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Application Progress of New Progressive Wrist Orthosis in Children's Hand Joint Contracture

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Abstract: Congenital multiple joint contracture is a rare deformity.It is characterized by the occurrence of most joint contractures in the hand after birth. It is caused by contractures of soft tissues such as nerves, muscles, and skin[1]. The common treatment for these patients is rehabilitation and drafting techniques, simple orthopedic devices made of splints or plaster to place the joints in a functional position, and prevent joint contractures.

The orthosis uses the principle of creep and stress relaxation and the soft tissue surrounding the hand joint has the characteristics of viscoelasticity to stretch the soft tissue around the joint to expand the range of motion of the hand joint. The effect of the orthosis in treating congenital joint contracture is good. The design is convenient and concise, and the probability of complications is low. Whether the patient is in the hospital or returning home, the orthosis can replace the therapist's rehabilitation method to play a good role in the treatment of contracted joints. This article focuses on the research The mechanism, manufacturing method and precautions of the new progressive orthosis for children's hand joint contracture are discussed.

I. PRINCIPLE OF NEW PROGRESSIVE WRIST-HAND ORTHOSIS FOR CHILDREN'S HAND JOINT CONTRACTURE

A. The pathogenesis of congenital joint contracture in children

Joint development begins at 2 months of gestation, and pathological changes in uterine movement, uterine hypoplasia, multiple births, or oligohydramnios can lead to contractures in the hands of children. Congenital polyarticular contractures are due to neurogenic, myopathy Caused by sexual and related tissue diseases. There is a direct relationship between the early onset of fetal dyskinesias and the severity of contractures. The earlier and longer the duration of reduced movement, the more severe the contracture at birth [2].

Under normal circumstances, the connective tissue inside and outside the joint is in a balance with the decomposition and synthesis of other extracellular matrix. This balance maintains the biomechanical characteristics and tissue structure required for normal tissue function. When the joint function changes significantly, the tissue will A series of changes in biological morphology, biochemistry, and biomechanics occurred. Frost et al. [3] described this phenomenon as "structural adaptation to biomechanics". Adhesion is an important cause of limited joint activity, and fluid leakage between tissues Scar tissue formed after injury or injury can cause adhesions. Soft tissues are fixed at the same location for a long time, and muscles will also undergo morphological changes, the number of sarcomerees will decrease, and muscle tissues will shorten, resulting in limited joint movement.

B. Principles of orthotics for children with congenital hand contracture

Some studies suggest that when other traditional treatments are ineffective and there is no heterotopic ossification, static progressive orthosis should be considered.[4] Slimani et al. [5] believe that long-term fixation of the joints will lead to the loss of proteoglycans and water in the connective tissue around the joints, which will lead to the formation of new cross-links within and between the molecules of collagen fibers, which will reduce the ductility of the tissue. The tissue has viscoelastic properties, which can be drawn after shortening. This property allows it to reach a stage of elastic or plastic deformation after damage.

Orthotics use two principles of creep and stress relaxation to achieve plastic deformation of soft tissue. Creep refers to the phenomenon that the strain increases with time under the condition that the solid material maintains the same stress; if the total strain is constant, the internal The viscous strain component continues to increase with time, and the rebound strain component gradually decreases with time, resulting in a gradual decrease in the deformation recovery force with time. It is called stress relaxation. Static progressive orthotics use static progressive draft and stress relaxation as Principle, gradually make the soft tissue plastically deformed, and have achieved satisfactory results in the treatment of wrist, elbow, knee, and ankle stiffness [6]. Compared with creep load, stress relaxation load is applied to soft tissue, which can The soft tissue quickly reaches the stage of plastic deformation. These two principles can also be applied to the drafting of a progressive wrist orthosis. This type of stretching requires keeping the joint straight and pulling the contracted soft tissue at the end of the joint mobility The gradually increasing joint displacement causes plastic deformation of the soft tissue and improves joint mobility.

II. TRADITIONAL METHODS FOR TREATING CHILDREN WITH CONGENITAL HAND CONTRACTURES

A. Plaster external fixation method

The traditional plaster external fixation method is to first make a plaster cast according to the characteristics of the patient's hand; then soak the plaster to place the plaster in front of the patient's forearm. The surgeon draws the patient's finger and flexes it, straightens it and maintains the shape until the plaster is completely shaped; at the same time, the assistant

fixes the plaster with a bandage. It improves the wearing comfort and compliance of the child. If further rehabilitation is needed, the cast must be replaced and replaced. Therefore, it takes a lot of time and energy for the child and his family, and the use and treatment results are poor.

B. Traditional static wrist orthosis

Fixed wrist orthosis is also called static wrist straightening orthosis.This type of orthosis is characterized by stable structure, good support for the joints of the hand, and maintaining the functional position of the forearm. McGrath et al. [7] performed 47 wrist joints. Stiff patients are treated with static orthotics, and the frequency of use is 1-3 times a day, 30-60min each time. After 10 weeks of treatment, the wrist joint activity has increased by an average of 35 °. It can be seen that the principle of stress relaxation The wrist joint is stretched, and the treatment of wrist-hand joint contracture is an effective treatment plan. However, the traditional static wrist-hand straightening orthosis can not adjust and change the angle, so it has little effect on the expansion of stiff joint angle and the improvement of dysfunction. It can be seen that the traditional static wrist and hand straightening orthosis is not ideal for the rehabilitation of children with congenital hand joint contractures.

C. Powered wrist orthosis

Dynamic wrist-hand orthosis is a commonly used treatment method for treating joint contractures, which mostly adopts the principle of dynamic stretching and low-load gradual progress. This type of dynamic orthosis applies a continuous stretching force to extend the soft tissue and achieve the effect of contracture. The effect of joint distraction. However, the treatment of joint stiffness by dynamic orthosis is long, time-consuming and difficult to control the size of the distraction force. Nuismen et al. [8] introduced the use of dynamic distraction orthosis to treat 18 cases of joint contracture. Among them, there were 2 cases of wrist joints, 12 cases of elbow joints, and 4 cases of knee joints, with an average of 6.47 hours per day. After 3 months of treatment, no significant improvement was found in 2 patients, and the joint mobility of other patients was improved. The range of 6 ° ~ 66 °. Gaspar et al. [9] observed the use of dynamic orthosis for the treatment of adhesive arthritis, and found that it is more effective than traditional rehabilitation techniques, but the treatment lasts longer and decreases. These studies demonstrate that although dynamic wrist-wrist orthosis has a certain therapeutic effect, it makes patients not only face the limitations of hand joint movements caused by congenital contractures, but also the treatment week.Complications caused by a longer period and improper control of drafting strength. And for younger children, it is difficult to determine the adjustment of the drafting tension by judging whether it is uncomfortable, except for medical imaging analysis. Therefore, the dynamic wrist-hand orthosis is not suitable for the rehabilitation treatment of congenital hand joint contracture in children.

III. DESIGN PRINCIPLES OF A NEW PROGRESSIVE WRIST ORTHOSIS

A. Personalization

The rise of 3d printing technology and the rapid development in the field of medical aids bring the gospel to the treatment of children with congenital deformities. Wrist orthosis printed by additive manufacturing technology is light and breathable, biomechanical, comfortable and beautiful. Advantages, and its surface accuracy is high, which greatly improves the compliance of patients. The wrist-hand orthosis made by 3d printing has achieved personalized customization, which can prevent and correct deformities in the treatment of congenital deformities, and improve the disease. Children's hand deformities have played an important role in improving the grasping ability of the fingers; the traditional wrist orthosis devices currently on the market have been solved, and the production process is complicated, cumbersome and unattractive, and cannot be adapted to the actual conditions of the children's hands, and This leads to the problem of poor compliance after wearing, which greatly reduces the treatment effect.It prevents the orthosis from being frequently changed due to the inability to adjust the deformity during long-term wearing, which brings great inconvenience to the family of the child. And the risk of ischemic muscle atrophy in the hand if the peripheral blood circulation is not smooth if it is not replaced in time.

B. Wedge block interventional treatment

Because plastic deformation of tissue is a physiological process that takes time to pass, draft strength is a key factor in treatment. If the draft strength is increased too much, it may cause tissue damage and tissue inflammation, and then increase the tissue fibers. Tissue damage caused by drafting is also related to the drafting speed and duration of force, as well as the surface temperature and initial state of the tissue [10]. Free tissue experiments show that when the tissue strain exceeds 2%, it will lead to permanent Connective tissue damage.

Therefore, the new progressive wrist orthosis uses a wedge-shaped block made by selective laser sintering (sls) technology to gradually change the drafting strength. For different degrees of hand contracture deformity, the angle of the wedge-shaped block is correspondingly different. Changing the wedges at different angles can quickly achieve the effect of progressive treatment of congenital hand joint contractures, which better fits the contracture deformity of the hand, which is in line with the principles of biomechanics.

IV. CLINICAL APPLICATION AND PRECAUTIONS OF NEW PROGRESSIVE WRIST-HAND ORTHOSIS FOR CONGENITAL HAND JOINT CONTRACTURE

A. Intervention timing of orthosis

The role of the orthosis is to prevent and correct joint deformities and compensate for the lost function.The new progressive wrist orthosis uses the principle of stress relaxation and creep to expand the range of motion of the hand joint after its stiffness causes dysfunction.

The timing of orthopedic intervention for the rehabilitation of hand joint stiffness should be as soon as possible, and the early rehabilitation effect is obvious. In order to avoid hand joint dysfunction, joint-based rehabilitation therapy must be performed as soon as possible. Myofibroblasts have contraction and secretion. When its function is excessively contracted, it can cause contracture of soft tissues. Therefore, early treatment with orthosis should be performed to obtain better results.

B. Wearing dose of orthosis

The dose should be considered when using the orthosis.

The dose is also called the total amount of distraction. It should include factors such as the strength, duration and frequency of using the orthosis.

While achieving the effect, more attention should be paid to prolonged wearing will not only cause inconvenience to patients' daily life, but also may cause skin damage and poor blood circulation due to long-term pressure on the hands. McClure et al. [11] suggested that The daily TERT is 1 hour, and the wearing frequency can be 4 times a day, 15 minutes each time, or 2 times a day, 30 minutes each time. TERT refers to the number of times (frequency) and duration that the joint is placed in the terminal activity position every day. The product of time. TERT is a key regulator of static progressive braces in the treatment of joint contractures. For example, after a period of treatment, the joint activity of the patient does not improve significantly, and TERT should be increased first. However, the maximum value of TERT varies from person to person. When increasing TERT again, you can consider increasing the tension. Gallucci.GL et al. [12] recommends that patients wear 4 times during the day, 2h each time, and the joint mobility improves by 37 ° after an average of 78 days. Gelinas JJ et al. [13] recommends Patients wear static orthopedic orthotics at a dose of 20 hours per day. In short, the new progressive wrist orthosis can also be compared to this. The new progressive wrist orthosis is stretched by adding the tension band to the orthosis. Scale to make draftThe intensity is controlled, and the rehabilitation time is scientifically performed in combination with the recommended use time.

C. Pain assessment

Commonly used to evaluate pain are the Language Evaluation Scale (VDS), Facial Pain Expression Scale (FPS-R), Complaint Pain Rating Scale (VRS), Visual Analog Scale (VAS), and Digital Evaluation Scale (NRS). The visual analogue scale (VAS) is commonly used. The VAS ruler is a 10 cm scaled straight line. One end is "no pain" and the other end is "the most painful". The patient indicates the pain level according to the scale. The pain of the patient increases during the treatment. The patient should be examined and evaluated to find out the cause of the increased pain. The improper or incorrect use of the orthosis in general is an important cause of the increased pain. The orthosis should be replaced or adjusted to further teach The patient wears the orthosis correctly. If the orthosis is selected and used correctly, the most likely cause of the increased pain is the response of the joint tissue to the applied tensile stress. The intensity of the tensile stress applied by the orthosis should be reduced, or shortened. The orthosis wears time to allow the joint response to subside. Re-evaluate the patient to adjust the frequency, duration, and stretch stress intensity of the orthosis treatment.

D. Joint mobility assessment

The evaluation of hand joint mobility generally requires the selection of the joint with the most restricted or the most important joint function. Measuring hand joint mobility is of great significance for evaluating the treatment effect of progressive wrist orthosis. The TAM scale or Jabsen hand function assessment scale is used. The TAM assessment method is total finger active range measurement (TAM): the metacarpophalangeal joint (MP), the proximal interphalangeal joint (PIP), and the distal interphalangeal joint (DIP) The sum of active flexion, minus the sum of the active straightening limitation of each joint, is the active degree of motion of the finger (TAM). The straightening of each joint is 0 °, and the overextension is not counted. TAM = (MP + PIP + DIP)-(MP + PIP + DIP), total active activity = sum of flexion of each joint-sum of limit of each joint. Evaluation criteria: excellent-normal range of motion; good-TAM> 75% of the healthy side Yes—TAM> 50% of the healthy side; Poor—TAM <50% of the healthy side. When measuring, observe the actual situation of the actual joint motion change and minimize the measurement error. Changes in joint motion are generally considered to be true changes Rather than measuring errors. Joints should be pre-prepared before joint motion is measured becausePreparation activities may affect the accuracy of the measurement of motion.

E. Indications to discontinue orthopedic treatment

There are two indications to terminate orthopedic therapy: (1) the purpose of restoring joint mobility has been achieved without further improvement of joint mobility; (2) orthopedic therapy has reached the maximum distraction intensity for a long time, but joint mobility There is still no improvement. Many severe congenital joint contractures may still require surgery, but orthopedic treatment is a small trauma to children and is an important method to supplement or replace surgical treatment. Successful treatment depends on the selection of the appropriate orthosis and the appropriate Treatment options.

V. RELATED PRODUCTS AND APPLICATIONS OF WRIST ORTHOSIS AT THE PRESENT STAGE

For different degrees and stages of contracture deformities, various wrist orthosis have been developed. All of them have the advantages of saving time, easy to accept by patients and low cost. According to the investigation of Sueoka et al. [14], the average time needed to make a static progression orthosis in the United States is only 25min, and the cost is $25.Anmeiwen and others have designed an adjustable deformable hand orthosis (patent number cn 107088084 b), which involves deformed hands, especially burns. Morphological correction of deformed hands caused by posterior scar contracture.

Chen Wei et al. Designed a wrist orthosis based on 3D printing (patent number cn 206214248 u), which has a simple structure, convenient manufacturing, and light weight.The orthosis is fixed to the human wrist with a magic tape or bandage To achieve the purpose of fixing the injured wrist of the patient.

SUMMARY

The orthosis has achieved good results in the treatment of congenital hand joint contractures. With the advancement of science and technology, the traditional orthosis has been greatly improved. Its materials, design, use concept, manufacturing scheme, and specific treatment methods are all There are different degrees of improvement. The treatment risk of static orthotics is small and it is not easy to cause damage to soft tissues. Therefore, the progressive wrist orthosis designed in this study conforms to the definition of static orthotics and is more suitable for children to wear and reduce Risk of treatment. More strict and systematic research is needed on the intensity and time of wearing orthotics for children, such as collecting data on children with congenital hand contractures and comparing orthopedic therapy with conventional rehabilitation Studies and follow-up studies of treatment effects. L Miller [15] et al. Believe that at least 100 participants in each group need

to use parametric tests to obtain 80% of treatment results at a 5% significance level.

In the design of a progressive wrist orthosis, forces and moments should be considered. At present, 3D printing technology is being promoted to scan children's hands instead of traditional low-temperature thermoplastic sheets to shape the children's hands. The orthosis is more in line with the principles of biomechanics, there are many air holes for ventilation, and progressive treatment with wedge-shaped pads makes the overall orthosis more practical and beautiful.

For patients who fail to perform other physical therapy techniques, orthotics are effective in restoring joint angles and improving hand deformities. Most patients are satisfied with orthopedic treatment without complications, which improves patient compliance and thus improves The joint mobility of deformed hands has improved the daily life of patients, and the risk of surgery can also be avoided. The treatment of joint stiffness, contractures and deformities by orthotics is in line with current treatment trends, and it is constantly improving.

Future wrist-hand orthosis can start from two aspects of materials and artificial intelligence. At the same time, it is committed to creating more portable and lightweight orthosis, so that patients have better practicability and compliance, such as original components and sensors to increase measurement strength. This makes the applied drafting stress more precise and controllable.It is equipped with a heating temperature control element to help alleviate the pain and even swelling caused by the drafting force of the soft tissue through the thermal effect while drawing. In general, we still need to keep To explore more advanced wrist orthosis and more scientific use.

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