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Research Progress of Guided Growth Technique in the Correction of Angular Deformities of Children's Bones

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ABSTRACT
Angular deformities of children's bones mainly occur due to the imbalance of bones during the development process under the influence of various factors. This leads to abnormal changes in the mechanical axis of the limbs, and the growth plate shows asymmetric growth, resulting in conditions such as genu varum and genu valgum, which seriously affect the quality of life of patients. The guided growth technique fixes the epiphyseal plate, restricts the growth of the bone on the fixed side, and maintains the growth of the opposite side of the same bone, thereby improving the angular deformity of the patient's limbs. In the correction of angular deformities of children's bones, the guided growth technique is not only easy to operate and causes little trauma to the patient's body, but also can avoid osteotomy and has a lower correction risk. Currently, the guided growth technique has been widely applied in the correction of the spine, hip joint, knee joint and ankle joint. Moreover, with the continuous progress of modern medical technology, the improvement of implants has further enhanced the correction effect of the guided growth technique in angular deformities of children's bones.

KEYWORDS
Guided Growth Technique; Angular Deformities of Bones; Research Progress

Angular deformities of bones are very common during the growth and development process of children. Clinically, according to the causes of the disease in patients, it is divided into physiological deformity and pathological deformity. Under the influence of Blount's disease, hypophosphatemic rickets, trauma, congenital metaphyseal dysplasia, tumor diseases and their own genes, patients suffer from epiphyseal plate injury and deformity, resulting in conditions such as genu varum and genu valgum [1]. Clinical studies have found that during the growth and development process of children, physiological deformities can gradually be spontaneously corrected. However, for pathological deformities, early intervention is required to avoid the aggravation of the deformity in patients, abnormal gait, affecting the stability of the limb joints, increasing limb pain, increasing joint load, developing osteoarthritis, limiting joint movement and affecting the appearance [2]. In the past, for angular deformities of bones, external fixation correction surgery and osteotomy surgery were more often adopted for treatment. Although these methods can correct the angular deformities of children's bones, they cause relatively large trauma to the patient's body. After the operation, patients may have massive bleeding, the postoperative recovery time is relatively long, the nursing difficulty is high, and the treatment cost is relatively high, bringing a huge economic burden to the family. In order to further explore the treatment methods for angular deformities of children's bones, this study reviews the guided growth technique.

1 Analysis of the Current Treatment Status of Angular Deformities of Children's Bones

The research by Li Anping, et al. [3] shows that by performing a rectangular resection of the epiphyseal plate, metaphysis and epiphysis, adjusting the two ends of the bone fragment after resection and then reinserting it, the continuous growth of the longer side limb can be restricted. At the same time, it promotes the continued growth of the epiphyseal plate on the opposite side. In this way, the epiphyseal deformity can be corrected during the subsequent self-development. The research by Liu Yan, et al. [4] shows that by applying a certain compressive force to both ends of the epiphyseal plate, the continuous growth of the deformed bone can be prevented. After the implant is removed, the compressive force is released, and the bone can continue to grow normally. The research by Shen Shouren, et al. [5] shows that by temporarily fixing the epiphysis, it can not only reduce the damage to the epiphyseal plate and ensure its integrity, but also not affect the continued growth of the epiphysis on the fixed side after the implant is removed. Although surgical treatment can correct angular deformities of children's bones, generally speaking, it will still cause bone damage to varying degrees. Currently, the widely used implant is the Blount nail.

2 Application of Guided Growth Technique in the Correction of Angular Deformities of Children's Bones

The guided growth technique, also known as hemi-epiphysiodesis, mainly prevents and delays bone growth by

applying pressure on chondrocytes during the correction process, based on the Hueter-Volkmann principle. By inserting an implant into the patient's epiphyseal plate and continuously applying external pressure on both sides of the epiphyseal plate, the epiphyseal plate is locked, thus restricting the growth of the bone. However, the bone on the opposite side can still continue to grow. Through adjusting the proximal end of the epiphyseal plate, the original deformity is gradually improved, and the bone is guided to return to normal growth, so as to achieve the purpose of correcting the angular deformity of the bone.

Compared with other surgical treatment methods, the guided growth technique is not only more convenient and simple to operate, but also can reduce the trauma to the patient's body. It is also more convenient to adjust. It can replace external fixation and osteotomy correction surgery to achieve better results in the correction of angular deformities of children's bones. Moreover, it can effectively reduce the risk of complications for patients, with a better prognosis, and can promote patients to return to normal life and study as soon as possible.

2.1 Correction of Angular Deformities of the Knee Joint

Angular deformities are more likely to occur around the knee joint in children, which is also the main cause of coronal plane deformities in patients, leading to genu varum and genu valgum. The research by RAFAEL DENADAI, et al. [6] shows that traumatic genu varum and valgum, rickets, idiopathic genu varum, multiple arthrogryposis, and joint laxity are the main causes of the correction of angular deformities of the knee joint.

2.1.1 Correction of Angular Deformities of the Coronal Plane of the Knee Joint

The research by Zhang Qiang, et al. [7] shows that for coronal plane deformities, applying the guided growth technique to the distal femur can effectively improve the problem of idiopathic genu valgum. The correction speed can reach 1.26° per month, and it will not cause damage to the patient's epiphyseal plate during the correction process, allowing patients to normally participate in physical activities. Through the analysis of the correction of angular deformities of the coronal plane around the knee joint by the guided growth technique, it is found that the correction speed is often closely related to the patient's age, the degree of deformity, and the direction. In the correction of angular deformities by the guided growth technique, the time-consuming for femoral angular deformities is shorter than that for tibial angular deformities, and the correction of femoral valgus deformities is faster than that of femoral varus deformities. In addition, the correction speed also has a certain relationship with the timing of implant removal after surgery.

Therefore, in order to further improve the correction speed, attention should be paid to grasping the timing of implant removal after surgery. Through the analysis of the patient's age, it is found that the younger the age, the milder the degree of deformity, and if the child's weight is relatively light and the bones have not yet fully matured, a better correction effect can be achieved. Therefore, angular deformities of the knee joint should be corrected as early as possible.

2.1.2 Correction of Angular Deformities of the Sagittal Plane of the Knee Joint

The research by Sun Xiwei, et al. [8] shows that for patients with knee flexion contracture caused by neuromuscular diseases in clinical treatment, the guided growth technique can be implemented on the anterior side of the distal femur for correction. During the correction process, medical staff need to pay attention to the extension effect of the patient's knee joint and the bone maturation situation at any time, and reasonably grasp the timing of implant removal. This can effectively improve the knee flexion contracture, reduce the risk of infection and femoral condyle fracture in patients, and achieve a more satisfactory correction effect.

Moreover, for patients with a relatively young age, those who undergo the guided growth technique have more correction time. Through evaluation, it is found that patients with a growth potential of more than 2 years can even achieve a complete correction effect.

2.2 Correction of Angular Deformities of the Ankle Joint

In patients with angular deformities of the ankle joint, varus or valgus of the ankle joint can be found in the coronal plane, and a significant reduction in the range of ankle dorsiflexion can be observed in the sagittal plane. Data statistics show that the cases of ankle varus are generally fewer, and the causes of ankle valgus deformity are often related to cerebral palsy, poliomyelitis, myelodysplasia, and osteotomy of congenital pseudarthrosis of the tibia. The research by Xu Ping, et al. [9] shows that for patients with a younger age, because the bones have not yet matured, angular deformities of the ankle joint can achieve better results in the correction by the growth technique. Currently, there are many implants available for the correction of angular deformities of the ankle joint by the growth technique, including tension band plates, epiphyseal plate screws, figure-of-eight plates, U-shaped nails, and Blount nails.

2.2.1 Correction of Angular Deformities of the Coronal Plane of the Ankle Joint

The research by Huang Shunying, et al. [10] shows that for patients with angular deformities of the coronal plane of the ankle joint, epiphyseal plate screws and tension band plates can effectively correct the problem of ankle valgus. However, compared with the tension band plates, epiphyseal plate screws have a faster correction speed, but there are also certain risks. During the correction process, the screws are prone to bending, displacement and fracture. If the screw head protrudes, it will also increase the difficulty of removal. Although the tension band plate has a slower correction speed, the risk of complications is lower.

Through the analysis of the problem of difficult screw removal, if the patient is relatively young and the screw is placed for a long time, it will be even more difficult to remove. In order to solve the problem of difficult screw removal, a special screw extraction device can be used during the operation, and the timing of screw removal should be well grasped. In order to reduce the problem of epiphyseal plate bone bridges, the use of epiphyseal plate screws at the distal end of the tibia should be avoided as much as possible to prevent the epiphyseal plate screws from damaging the epiphyseal plate, leading to the premature closure of the epiphyseal plate and having an adverse impact on the growth and development of the bones.

In addition, it should be noted that in the selection of implants, due to the relatively small amount of soft tissue on the medial side of the ankle joint and the relatively thin skeletal muscle tissue, figure-of-eight plates and Blount nails are relatively thick, which will stimulate the skin, cause ulceration and increase the patient's pain. If the patient has a severe ankle valgus and a significant protrusion of the medial malleolus, the figure-of-eight plate should be avoided as an implant as much as possible to avoid affecting the recovery of the skin incision.

2.2.2 Correction of Angular Deformities of the Sagittal Plane of the Ankle Joint

Angular deformities of the sagittal plane of the ankle joint are often related to congenital clubfoot. The main clinical symptoms of patients are a relatively small range of ankle dorsiflexion activities and the inability to squat normally. The research by Wen Zuzhou, et al.[11] found that for patients with angular deformities of the sagittal plane of the ankle joint, by implementing the guided growth technique at the distal end of the tibia to treat the flat-topped talus, the range of dorsiflexion activities of the distal end of the tibia can be improved. Selecting epiphyseal plate screws as implants can increase the correction speed, but it is likely to cause the screw head to protrude and increase the difficulty of screw extraction. The figure-of-eight plate can better protect the epiphyseal plate and solve the problem of difficult screw extraction. However, due to the special structure of the medial side of the ankle joint, there are still certain limitations in the clinical application of the figure-of-eight plate. The U-shaped nail is not only simpler to implant, but also has a low profile and can fit more closely with the cortical bone, avoiding the problem of screw head protrusion and having higher safety.

2.3 Correction of Angular Deformities of the Hip Joint

The causes of angular deformities of the hip joint are often related to factors such as cerebral palsy, avascular necrosis of the femoral head, and developmental dysplasia of the hip joint. The research by Huang Shunying, et al. [10] found that correcting angular deformities of the hip joint through the guided growth technique can not only improve hip valgus, lameness, Trendelenburg symptoms, and the range of motion, but also prevent excessive growth of the greater trochanter of the femur and relieve the patient's pain. Moreover, implementing the guided growth technique for correction can further ensure the stability of the hip joint. If the nail comes off during the growth process of the femur in the patient and the epiphyseal plate grows out at the top of the screw, replacing the screw will not cause major trauma, which can reduce the patient's pain.

2.4 Correction of Angular Deformities of the Spine

When the guided growth technique is applied to correct the vertebrae in angular deformities of the spine, the growth rate is delayed, and a better correction effect can be achieved. Currently, U-shaped nails, the Shilla system, and the vertebral body tethering system can all be used as implants for the correction of angular deformities of the spine. The research by Li Yetian, et al. [12] found that for patients with a relatively small degree of scoliosis in the spine, adopting the guided growth technique for correction can achieve a better correction effect. However, it should be noted that under the influence of the mobile intervertebral disc, the U-shaped nail bears increased force and is prone to loosening, falling out, and breaking. While the vertebral body screw tethering system provides fixation, the longitudinal growth is restricted, and it will not affect the intervertebral movement. The force is dispersed, which can effectively reduce the risk of nail detachment.

2.5 Correction of Hallux Valgus

Hallux valgus more commonly occurs in adolescents and children, and it is a very common forefoot lesion. It can be seen that the first metatarsal bone and the first proximal phalanx of the toe show varus and valgus respectively. Data statistics show that the incidence rate of hallux valgus in adolescents and children reaches 4%, and the probability of hallux valgus in girls is 15 times that in boys. It not only affects the patient's ability to wear shoes, but also impairs the patient's function. It is likely to cause pain in the first metatarsal bone during walking, and the risk of pressure sores and tenderness is higher. The research by He Yuanfei, et al. [13] found that for the correction of hallux valgus using the guided growth technique, fixing the proximal end of the first metatarsal bone with epiphyseal plate screws can not only reduce the trauma to the patient's body, but also will not affect the normal weight-bearing of the patient's limb, which has higher safety and can also reduce the postoperative recurrence rate of the patient.

3 Conclusion

The guided growth technique has a good effect in the correction of angular deformities of children's bones. It can reduce the trauma to patients and has higher safety. With the continuous development of modern medical technology, there are more and more types of implants. In clinical treatment, the implants should be reasonably selected according to the patient's age and growth rate, and the correction speed should be well controlled, so as to reduce the incidence of complications in patients and achieve a better correction effect.

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