slip angle (SA) decreased significantly [preoperative (89.20°±5.03°) *vs.* 1 month (84.45°±4.89°), P=0.010]. Sacral slope (SS) and radial abduction angle (RAA) showed significant postoperative changes compared with preoperative assessments; after surgery, SS increased significantly [preoperative (31.33°±8.23°) *vs.* 1 month (37.65°±8.19°), P=0.006), while RAA decreased significantly [preoperative (42.32°±8.12°) *vs.* 1 month (35.45°±7.67°), P=0.021]. Moreover, the increase of LL was both significantly correlated with the decrease of the VAS low back pain (P=0.009) and the VAS hip pain score (P=0.038).

Conclusions: Total hip arthroplasty was associated with the anatomical changes in lumbosacral vertebrae.

Keywords: Hip osteoarthritis (HOA); total hip arthroplasty; anatomy of lumbosacral vertebrae; lumbago

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Introduction

Hip osteoarthritis (HOA) is a common degenerative joint disease that causes progressive damage to the articular cartilage and surrounding structures. It is a common disease in the middle-aged and elderly (1). HOA can be divided into primary and secondary types, and the secondary type is often caused by gout, chondrocalcinosis, or hemochromatosis (2). There is a 25% lifetime risk of symptomatic HOA for people who live to age 85 and a 10% lifetime risk of total hip replacement for end-stage HOA, which seriously affects people's health (3). The sagittal force line of the entire spine changes after damage to the hip joint. Under normal circumstances and with increasing age, the lumbar lordosis angle decreases, and the sacrum gradually tilts backward over time. In patients with HOA, the lumbar lordosis angle remains unchanged or slightly increases, and the sacrum does not tilt backward (4). With the further aggravation of local inflammation in the hip joint, the range of motion is gradually limited, resulting in weakened hip adduction, flexion and extension, changes in local anatomical morphology, abnormal walking gait, changes in the sagittal force line of the lumbar spine, and facet joint-derived low back pain (5). The outcome of HOA progression is total hip arthroplasty.

The reduction of the sacral inclination angle and the loss of the lumbar lordosis angle are key factors causing low back pain symptoms and an increased risk of vertebral spondylolisthesis. Additionally, the increase of the inclination angle of the sacrum leads to the increase of lumbar lordosis, resulting in a greater shear force on the intervertebral discs, facet joints, and muscle-associated ligaments than in the previous stage, and muscle tension increases. Over time, the abdomen and back muscles become excessively tired, resulting in low back pain caused by facet joints in the lower back. However, it remains unclear whether anatomical changes in lumbosacral vertebrae for HOA patients after total hip arthroplasty were associated with facet joint-derived low back pain. The potential associations may influence clinical decision processes and improve surgical qualities. Thus, we aimed to analyze the anatomical changes in the lumbosacral spine and their correlation with facet joint-derived low back pain in patients with HOA after total hip arthroplasty. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-999/rc).

Methods

General information

This cohort study included 74 patients with HOA (excluding other lower limb injury diseases) who were treated in our hospital and underwent total hip arthroplasty from Jan 2019 to Jan 2021. The sample size calculation was based on the assumption that the standard derivation would be 10 and the precision would be 2.5. With a α of 5% and a power of 80%, a sample size of 72 patients was calculated, including a 15% dropout rate. Thus, a sample size of 74 is sufficient in this study. The patients' age range was 65–81 years old, with an average age of 68±2.45 years. After admission, the patients were given a detailed explanation of the process of total hip arthroplasty, including its advantages and disadvantages and potential postoperative complications, and underwent various preoperative examinations. All patients agreed to participate in the follow-up observations. The inclusion criteria were as follows: (I) the patient had been diagnosed with HOA for more than one year before admission. After conservative treatment, the effect was poor or unsatisfactory, and the patient agreed to undergo total hip arthroplasty; (II) no other lower limb joints and other diseases were confirmed by preoperative examination; (III) imaging and physical examination results supported the diagnosis; (IV) the diagnosis of HOA was accompanied by symptoms of low back pain (facet-derived low back pain); (V) X-ray examination did not show lumbar disease, scoliosis, or other spinal system diseases; (VI) the included patients were able to undergo a standing position full spine lateral radiograph before and after surgery. The exclusion criteria were as follows: (I) patients with other lower limb joint diseases and lumbosacral lesions; (II) those who had a history of lumbosacral vertebra or hip surgery; (III) poor compliance and mental disorder; (IV) patients with severe heart, liver, or kidney dysfunction; (V) those who could not stand normally before and after surgery; (VI) patients who had undergone lower extremity deep venography or color Doppler ultrasound showing lower extremity deep venous thrombosis and who were not suitable for early rehabilitation training.

Preoperatively, all patients demonstrated abnormal standing, significant hip and lower back pain, and limited movement. They all underwent hip arthroplasty for the first time, using a biological prosthesis. All patients were followed up by outpatient visits at 1, 3, 6, and 12 months after discharge, with an average follow-up time of 6.24±2.33 months. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Huangyan Hospital of Wenzhou Medical University, Taizhou First People's Hospital (2021-184) and informed consent was taken from all the patients.

Surgical methods and postoperative management

See *Figure 1* for the surgical methods and postoperative management.

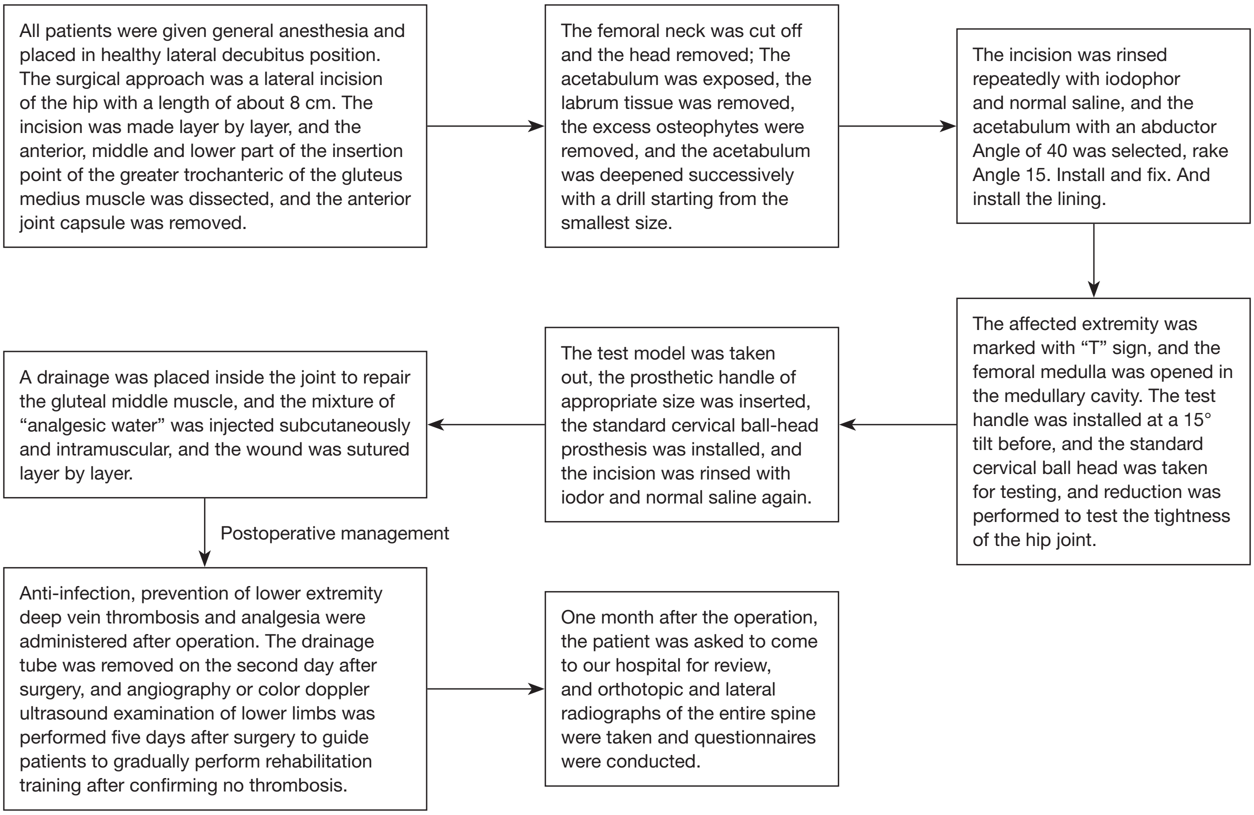

Figure 1 Surgical methods and postoperative management.

Rating criteria

Hip function and lumbar function were evaluated by the Harris Hip Score (HHS) and the Oswestry Disability Index (ODI). The degree of low back pain was assessed by the Visual Analogue Scale (VAS) score.

The anatomical observation indices of the lumbosacral vertebrae included spinal sagittal plane parameters, pelvic sagittal plane parameters, hip parameters, pelvic anteversion, and anteversion in the standing position. The specific measurement indices are shown in *Figure 2*.

Statistical analysis

SPSS (version 26.0; SPSS Inc., Chicago, IL, USA) statistical software was used to analyze the collected data. The measurement data were expressed as the mean and standard deviation ($\bar{x}\pm s$). Paired *t*-tests were used to analyze and compare the differences in the various index scores before and after surgery, and independent sample *t*-tests were used for the between-group comparisons. Pearson's correlation analysis was used to analyze correlations among parameters. The significance level of 5% was adopted for all comparisons (two-tailed P<0.05).

Results

General information

The total number of 74 patients with HOA included 39 males (52.7%) and 35 females (47.3%), with an average age of 68±2.45 years and an average follow-up of 6.24±2.33 months. There was no significant difference in gender and age among the included patients (P>0.05).

Harris score

The pre- and postoperative Harris scores (6) showed significant differences. The 3- and 6-month postoperative Harris scores were significantly higher than the preoperative scores (both P<0.05), demonstrating a significant improvement in hip functioning following total hip arthroplasty. See *Table 1*.

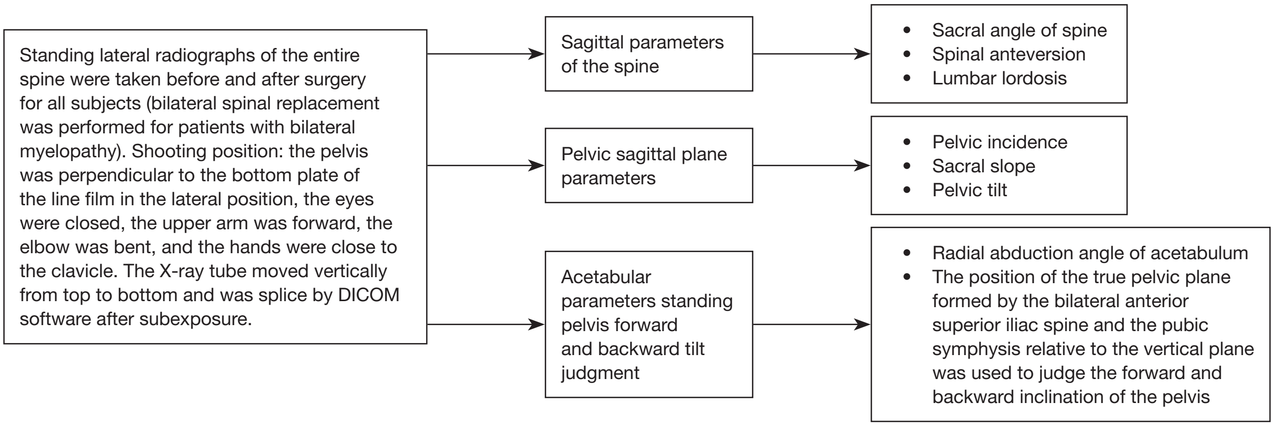

Figure 2 Measurement parameters of lumbosacral anatomy and morphology.

Table 1 Comparison of pre- and postoperative Harris scores

Group	Preoperative (n=74)	3 months after surgery (n=74)	6 months after surgery (n=74)	P value
Harris score	43.56±4.34	80.34±5.23*	84.37±4.78$^{\Delta}$	<0.05*$^{\Delta}$

*, the statistical difference between preoperative and 3-month postoperative scores, P<0.05; $^{\Delta}$, the statistical difference between preoperative and 6-month postoperative scores, P<0.05.

Table 2 Comparison of pre- and postoperative Oswestry scores

Group	Preoperative (n=74)	3 months after surgery (n=74)	6 months after surgery (n=74)	P value
Oswestry score	36.26±5.34	26.44±3.23*	19.34±3.27$^{\Delta}$	<0.05*$^{\Delta}$

*, the statistical difference between preoperative and 3-month postoperative scores, P<0.05; $^{\Delta}$, the statistical difference between preoperative and 6-month postoperative scores, P<0.05.

Oswestry score

Our results showed a significant difference in the pre- and postoperative ODI scores (7) after total hip arthroplasty. The preoperative ODI score of 36.26±5.34 decreased to 26.44±3.23 three months after surgery (P<0.05) and to 19.34±3.27 six months after surgery (P<0.05), demonstrating a significant improvement in lumbar function following total hip arthroplasty. See *Table 2*.

VAS score

There was a statistically significant difference in the preoperative VAS scores compared with the 3- and 6-month postoperative scores (P<0.05). At the first follow-up 3 months after surgery, the VAS low back pain score decreased from 5.24±1.21 to 2.89±1.03 (P<0.05), and the VAS hip pain score decreased from 7.45±1.32 to 2.34±1.12 (P<0.05). At the second follow-up 6 months after surgery, the VAS low back and hip pain scores showed further improvement. See *Table 3*.

Evaluation of sagittal parameters of the spine

In the 74 patients who underwent total hip arthroplasty, slip angle (SA) and lumbar lordosis (LL) demonstrated significant differences in pre- and postoperative parameters (P<0.05); after surgery, LL increased significantly, while SA decreased significantly. There was no significant difference in the pre- and postoperative spino-sacral angle (SSA) measures, which may be due to the small sample size. The results showed that after total hip arthroplasty, lumbar lordosis had increased, and the spine was in a more forward position than before. See *Table 4*.

Table 3 Comparison of pre- and postoperative VAS score in the hip and lumbar

Group	Preoperative (n=74)	3 months after surgery (n=74)	6 months after surgery (n=74)	P value
Lumbar	5.24±1.21	2.89±1.03*	2.23±0.89$^{\Delta}$	<0.05*$^{\Delta}$
Hip	7.45±1.32	2.34±1.12*	0.87±0.42$^{\Delta}$	<0.05*$^{\Delta}$

*, the statistical difference between preoperative and 3-month postoperative scores, P<0.05; $^{\Delta}$, the statistical difference between preoperative and 6-month postoperative scores, P<0.05. VAS, Visual Analogue Scale.

Table 4 Comparison of pre- and postoperative spinal sagittal parameters

Group	SSA	SA	LL
Preoperative	126.21°±10.23°	89.20°±5.03°	43.46°±13.89°
1 month after surgery	128.34°±10.32°	84.45°±4.89°	48.27°±14.42°
t value	–1.231	3.432	–2.133
P value	0.678	0.010	0.001

SSA, spino-sacral angle; SA, slip angle; LL, lumbar lordosis.

Table 5 Comparison of pre- and postoperative pelvic sagittal and acetabular parameters

Group	PT	SS	PI	RAA
Preoperative	17.56°±9.13°	31.33°±8.23°	49.13°±10.19°	42.32°±8.12°
1 month after surgery	13.76°±9.32°	37.65°±8.19°	48.78°±10.42°	35.45°±7.67°
t value	–1.731	–3.223	0.000	–2.333
P value	0.189	0.006	1.000	0.021

PT, pelvic tilt; SS, sacral slope; PI, pelvic incidence; RAA, radial abduction angle.

Evaluation of pelvic sagittal parameters and acetabular parameters

In the 74 patients who underwent total hip arthroplasty, there were significant differences in the pre-and postoperative SA and radial abduction angle (RAA) measures (P<0.05); postoperative sacral slope (SS) measures increased significantly, and postoperative RAA measures decreased significantly. There were no significant differences in the pre- and postoperative pelvic tilt (PT) and pelvic incidence (PI) measures, which may have been due to the small sample size. After total hip arthroplasty, our results showed that the pelvis demonstrated obvious anteversion compared with the preoperative observations. See *Table 5*.

Correlation of anatomical changes in lumbosacral vertebrae with VAS score

Pearson's correlation analysis revealed that the increase of LL after surgery was both significantly correlated to the decrease of the VAS low back pain score (P=0.009) and the VAS hip pain score (P=0.038) at 6 months postoperatively; however, there were no significant correlations of other anatomical parameters with the VAS scores (P>0.05).

Discussion

Severe HOA may lead to an abnormal sagittal alignment of the spine and changes to the morphology of the lumbosacral spine, causing the patient difficulty in maintaining proper balance and resulting in an unsteady gait and facet joint pain in the lower back (8). The hip joint is the only connection point between the upper and lower limbs. It bears the stress transmitted by the upper limbs and transmits it to the foot through the hip joint. When the hip joint sustains damage, its function is destroyed, resulting in changes in the normal spinal force line, manifested as scoliosis and pelvic inclination, and leading to an unequal lower limb length (9). To maintain the sagittal balance of the body, the compensatory function of adjacent joints may be required to achieve overall balance and stability. Total hip arthroplasty is an orthopedic operation that can correct hip deformity. It is the primary treatment for patients with serious HOA (10). The changes in the anatomical morphology of the lumbosacral vertebrae mainly involve the hip-spine syndrome and changes in the sagittal position of the pelvis and spine. Due to the hip joint function damage caused by inflammation, the morphology of the spine joints becomes unstable, compensatory function increases, and the symptoms of facet joint-derived low back pain emerge (11). Therefore, it is essential to analyze the relief of low back pain and the effects of total hip arthroplasty on pelvic and spinal sagittal parameters in patients with HOA.

The results of this study indicated that HOA patients with facet joint-derived low back pain reported significantly improved low back pain symptoms after total hip arthroplasty, similar to the findings of Ben-Galim *et al.* (12). The VAS lumbar and hip pain scores decreased significantly 3 months after surgery. The VAS lumbar pain score decreased from 5.24±1.21 to 2.89±1.03, suggesting that patients with HOA have a good recovery from low back pain after total hip arthroplasty. In this study, the postoperative LL of HOA patients showed a significant increase compared with the preoperative measures ($P<0.05$). There was a close relationship between the curvature of the lumbar spine and the sagittal inclination of the pelvis—the greater the inclination of the sacrum, the greater the LL angle. We found a correlation between lumbar pain and LL. The normal reference values of LL and SS are 47.9°±22.8° and 41.1°±15.2°, respectively. In our study, the SS of patients pre- and postoperatively was less than the normal reference value, but there was an obvious increasing trend postoperatively. Similarly, the postoperative LL of patients also demonstrated an increasing trend. It has been suggested that the reduction of the sacral inclination angle and the loss of the lumbar lordosis angle are key factors causing low back pain symptoms and an increased risk of vertebral spondylolisthesis (13). The increase of the inclination angle of the sacrum may lead to the increase of LL, resulting in a greater shear force on the intervertebral discs, facet joints, and muscle-associated ligaments than in the previous stage, and muscle tension increases. Over time, the abdomen and back muscles become excessively tired, resulting in low back pain caused by facet joints in the lower back (14).

In this study, the angle after RAA was significantly larger than before RAA. This result is consistent with that of Lazennec *et al.* (15). The volume represented by PA and SS is a parameter that indicates the inclination of the pelvis in the sagittal position at the same PI level. Jing *et al.* (16) considered that there is a necessary correlation between RAA, SS, and PT. Therefore, for HOA patients with anatomical changes to the lumbosacral vertebrae, the impact of pelvic position on acetabular prosthesis implantation should be fully considered during total hip arthroplasty and an appropriate prosthesis position should be adopted for patients with pelvic sagittal position changes in the standing position. The applicable range of the abduction angle of the prosthesis implanted in the acetabulum is 40°±10°. In the clinical practice, the abduction angle is usually 42°, and the preoperative inclination angle is usually 15° (17). In this study, the postoperative RAA angle for HOA patients was in the normal range. Due to the structural factors of the hip joint, the abduction angle of the acetabulum is reduced, and the covering surface of the acetabulum to the femoral head will also be slightly reduced, resulting in instability of the hip joint structure, which damages the hip joint in excessive weight-bearing activities. It can be seen that maintaining a normal RAA angle is essential for the long-term stability of the hip joint. RAA will follow the position of the pelvis forward and decrease slowly. In total hip arthroplasty, changes to the pelvic position (anteversion and anteversion angle) should be considered in the implantation of biological prostheses for HOA patients. Reducing RAA and the anteversion angle will gradually affect the femoral anteversion angle and increase its dependence. When the size of RAA is less than 35°, and the anteversion angle is less than 8°, the size of the femoral anteversion angle should be controlled between 13–28° when the femoral end prosthesis is implanted during surgery. If the anteversion angle of the femur is too large due to surgical difficulties, it will lead to limited external rotation movement of the hip joint and reduce; if the angle of forward inclination is too small, it will lead to limited flexion movement of the hip (18). When RAA >55°, the outer upper edge of the implanted prosthesis is more vulnerable to wear, which greatly reduces its service life. In addition, our results showed that after total hip replacement, the LL of HOA patients was greater, and the spine and pelvic positions had more forward inclination than before. Therefore, when the prosthesis is implanted, the angle of the prosthesis placement should be selected carefully to prevent the decrease of RAA and the anteversion angle, as problems with pelvic anteversion in HOA patients can eventually lead to impairments in hip functioning. Before surgery, clinicians should not only understand the condition of the diseased hip joint but also the position of the patient's spine and pelvis so as to select the appropriate position for the acetabular prosthesis. This can avoid complications, such as acetabular impact and dislocation, and improve the service life of the prosthesis.

In conclusion, total hip arthroplasty improved the lumbar anatomy and symptoms of facet joint-derived low back pain in patients with HOA. After total hip arthroplasty, hip and lumbar spine functioning showed significant improvements, low back pain symptoms were significantly relieved, the lordosis of the lumbar spine increased, and the spine was in a more forward position than before. However, there was no significant difference in PT and PI after surgery, which may be due to the small sample size. In our next study, the sample size will be expanded to increase the study's statistical power. Total hip arthroplasty is effective in alleviating all symptoms of HOA. When performing total hip arthroplasty, surgeons should consider all aspects of the patient's condition, make a comprehensive evaluation, and carefully select the implant angle of the prosthesis so as to minimize the patient's pain, reduce the potential surgery risks, and prolong the service life of the prosthesis.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-999/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-999/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-999/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Huangyan Hospital of Wenzhou Medical University, Taizhou First People's Hospital (2021-184) and informed consent was taken from all the patients.

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