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Research progress of posterior scleral reinforcement in the treatment of high myopia

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Abstract: High myopia is associated with a variety of factors, pathogenic dominant genes, the latest femtosecond excimer laser lamellar keratoplasty can only correct refractive problem, does not stop the development of the disease, the posterior sclera reinforcement method from pathological mechanism on the treatment of the disease, this article from the clinical and experimental scleral reinforcement surgery for the treatment of high myopia after material, surgery, clinical curative effect were reviewed, to explore its clinical significance and prospect.

1. Introduction

High myopia (HM) is a refractive disease. Its definition varies from study to study. It is mainly defined as myopia with a diopter greater than -6.00 d [1]. About 163 million people worldwide suffer from HM [2]. In Asia, the prevalence of HM in young people is 6.8% ~ 21.6%, and that in middle-aged and elderly people is 0.8% ~ 9.1%. China is one of the countries with high incidence of HM, and the prevalence rate of adolescents is 6.7% ~ 38.4% [3]. Its etiology has been controversial. At present, it is considered that HM is caused by genetic factors, environmental factors, lens induction, form deprivation induction and immune disorder [4]. Genetic factors play a leading role and have an obvious tendency of family aggregation [5], among which autosomal inheritance is the most common genetic mode [6].

Because the sclera of HM patients is relatively weak, they progress faster than the general myopia, which is characterized by the progressive extension of axial length and the continuous change of diopter. In the early stage of HM, there is only the decline of far vision or / and corrected far vision. However, with the increase of the severity of myopia, excessive axial elongation of the eyeball will produce biomechanical tension on the posterior pole and develop into pathological myopia. It is a disease that seriously threatens vision, and there will be a variety of concurrent diseases, such as different degrees of optic disc tilt, posterior scleral staphyloma, retinal degeneration and atrophy, choroidal leopard pattern atrophy, etc; Severe cases include retinal detachment, macular degeneration and choroidal detachment [7]. The incidence rate of imminent myopia and high myopia is increasing. It has attracted much attention. Therefore, it is imminent to explore more effective methods to prevent and treat HM.

Due to the particularity of the etiology of HM, inhibiting the extension of ocular axis from the

pathogenesis is the most effective way. Posterior scleral reinforcement (PSR) is a method of using biological or non biological materials to strengthen the weak area of posterior pole sclera, which can prevent the elongation of axial length of eyeball.

2. Posterior scleral reinforcement materials

2.1 Development of biomaterials

Biomaterials have gradually developed from the earliest fascia lata, dura mater and umbilical cord tissue to bovine pericardium, artificial pericardium, allogeneic sclera, acellular dermal matrix and so on. For the first time, sheveler used fascia lata to perform PSR on cadavers. AP nesterov et al. [8] used fascia lata as a material to strengthen the posterior sclera of HM patients. D COSTIN et al. [9] performed PSR with dura mater in 127 eyes of HM patients. During the follow-up, it was found that the development of myopia stopped in more than 60% of cases. Zaikova et al. [10] performed PSR on 144 patients (229 eyes) with umbilical cord tissue, and analyzed the postoperative results and complications. The research shows that umbilical cord tissue can inhibit the development of myopia. Cheglakov et al. [11] performed PSR on 89 patients (161 eyes) with treated bovine pericardium. After 4 years, it was found that the stabilization effect related to myopia was 88.3% - 92.6%. The sclera thickness and sound density of the posterior pole of the eyeball increased, and the hemodynamic and retinal electrophysiological functions improved. Yan et al. [12] tested three kinds of scleral reinforcement materials (artificial pericardium, allogeneic sclera and whole dermal matrix) on Japanese white rabbits. It was found that artificial pericardium and allogeneic sclera have good biomechanical properties. Wang Tian et al. [13] used allogeneic acellular dermal matrix as material to perform PSR on Japanese white rabbits. The study found that allogeneic acellular dermal matrix had good compatibility with tissue, increased expression of scleral basic fibroblast growth factor and synthesis of extracellular matrix such as collagen, which played a reinforcing role.

2.2 Development of non biological materials

The non biological materials of PSR include polyester fiber net, polyester chip, plasma, silica gel, gelatin sponge, gel polymer and so on. Svirin et al. [14] used collagen sponge as an implant. The part of the sponge will form new extrascleral connective tissue. The thickness of this tissue is 1.5-2.5 times greater than that of rabbit sclera, which can prevent the progress of myopia. Chen Lizhong et al. [15] used polyester sheet as material to perform PSR on rabbits. It was found that polyester adhered closely to the recipient sclera and was rich in neovascularization. Tarutta et al. [16] used plasma breeding silica gel as implant material. The study showed that it increased the connection between sclera and connective tissue. The curative effect was 97% after 3-year follow-up. Zhao Xiaoming [17] mixed the chitosan with glycerol phosphate two sodium to prepare thermosensitive gel, and injected it into the outer quadrant fasciae of rabbits with the method of ball injection. The results showed that the material could play a certain role of reinforcement, and had good biocompatibility, safety and histocompatibility. Wang Yuan and other [18] used gel polymer as a material for peri scleral reinforcement in guinea pigs. The results showed that the gel polymer could effectively inhibit the further growth of lens axis in guinea pig lens induced myopia, and keep the diopter relatively stable, and then reconstruct the scleral collagen.

2.3 Development of crosslinking materials

Crosslinking materials mainly include physical crosslinking and chemical crosslinking of biomaterials. Zhou Xibin [19] crosslinked bovine pericardium with 0.625% and 0.25%

glutaraldehyde respectively to obtain high-strength and medium-strength crosslinked bovine pericardium. The elastic modulus, breaking strength and stiffness of medium and high crosslinked groups were significantly higher than those of pure bovine pericardium and human sclera, and the highly crosslinked bovine pericardium was the highest. Xue et al. [20] found that the tensile strength and degradation rate of genipin crosslinked allogeneic sclera were improved. Zhang Yali [21] found that riboflavin ultraviolet collagen crosslinking can significantly increase the biomechanical properties of sclera. In recent years, genipin has attracted much attention as a safe crosslinking agent. Genipin crosslinking materials are used to enhance the strength of articular cartilage, patellar ligament and posterior sclera, and have excellent biocompatibility [22-23]. Zhao Yafang [24] injected genipin into the posterior Tenon's capsule of rabbit eyes to crosslink it with scleral collagen. It was found that the biomechanical strength of sclera after crosslinking was significantly improved, which effectively prevented the development of myopia in animal model. Liu Xiaojun et al. [25] used fresh bovine pericardium as raw material, used acellular technology to decellularize it, and then crosslinked it with biological crosslinking agent genipin to prepare genipin modified bovine pericardium scleral biological patch. Its mechanical properties, moisture content and thermal stability are higher than those of the non crosslinked group, with good physical and chemical properties and biocompatibility. The preparation of geniping crosslinked gelatin gel prepared by Shao Jie [26] has porous porous network structure, which can provide reinforcement and support, good tissue biocompatibility, and beneficial to scleral collagen reconstruction. It is expected to be used as reinforcing material in PSR.

3. Development of posterior scleral reinforcement

In patients with HM, visual loss results from myopic macular degeneration, which is closely related to the axial length of the eye. Therefore, axial length control is a valuable option to reduce vision loss. PSR is an effective operation to control the progression of myopia by slowing down the changes of diopter and axial length. The surgical methods in the 20th century are mainly strip type and chip type. Strip type is divided into single strip and x-y-shaped strip. Injection type began to develop in the 21st century. In order to control the progress of myopia, shevelev first proposed posterior scleral reinforcement in 1930 [27], and Curtin proposed X-type operation of cross fascia lata graft extending from the four quadrants of the eyeball in 1961. However, the operation is complex, the external rectus muscle needs to be cut off during the operation, with serious complications such as retinal artery occlusion, optic nerve compression and optic nerve atrophy. The long-term effect is poor and the treatment effect is questionable [28]. Snyder and Thompson modified the single band PSR in 1972 and 1978 respectively [29-30], which was later called Snyder Thompson posterior scleral reinforcement. The operation method is: the implant is inserted into the inferior oblique muscle from under the rectus muscle of the eye, the implant is fixed in the macular area, and the two ends of the graft are sutured to the upper and lower nasal quadrants, the shallow layer of sclera, and there is no suture at the posterior pole [31]. In 2009, ward [32] made some modifications to the single wide strip PSR method, using wide endophytes to support the posterior pole, with the middle part 70-80mm long and 10-12mm wide. In 2009, Zhu [33] et al. Used the method of supporting posterior pole staphyloma by placing an additional 8 between the graft and the eyeball × 8mm2 scleral band to support the macular area. No matter what kind of PSR operation, there will be inevitable complications. When the pressure is tight, it will cause limited eye movement, compression of vortex vein, increased intraocular pressure, and iatrogenic puncture of weak sclera during reinforcement suture.

Ophthalmologists in the former Soviet Union first proposed sclera forcing injection (SFI). In 1981, Remizov [34] reported that the mechanical posterior sclera strengthening operation was replaced by peribulbar injection of substances or reinforcing agents that promote the formation of fibrous tissue.

SFI makes use of the advantages of the material to inject it into the tenon's capsule. The material or cross-linked with the sclera. Through local stimulation of inflammation, neovascularization and granulation tissue proliferation, SFI can fuse the sclera with the material and play a reinforcing role. The operation method is [35]: make a bulbar conjunctival incision with a length of about 5.0mm at the place about 8.0mm behind the corneal limbus in the lower temporal quadrant of the operation eye, passively separate the subconjunctival tissue and expose the sclera; Then the blunt needle was used to clean the fluid in the fasciae sac, and the gel polymer 1.0ml was slowly injected and injected into the posterior pole of the eyeball and the external scleral fasciae of the equator with a specially made arc length 20.0mm blunt needle.

4. Clinical efficacy

At present, the clinical treatment is mainly based on the improved Snyder Thompson PSR operation. The materials are mainly allogeneic sclera or cross-linked allogeneic sclera, and a few use SFI. Chen et al. [36] performed modified Snyder Thompson posterior scleral reinforcement surgery on HM children with an average follow-up time of 4.99 ± 1.3 years. The study found that the modified Snyder Thompson PSR was effective and safe in controlling HM in children. Dong et al. [37] performed modified Snyder Thompson PSR on 46 Chinese HM children (72 eyes) with circular scleral patch as material, and 43 Chinese HM children (67 eyes) wearing glasses only as control. After three years of prevention, it was found that the modified Snyder Thompson PSR with circular scleral patch as material can effectively limit the progress of ocular axis elongation of Chinese HM children, with safe operation and little damage. Xue et al. [38] performed modified Snyder Thompson PSR on 40 young patients with progressive HM (< 18 years old). One eye used genipin cross-linked donor sclera strip, and the other eye was used as synchronous control. During the follow-up period of 2 to 3 years, the axial length of the operated eye increased by 0.32mm and the contralateral eye increased by 0.82mm, It is proved that the modified Snyder Thompson PSR of genipin cross-linked sclera is safe and effective in inhibiting eye elongation in young patients. Zhu et al. [39] also made similar reports in the same year. Wang Yuan [40] divided 56 adolescents (56 eyes) of HM patients into 25 groups: the treatment group (25 cases) and the control group (31 cases). In the treatment group, both eyes were injected with gel polymer reinforcement, and the right eye group was selected. The reinforcing materials were imported from Russia by gel polymer, and the control group was not treated. The contrast analysis showed that the application of gel polymer reinforcement around the globe can effectively improve the vision and inhibit the axial growth of the young patients in early stage. Effectively delaying its development provides us with new ideas. As far as the current reports are concerned, SFI has the advantages of simple operation, less complications, effective for progressive HM, and is especially suitable for early prevention.

5. Conclusions and Discussion

PSR mainly inhibits the development of HM by implanting or injecting reinforcement materials. Due to the stimulation of materials, local inflammatory reaction occurs. The proliferative connective tissue and scar tissue fuse the sclera with the materials, strengthen the weak sclera at the posterior pole, inhibit the elongation of the ocular axis, accompanied by the growth of capillaries and improve the local blood supply [41]. It is also reported that the implantation of reinforcement materials can promote the regeneration of collagen [42]. With the development of technology, PSR is also constantly innovating and new materials are emerging, which makes the traditional PSR operation more perfect and stimulates the development of new operation SFI. People are looking for a suitable material to strengthen the posterior sclera through peribulbar injection and minimize the trauma. Although PSR has been developed for nearly a century, the complications still exist. Clinicians need to improve their

surgical skills to avoid the complications caused by improper operation. In short, looking for reinforcement materials with good histocompatibility and no local degradation, and exploring surgical methods with simple methods, convenient operation and less complications are still hot research. More perfect treatment methods will bring good news to patients with high myopia.

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