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Effect of Scarf and Chevron combined with Akin on postoperative balance in patients with moderate to severe foot bunion

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Abstract. – OBJECTIVE: The aim of this study was to analyze the effect of Scarf and Chevron combined with Akin on a postoperative balance of patients with moderate to severe foot bunion.

PATIENTS AND METHODS: One hundred (100 feet) patients with moderate to severe bunion cysts treated at our hospital from January 2019 to January 2022 were retrospectively selected as subjects and divided into 2 groups according to their surgical procedure. The control group received Scarf combined with Akin, and the study group received Chevron combined with Akin. Oxidative stress mediators [late oxidized protein product (AOPP), lipid peroxide (LPO)], inflammatory factors [interleukin-1β (IL-1β), procalcitonin (PCT)], Hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal joint angle (DMAA) Angle, ankle-hind foot American Orthotic Foot and Ankle Association (AOFAS) score, pain visual analog scale (VAS) score and balance Berg Balance Scale (BBS) score were compared between the two groups before and after surgery. The effectiveness and safety of the operation were compared.

RESULTS: The levels of AOPP and LPO in the study group decreased most significantly, t=1.081 and 10.850, p=0.001; the levels of IL-1β and PCT in the study group increased most significantly, t=16.970 and 12.260, p=0.001; the indexes of HVA, IMA, and DMAA in the study group increased significantly, t=11.890, 11.550, and 12.670, p=0.001; the AOFAS and BBS scores in the study group increased significantly, while the VAS score in the study group decreased significantly, t=14.760, 13.580, 5.994, p=0.001; the total effective rate of treatment in the study group was the highest, χ^2=6.960, p=0.00; the total incidence of complications in the study group was the lowest, χ^2=1.834, p=0.175.

CONCLUSIONS: Chevron combined with Akin is more effective than Scarf combined with Akin in treating moderate to severe foot bunion, the former is more minimally invasive and has a better effect in promoting postoperative balance recovery.

Key Words:
Scarf, Chevron, Akin technique, Moderate to severe foot bunions, Ability of balance.

Introduction

Clinically, foot bunion valgus is a common forefoot deformity, especially among women, due to lifestyle changes, and its incidence increases with age leading to more episodes and surgeries[1,2]. Bunions occur when the first phalanx of the foot is tilted too far outward. The relaxation of foot joint ligaments and muscle weakness with age worsen the degree of deformity. Foot bunions have gained more attention due to the improvement of living standards, self-image awareness, and fast-paced lifestyles[3].

Foot hallux valgus, a type of orthopedic disease, is mainly caused by excessive lateral deflection of the hallux at the first metatarsophalangeal joint. The primary causes are genetic factors, standing for long periods, and wearing high heels and pointy shoes. Patients may experience pain, swelling, limited mobility, and inability to wear shoes, leading to varying degrees of impact on daily life and mobility[4,5]. Without effective and timely treatment, it can cause serious symptoms, pose a threat to weight-bearing capacity, and increase the risk of bone and joint diseases, which could seriously affect patients' daily life and activity ability. Surgical treatment is the best option for patients with foot bunion valgus, and the best surgical method varies depending on the patient's symptoms[6].

Mild cases of foot bunion valgus deformity can be corrected with orthotic pads. However, moderate to severe cases require surgical osteotomy to

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correct the deformity, as conservative treatments have limited effects[7,8]. Proximal osteotomy is commonly used for patients with moderate to severe foot bunion valgus due to the limited ability of distal osteotomy of metatarsal diaphysis (IMA) Angle I and II[9]. Scarf osteotomy and Chevron osteotomy are frequently used in clinical practice, with fewer complications and better results in patients with foot bunion. Currently, Scarf osteotomy + Akin and Chevron osteotomy + Akin are the focus of research in patients with foot bunion[10]. However, the literature on Scarf and Chevron in combination with Akin for treating bunions is limited[11,12]. Thus, this study employed multiple treatment methods to treat patients with bunion exostosis and evaluate the effect of postoperative balance.

Patients and Methods

General Information

One hundred (100 feet) patients with moderate to severe bunion cysts treated at our hospital from January 2019 to January 2022 were retrospectively selected as subjects and divided into 2 groups according to their surgical procedure. The control group consisted of 40 patients who underwent a specific surgical procedure. They had an average age of 46.50 years and ranged from 35 to 58 years. Among these patients, 21 had moderate foot bunions, and 19 had severe foot bunions. Before the surgery, we measured the levels of the advanced oxidized protein products (AOPP) and lipid peroxide (LPO) in their feet. The average values were found to be 15.39 for AOPP and 8.57 for LPO. We also measured the levels of interleukin-1β (IL-1β) and procalcitonin (PCT), which were 3.85 and 2.48, respectively. Additionally, we assessed the Hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal joint angle (DMAA), which were 38.64°, 21.36°, and 16.57° respectively. Furthermore, we used the American Orthotic Foot and Ankle Association (AOFAS) score, the visual analog scale (VAS) score, and the Berg Balance Scale (BBS) score to evaluate their foot function, pain level, and balance. The preoperative AOFAS score was 43.25 points, the VAS score was 16.54 points, and the BBS score was 24.48 points.

The study group comprised 60 patients who underwent a different surgical procedure. They had an average age of 47.51 years ranging from 35 to 60 years. Among these patients, 43 were females and 17 were males. The preoperative measurements for this group showed similar results to the control group. The average values for AOPP and LPO were 15.26 and 8.45 respectively. The levels of IL-1β and PCT were found to be 3.76 and 2.25, respectively. Similarly, the angles of HVA, IMA, and DMAA were similar to the control group, measuring 38.71°, 21.31°, and 16.63° respectively. The preoperative AOFAS score, VAS score, and BBS score for this group were 43.48 points, 16.48 points, and 24.56 points respectively.

In comparing the two groups, we conducted a statistical analysis to determine if there were any significant differences in these parameters. After analyzing the data, we found that there were no statistically significant differences between the control group and the study group for any of the measured variables ($p>0.05$). This indicates that the two surgical procedures had comparable outcomes in terms of biochemical markers (AOPP, LPO, IL-1β, PCT), anatomical measurements (HVA, IMA, DMAA), and functional assessments (AOFAS, VAS, BBS).

Inclusion Criteria

(1) All subjects were diagnosed with hallux valgus by clinical examination and imaging[13].
(2) Conservative treatment was ineffective and affected patients' daily life.
(3) The patient voluntarily requested surgery.
(4) Patients and their families were able to understand the operation and signed the informed consent form, which was approved and implemented by the hospital Ethics Committee.

Exclusion Criteria

(1) Mental disorders or malignant tumors.
(2) Pregnant and lactating women.
(3) Patients who were unable to cooperate with the treatment.

Methods

1. Before surgery, all patients were instructed on proper nutrition to ensure smooth bowel movements. They were given high-calorie, high-protein, vitamin-rich food. Patients were also educated on the psychological effects of surgical treatment. If any adverse mood or mental state was observed, patients' concerns were addressed, and their overall physical condition was evaluated to ensure they were in the best psychological state for the operation.
2. The surgical procedure included Scarf osteotomy + Akin:
   (1) Routine examinations were conducted, and the patients were given epidural anesthesia in the supine position.

(2) A 2 cm longitudinal incision was made at the 1st and 2nd metatarsal bones. The lateral joint capsule and the intersesamoid ligament of the 1st metatarsal joint were cut longitudinally, and a longitudinal incision was made on the medial side of the 1st metatarsal bone.
(3) Scarf osteotomy was performed by making a longitudinal osteotomy along the metatarsal shaft on the inside of the first metatarsal, followed by a transverse osteotomy. Two guide wires were inserted, and the excess bone was excised with pressure screw fixation.
(4) Akin osteotomy was performed by making a proximal osteotomy with a micro-pendulum saw parallel to the base of the phalanges. The triangular thin bone slices were then cut laterally in the form of width inside and width outside. A double-threaded compression screw was used to intercept the patient's bone in a diagonally fixed manner.
(5) After an X-ray examination to confirm the satisfactory internal fixation position, the incision was rinsed and closed layer by layer.

3. Chevron osteotomy + Akin was performed:
(1) Routine examination was conducted upon admission. On the second or third day, surgical treatment was performed using iodophor for disinfection, epidural anesthesia, or periankle nerve block anesthesia, and the patient was placed in the supine position.
(2) The transverse and sesamoid ligaments between the first and second metatarsal bones were cut off. An incision was made in the foot to remove the osteophyte and cut off the joint capsule. The angle between the two osteotomy surfaces was maintained at 60°.
(3) After complete dissection, a 3.0 mm diameter double-threaded hollow compression nail was used for fixation. Excess bone was removed, and the two ends of the osteotomy were closed and fixed.
(4) The wound was washed, bleeding was stopped, and the incision was sutured and bandaged. The affected foot was maintained in a neutral position.

After the operation, the affected limb was elevated, and small gauze rolls were placed between the first and second toes of the affected foot to ensure that the medial joint capsule was tight. Routine anti-infection treatment was still needed for no more than 72 hours. The patient was able to bear weight on the affected foot on the third day after surgery, and stitches were removed two weeks after surgery based on the results of the X-ray examination.

Observation Indicators

Comparison of oxidative stress mediators (AOPP and LPO) between the two groups

The level of AOPP was detected using chloramine colorimetry [kit: Qiyi Biotechnology (Shanghai) Co., LTD., Shanghai, China.], and the level of LPO was detected using thiobarbiturate [kit: Shanghai Yanqi Biotechnology Co., LTD., Shanghai, China.] by specialized medical staff.

Comparison of inflammatory index levels between the two groups

Serum interleukin-1β (IL-1β) and procalcitonin (PCT) index levels were obtained from both groups of subjects using an enzyme-linked immunoassay. The assay was performed strictly according to the kit instructions (kit: Shanghai Enzyme Linkage Biotechnology Co., LTD., Shanghai, China.).

Comparison of the levels of HVA, IMA, and DMAA between the two groups of patients

IMA, HVA, and DMAA were observed and determined by professional surgeons.

AOFAS score, pain VAS score, and balanced BBS score of the two groups

American Orthotic Foot and Ankle Association (AOFAS)[14,15] scores were used in this study to evaluate the efficacy of the surgical procedures in improving foot function and overall outcomes in patients with moderate to severe bunion cysts. The pain VAS scoring scale[16,17] was used to determine the degree of surgical pain in both groups. The higher the score, the more severe the pain. The Berg Balance Scale[18,19] (BBS) was used to assess the balance function of the two groups of patients. A cumulative score of 50 points was assigned, with higher scores indicating a better balance function.

Statistical Analysis

SPSS 24.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. The medica-

tion was provided by Pfizer Inc. (New York, NY, USA), and the surgical instrument was manufactured by Johnson & Johnson (New Brunswick, NJ, USA) which was used for data processing. The measurement data were expressed as (±s). Comparisons of IMA, HVA, DMAA, AOFAS scores and BBS scores between the two groups were performed by *t*-test, and comparisons of gender were performed by χ^2 test. $p<0.05$ was considered statistically significant.

Results

Comparison of Indexes of Oxidative Stress Media

There was no statistical difference in the preoperative AOPP and LPO between the two groups ($p>0.05$). After surgery, the levels of AOPP and LPO in the study group decreased most significantly, t=1.081 and 10.850, p=0.001 (Table I).

Comparison of Inflammatory Factors

Preoperative IL-1β and PCT were not significant in both groups ($p>0.05$). After surgery, the levels of IL-1β and PCT in the study group increased most significantly, t=16.970 and 12.260, p=0.001 (Table II).

Comparison of HVA, IMA and DMAA

The preoperative HVA, IMA, and DMAA comparisons were not significant ($p>0.05$). After treatment, the indexes of HVA, IMA, and DMAA in the study group increased significantly, t=11.890, 11.550, and 12.670, p=0.001 (Table III).

Comparison of AOFAS, VAS and BBS Scores

Pre-surgery AOFAS, VAS and BBS scores were not significant ($p>0.05$). After surgery, the AOFAS and BBS scores in the study group increased significantly, while the VAS score in the study group decreased significantly, t=14.760, 13.580, 5.994, p=0.001 (Table IV).

Table I. Comparison of indexes of oxidative stress media ($\bar{x} \pm s$).

Group	The number of cases	AOPP		LPO	
		preoperative	postoperative	preoperative	postoperative
Control group	40	15.39±3.21	32.61±5.34	8.57±1.69	21.63±2.49
Study group	60	15.26±3.14	25.43±5.27	8.45±1.54	16.35±2.31
t-value		0.201	1.081	0.367	10.850
p-values		0.841	0.001	0.714	0.001

Table II. Comparison of inflammatory factors ($\bar{x} \pm s$).

Group	The number of cases	IL-1 beta		PCT	
		preoperative	postoperative	preoperative	postoperative
Control group	40	3.85±0.74	8.98±1.31	2.48±0.46	7.69±1.52
Study group	60	3.76±0.68	5.25±0.89	2.25±0.39	4.96±0.67
t-value		0.625	16.970	2.688	12.260
p-values		0.532	0.001	0.008	0.001

Table III. Comparison of HVA, IMA, and DMAA ($\bar{x} \pm s$).

Group	The number of cases	HVA		IMA		DMAA	
		pre-operative	post-operative	pre-operative	post-operative	pre-operative	post-operative
Control group	40	38.64±5.13	26.39±4.75	21.36±3.25	13.84±2.47	16.57±1.65	10.52±1.19
Study group	60	38.71±5.26	15.78±4.10	21.31±3.19	8.59±2.05	16.63±1.71	7.58± 1.10
t-value		0.065	11.890	0.076	11.550	0.174	12.670
p-values		0.947	0.001	0.939	0.001	0.861	0.001

Table IV. Comparison of HVA, IMA, and DMAA ($\bar{x} \pm s$).

Group	The number of cases	HVA		IMA		DMAA	
		pre-operative	post-operative	pre-operative	post-operative	pre-operative	post-operative
Control group	40	38.64±5.13	26.39±4.75	21.36±3.25	13.84±2.47	16.57±1.65	10.52±1.19
Study group	60	38.71±5.26	15.78±4.10	21.31±3.19	8.59±2.05	16.63±1.71	7.58± 1.10
t-value		0.065	11.890	0.076	11.550	0.174	12.670
p-values		0.947	0.001	0.939	0.001	0.861	0.001

Table V. Comparison of curative effects (n, %).

Group	The number of cases	Significant efficacy	Effective	Invalid	Total effective rate
Control group	40	21 (52.5)	10 (25.00)	9 (22.50)	31 (77.50)
Study group	60	35 (58.33)	22 (36.66)	3 (5.00)	57 (95.00)
χ^2 value					6.960
p-values					0.008

Table VI. Comparison of complications (n, %).

Group	The number of cases	Redness and swelling of the wound	Metastatic plantar pain	Non-healing of wound	Recurrence of malformation	Thrombosis of lower extremity	Over-correct and cause varus	Total incidence rate
Control group	40	2 (5.00)	0 (0.00)	2 (5.00)	1 (2.50)	0 (0.00)	0 (0.00)	5 (12.50)
Study group	60	1 (1.66)	0 (0.00)	2 (3.33)	0 (0.00)	0 (0.00)	0 (0.00)	3 (5.00)
χ^2 value								1.834
p-values								0.175

Curative Effect

The total treatment efficiency of the study group was significantly higher than that of the control group, χ^2=6.960, p=0.008 (Table V).

Complication

The total incidence of complications in the study group was obviously the lowest, χ^2=1.834, p=0.175 (Table VI).

Discussion

Clinically, bunions are a common foot deformity in foot and ankle surgery, which can cause pain, discomfort, and affect walking and normal life[20]. The cause of foot bunion deformity is not clear, but the most common causes are shoe-wearing, trauma, and iatrogenic injury, which can be examined and treated early[21]. The deformity is mainly caused by the abnormal structure of the first metatarsophalangeal joint and increased angles of the proximal and distal articular surfaces. The elevation of the first metatarsal head and the sinking of the second and third metatarsal bones result in the weakening or elimination of the transverse arch in the forefoot, causing it to widen. Hallux valgus is accompanied by pronation in some patients. The sesamoid bone of the tibial side shifts to the peroneal side. The first metatarsal joint capsule inside the toe is relaxed, while the lateral joint capsule, adductor pollicis, and the lateral head of the flexor longus tendon are contracted, forming a bow. The first metatarsal bone adducts and the second and third metatarsal bone angles increase, causing osteopathy and bunion formation. Plantar wedge joint relaxation and instability are also pathologic factors[22,23]. The

prevalence of foot bunion valgus is very high in women, mainly due to the use of women's pointed shoes and high heels, which impact the foot thumb, causing external rotation, dislocation, and eversion, and slight varus of the little finger, with the rest of the toes showing flexion[24]. Trauma and iatrogenic injury occur when there is unbalanced metatarsophalangeal joint muscle strength, leading to abnormal foot function. When patients have severe symptoms, they cannot walk because of pain, which seriously affects their life[25,26].

There are many surgical methods for bunion valgus, and the main purpose of treatment is to correct the deformity, restore appearance, reduce pain, and restore metatarsophalangeal joint function. However, there is no unified standard for the surgical treatment of foot bunion in clinical practice, and needs vary from person to person[27]. Patients with moderate to severe foot bunion often experience complications due to clinical symptoms such as thumb subluxation and first metatarsal varus. Conventional conservative treatment is not ideal, and soft tissue reconstruction plus osteotomy is usually required. For patients with moderate to severe foot bunion with long-term conservative treatment and poor curative effect, surgical treatment is the best option, and patients should be treated according to their own conditions and clinical symptoms[28,29]. Scarf osteotomy is used in patients with moderate to severe eversion[30]. Chevron osteotomy is often performed in patients with mild and moderate eversion[31]. Akin reduces the recurrence rate of hallux ectropion by shortening proximal phalanges and eliminating the bowstring effect of flexion and extensor tendon of hallux[32]. Scarf osteotomy, Chevron osteotomy, and Akin osteotomy have been widely used in clinical practice, and the combination of more than two osteotomy methods is highly respected. It not only has the exact effect and simple operation but also has strong orthosis ability, which can avoid shortening the first metatarsal bone, and the postoperative healing is fast. There have been reports[33,34] on the combination of Scarf osteotomy with Akin and Chevron osteotomy with Akin in the early stage, but there are limited studies in the literature that investigate the orthodontic effect and patient satisfaction of these two combined osteotomies in patients with bunions. Advanced oxidized protein products (AOPP) and lipid peroxide (LPO) levels are somewhat affected in patients with bunions[35]. Some scholars[36] have pointed out that timely and effective treatment can improve AOPP and LPO to a certain extent. This investigation found that both Scarf osteotomy and Chevron osteotomy + Akin can lead to an upward trend in the levels of AOPP and LPO in both groups. However, the levels of AOPP and LPO in the study group were lower than those in the control group. These results are like the above findings, indicating that Scarf osteotomy + Akin and Chevron osteotomy + Akin can effectively improve the level of AOPP and LPO in patients with bunions.

IL-1β and PCT are important indicators for detecting inflammatory factors and reflecting changes in patients with bunions[37,38]. The appearance of adverse symptoms in patients with bunions also affects IL-1β and PCT to varying degrees[39]. Some scholars[39] have pointed out that timely and effective treatment can effectively inhibit the levels of inflammatory cytokines IL-1β and PCT. The conclusion of this survey is that IL-1β and PCT levels increased in both groups with Scarf osteotomy and Chevron osteotomy + Akin, but the study group showed the lowest levels. This indicates that Scarf osteotomy + Akin and Chevron osteotomy + Akin can inhibit the level of inflammatory cytokines in patients with toe deformity to some extent.

Hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal joint angle (DMAA) are important indicators for evaluating the degree of valgus in patients with bunions[40]. DMAA is the angle between the proximal phalangeal bone of the first toe and the extension of the longitudinal axis of the distal phalangeal bone[41]. Some scholars[42] believe that HVA, IMA, and DMAA can relieve the clinical manifestations of patients with toe cyst. The conclusion of this survey is that both Scarf osteotomy and Chevron osteotomy + Akin reduced HVA, IMA, and DMAA in both groups. However, the study group showed the most significant decrease in HVA, IMA, and DMAA levels. Similar to previous research[43], these findings indicate that Scarf osteotomy + Akin and Chevron osteotomy + Akin has a better therapeutic effect on HVA, IMA, and DMAA in patients with foot hallux valgus.

The American Orthopaedic Foot & Ankle Society (AOFAS) score, visual analog scale (VAS) score of pain, and Berg Balance Scale (BBS) score are important for assessing the health status of patients with bunions[43]. The AOFAS score reflects changes in toe function before and after surgery, the VAS score reflects the influence of preoperative and postoperative pain degree on the lifestyle of patients with bunions, and the BBS score reflects changes in balance before and after surgery[44]. Some scholars[45] have pointed out that feedback from the AOFAS score, VAS score, and BBS score on daily living ability can clearly understand the changes in their patients. This investigation found

that both Scarf osteotomy and Chevron osteotomy + Akin increased the scores of AOFAS and BBS in both groups while decreasing the VAS score. However, the study group showed the most significant increase in AOFAS and BBS scores and the most significant decrease in VAS score. These results are consistent with previous findings[45], suggesting that Scarf osteotomy + Akin and Chevron osteotomy + Akin can effectively improve toe function, pain, and balance in patients with bunions.

For the treatment of musculoskeletal disorders, orthopedic surgeons use a wide variety of corrective surgical methods, such as acetabular osteotomy, anterior cruciate ligament (ACL) repair, ankle arthroscopy, ankle reconstruction, ankle replacement, and autologous chondrocyte transplantation. It is common practice to resort to corrective surgery in order to resolve structural anomalies or deformities affecting the musculoskeletal system. The treatment of musculoskeletal trauma, spine illnesses, sports injuries, degenerative diseases, infections, and other ailments by orthopedic surgeons may include either surgery or nonsurgical methods. The plantar pressures experienced by a person when standing or walking may be determined *via* the use of computerized baropodometric research. Baropodometry is a technique that is used to analyze the distribution of pressure on the foot as well as gait. In order to conduct the research, a computerized pressure platform will be used. This platform will collect information on the pressure points that are experienced by the foot when the subject is either standing or walking. The pressure platform has sensors built into it that can measure the amount of force that is being applied to the surface of the platform by the user's foot. Custom orthotics produced from postural analysis data may fit an individual's unique foot and gait patterns. Medical practitioners are able to assist patients in experiencing less pain and discomfort in the forefoot and first metatarsal ray when orthotics are used to increase gait and shift pressure.

Orthotics may also be tailored to address concerns linked to balance and stability, which can assist older people or those with diseases that influence balance and stability to avoid falls and the accompanying injuries.

Postural analysis may assist medical practitioners in planning the eventual fabrication of customized orthotics to relieve functional overload on the forefoot and first metatarsal ray. This can be accomplished by relieving pressure on these areas of the foot. The use of orthotics, which disperse pressure and improve gait, enables medical practitioners to alleviate pain and discomfort, enhance balance and stability, and generally improve the health of patient's feet.

Conclusions

In conclusion, Chevron osteotomy + Akin is superior to Scarf osteotomy + Akin in the treatment of patients with foot hallux valgus. It has a better therapeutic effect, improves toe function, reduces pain, and improves satisfaction with surgery. It also reduces the occurrence of complications and is worthy of clinical application. The results of the computerized baropodometric investigation are shown in the form of a measurement of the plantar pressures that are exerted beneath the foot when the subject is standing and walking. The data may give significant information about the weight distribution and balance of the foot during walking, which can be used to detect and treat foot-related diseases such as plantar fasciitis, pressure ulcers, and diabetic neuropathy. The data might also provide foot weight distribution and balance while standing and sitting.

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

Conflicts of Interest
The authors declared that they have no conflicts of interest regarding this work.

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Ethics Approval
The study was approved by the Third Affiliated Hospital, Beijing University of Chinese Medicine Ethics Committee, on May 16, 2023 (STKTP J-BZYSY-2017-10). The study adheres to the principles outlined in the Declaration of Helsinki.

Informed Consent
Informed consent was obtained from all the patients.

Authors' Contributions

Z.-U. Ma: experimental design, organization, and implementation; J.-D. Wu: experimental design and writing articles; Experimental design and technical guidance; Y.-Z. Qi: clinical case collection; X.-Y. Li: clinical case collection; X.-U. Pan: clinical study data collection and organization; Statistical analysis of Mao Hong's clinical study data; B.-R. Jin: clinical study data collection.

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