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Composition of pediatric corneal diseases treated with surgery in a tertiary hospital of Northwest China

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中国西北地区某三级医院行手术治疗的儿童角膜疾病构成分析

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摘要

目的:分析中国西北地区某三级医院中行手术治疗的儿童角膜疾病的疾病构成及其手术方式。

方法:本回顾性研究对 2018 年 1 月 1 日至 2022 年 12 月 30 日期间就诊于西安第一医院角膜病科接受相关手术治疗的儿童患者的临床资料进行了归纳总结,同时对其性别、年龄、疾病分型、手术方式及居住地等进行了分析。

结果:本研究共纳入 139 例(139 眼,年龄≤14 岁)的儿童角膜疾病患者,其中男性 67 例(48.2%),女性 72 例(51.8%)。后天非创伤性角膜疾病占比最高(67 例,48.2%),主要病因为感染性角膜疾病(41 例,29.5%);先天性角膜疾病 52 例(37.4%);后天创伤性角膜疾病 20 例(14.4%),其中男性 11 例,女性 9 例。按居住地分类,102 例(73.4%)患者来自陕西省,26 例(18.7%)来自甘肃省,8 例(5.8%)来自青海省,3 例(2.1%)宁夏回族自治区,但无患者来自新疆维吾尔自治区。按手术方式分类,65 例患者行穿透性角膜移植术(PKP),34 例行板层角膜移植术(LKP),31 例行羊膜移植术(AMT),另有 9 例接受了其他手术方式,其占比分别为:46.8%、24.4%、22.3%、6.5%,总角膜移植率为 71.2%。

结论:感染性角膜疾病、角膜皮样瘤及角膜外伤是住院手术治疗的儿童角膜疾病的主要病因。角膜移植手术是治疗儿童角膜疾病的重要干预手段,也是儿童角膜盲的有效治疗方法。

关键词:疾病分类;手术方法;儿童角膜疾病

Abstract

• AIM: To analyze the composition of diseases and surgical methods for pediatric corneal diseases treated with surgery in a tertiary hospital of Northwest China.

• METHODS: A retrospective analysis of the clinical data of patients treated at the Corneal Disease Department of Xi'an No. 1 Hospital and underwent related surgical treatments between January 1, 2018 and December 30, 2022 was conducted. The gender, age, disease classification, surgical method, and residence were analyzed.

• RESULTS: This study included 139 children (139 eyes, aged ≤14 y) with corneal diseases, comprising 67 males (48.2%) and 72 females (51.8%). Acquired non-traumatic corneal diseases constituted the largest proportion (67 cases, 48.2%), primarily due to infectious corneal diseases (41 patients, 29.5%). Congenital corneal diseases accounted for 52 cases (37.4%). There were 20 cases with acquired-traumatic corneal dieases (14.4%), involving 11 male and 9 female patients. Geographically, 102 (73.4%) patients resided in Shaanxi Province, 26 (18.7%) in Gansu Province, 8 (5.8%) in Qinghai Province, and 3 (2.1%) in Ningxia Hui Autonomous Region. No patients were from the Xinjiang Uygur Autonomous Region. Regarding primary surgical intervention, 65 patients underwent penetrating keratoplasty (PKP), 34 underwent lamellar keratoplasty (LKP), 31 underwent amniotic membrane transplantation (AMT), and 9 underwent other surgical procedures. The corresponding proportions of these primary surgeries were 46.8%, 24.4%, 22.3%, and 6.5%. The overall corneal transplantation rate was 71.2%.

• CONCLUSION: Infectious corneal diseases, corneal dermoids, and corneal trauma constitute the primary etiologies of pediatric corneal diseases treated with surgery in the hospital. Corneal transplantation surgery constitutes a cornerstone intervention for addressing these diseases and represents an effective therapeutic approach for pediatric corneal blindness.

• KEYWORDS: composition of diseases; surgical methods; pediatric corneal disease
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INTRODUCTION

Worldwide, corneal diseases constitute an important cause of pediatric blindness, with corneal transplantation surgery currently serving as the only effective treatment for corneal blindness. The global incidence of childhood blindness ranges from 0.3% to 1.5% of live births, reaching up to 0.9% in low and middle-income countries. Alarmingly, an estimated 70%-90% of the world's blind children (approximately 1.5 million) reside in impoverished regions of Africa and Asia[1]. The loss of sight profoundly affects these children's psychological, educational, and social well-being throughout their lives[2-5]. Wang *et al*[3] emphasized that corneal diseases-induced blindness constituted a critical public health challenge required urgent attention in developing countries. Although corneal blindness is well recognized as a major cause of visual impairment, reliable case series studies remain scarce. Consequently, this study included all pediatric patients with corneal diseases treated with surgery at the Xi'an No.1 Hospital from 2018 to 2022, retrospectively analyzing disease composition and surgical interventions to guide clinical decision-making, optimize surgical timing, and improves treatment success rate. It is noteworthy, however, that this study is merely a retrospective analysis of pediatric corneal patients who underwent surgical treatment at our hospital. Due to the limited follow-up and poor compliance of pediatric patients, as well as the impact of the Corona Virus Disease 2019 (COVID-19) pandemic, there is a relative lack of prognostic data. Therefore, this article does not address questions regarding the prognosis of the study subjects.

PARTICIPANTS AND METHODS

Ethical Approval This study was conducted in strict compliance with relevant laws, regulations, and ethical principles, and its implementation has been approved by the Ethics Committee of Xi'an No.1 Hospital (approval No.2025-058). The study was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was waived because of the retrospective and anonymous nature of this study.

Participants A total of 139 patients (139 eyes) aged ≤14 y who were treated at the Corneal Disease Department of Xi'an First Hospital and underwent related surgical treatments between January 1, 2018, and December 30, 2022, were collected. A retrospective analysis of their clinical data was conducted, including gender, age, residence, corneal disease, and surgical methods.

Methods

Disease classification Referring to the disease classification method of Yu *et al*[6], we divided children's corneal diseases into two major categories: congenital and acquired. Congenital corneal diseases were mainly summarized into the following categories: corneal dystrophy, corneal dermoid, corneal tumors, and corneal leukoma. The acquired category was further divided into traumatic and non-traumatic acquired diseases. Acquired traumatic corneal diseases were classified based on the cause of injury into mechanical and chemical injuries, with the latter including explosion injuries, acid-base burns, thermal burns, and other chemical substances entering the eye. Acquired non-traumatic corneal diseases were divided into infectious corneal diseases, metabolic corneal diseases, keratoconus, and other non-infectious corneal diseases. Infectious corneal diseases were further classified into bacterial, viral, fungal, and amoebic types based on the etiological examination results and clinical characteristics of our hospital's ophthalmic microbiology laboratory. The composition of children's corneal diseases was analyzed and summarized.

Surgical method Surgical methods were divided into penetrating keratoplasty (PKP), lamellar keratoplasty (LKP) and amniotic membrane transplantation (AMT), and other surgical methods. The proportion of different surgical methods was analyzed.

Residence All subjects' residences were classified by province to summarize the disease composition in different provinces.

Statistical Analysis Statistical software SPSS 26.0 was used for data processing. Quantitative data were expressed as percentages and the Chi-square test was applied for the comparison of composition situations.

RESULTS

This study included 139 pediatric patients (139 eyes) with corneal diseases from five provinces, comprising 67 males (48.2%) and 72 females (51.8%).

Disease Composition Analysis As detailed in Table 1, acquired non-traumatic corneal diseases constituted the largest disease category (67 cases, 48.2%). Infectious keratitis represented the primary etiology within this group (41 patients, 29.5%). While patients aged <1 y were under represented (3 cases, 7.3%), other age groups demonstrated substantial representation. Keratoconus was diagnosed in 12 patients (8.6%), exclusively in children aged 10-14 y, all underwent corneal transplantation. An additional 14 cases (10.1%) represented other acquired non-infectious corneal diseases.

Congenital corneal diseases accounted for 37.4% of the total number of patients, of which corneal dermoid were the most common one, about 29 cases (20.9%). And 16 children (55.2%) sought treatment and underwent corneal transplantation surgery before age 2. Other congenital anomalies included corneal leukoma (12 cases, 8.6%), corneal tumors (10 cases, 7.2%), and corneal dystrophy (1 cases, 0.7%). Among congenital corneal leukoma patients, 8 (66.7%) received surgical intervention before age 2. Of 10 corneal tumors patients, 5 underwent surgery before age 2. This cohort included 1 case of orbital lipoma with eyelid absence, 1 orbital tumor, and 2 patients requiring combined corneal transplantation with orbital tumor resection.

Corneal trauma, a significant preventable cause of pediatric corneal blindness, was documented in 20 patients (14.4%, 11 males, 9 females). According to the type of injury, there

Table 1 Composition analysis of pediatric corneal diseases

Disease	Number of patients (%)	Male	Female	Age (y)				
				<1	1-2	3-4	5-9	10-14
Congenital corneal diseases	52 (37.4)	29	23	9	20	9	9	5
Corneal dermoid	29 (20.9)	13	16	4	12	6	5	2
Corneal tumors	10 (7.2)	8	2	1	4	3	2	0
Corneal leukoma	12 (8.6)	8	4	4	4	0	1	3
Corneal dystrophy	1 (0.7)	0	1	0	0	0	1	0
Acquired traumatic corneal diseases	20 (14.4)	11	9	0	1	3	5	11
Mechanical injuries	7 (5.0)	3	4	0	0	1	1	5
Chemical injuries	13 (9.4)	8	5	0	1	2	4	6
Acquired non-traumatic corneal diseases	67 (48.2)	27	40	4	12	9	19	23
Infectious corneal diseases	41 (29.5)	16	25	3	10	6	14	8
Keratoconus	12 (8.6)	5	7	0	0	0	0	12
Other non-infectious corneal diseases	14 (10.1)	6	8	1	2	3	5	3
All	139 (100)	67	72	13	33	21	33	39

were 7 patients with mechanical injuries (5.0%), of which 5 patients were injured at the age of 10 or older. The causative agents of mechanical eye injuries were mostly sharp instruments, including 1 eye with a scissor stab, 1 eye with a book scratch, 1 eye with a block collision, and 3 eyes with a stick or bamboo skewer stab. One patient with prior corneal perforation underwent PKP with sutured intraocular lens implantation. There were 13 patients (9.4%) with chemical burns, of which 10 patients were injured at the age of 5 or older. Eight children were injured due to fireworks explosions, 4 patients were injured due to various types of chemical reagents accidentally entering the eye, and 1 patient was scalded with hot water.

Classification of Infectious Corneal Diseases A total of 41 patients with infectious corneal diseases were analyzed. Excluding 6 patients whose corneal tissues were not submitted for microbiological laboratory for etiological testing due to various unavoidable reasons, 35 cases obtained relatively reliable corneal smears and microbiological culture results. From the smear results, bacterial and fungal spores were found in 3 patients, while the remaining 32 patients' smears only indicated the presence of bacteria. From the microbiological culture results, 5 patients had positive bacterial cultures, as follows: 1 case of *Pseudomonas aeruginosa*, 1 case of *Staphylococcus warneri*, 2 cases of *Staphylococcus epidermidis*, and 1 case with positive results for *Staphylococcus warneri*, *Staphylococcus epidermidis*, *Fusarium solani*, and *Acanthamoeba*. Four patients had positive fungal cultures: 1 case of *Aspergillus flavus*, 1 case of Fusarium solani, 1 case of *Alternaria*, and 1 case of the aforementioned combined positive patient. Two patients had positive *Acanthamoeba* cultures, including 1 of the aforementioned combined positive patients, both patients had a history of wearing orthokeratology lenses. Herpes simplex virus and adenovirus monoclonal antibody tests were negative in all cases (Table 2).

Residence Analysis Most patients with corneal diseases originated from five Northwestern provinces. Distribution included Shaanxi Province (102 patients, 73.4%), of which 39 were from Xi'an, Gansu Province (26 patients, 18.7%), Qinghai Province (8 patients, 5.8%), and Ningxia Hui Autonomous Region (3 patients, 2.1%). No patients were from Xinjiang Uygur Autonomous Region among the 139 patients.

Surgical Method Analysis In Table 3, primary surgical interventions are summarized: PKP (65 cases, 46.8%), LKP (34 cases, 24.4%), AMT (31 cases, 22.3%), and other procedures (9 cases, 6.5%). The overall corneal transplant surgery rate was 71.2%.

Among the 52 patients with congenital corneal diseases, 50 patients (96.2%) underwent corneal transplant surgery. It is evident that corneal transplant surgery plays an important role in solving congenital childhood corneal diseases and has now become an important and effective treatment method for solving childhood corneal blindness. Among them, all 29 patients with corneal dermoid tumors underwent PKP surgery, 10 patients (83.3%) with corneal leukoma underwent PKP, and only 2 patients received LKP. Corneal tumors (10 patients) underwent LKP (9 patients), or AMT (1 patient). There was also one special case of corneal dystrophy that underwent corneal endothelial transplantation surgery.

Among the 20 patients with acquired traumatic corneal diseases, 13 cases (65%) underwent AMT, of which two combined with limbal stem cell transplantation due to traumatic damage to the limbal stem cells. There were 3 cases (15%) each of PKP and LKP patients, of which 1 patient underwent PKP combined with suture fixation of the artificial lens. One patient received limbal stem cell transplantation alone.

Among 67 patients acquired non-traumatic corneal diseases, corneal transplant surgery still remained most common (43 cases, 64.1%). All 12 patients with keratoconus underwent corneal transplant surgery, with PKP and LKP each accounting for 50%. PKP was performed on 39% patients with

infectious keratitis, LKP accounted for 29.3%, and AMT accounted for 31.7%.

DISCUSSION

Corneal blindness represents a significant public health burden in developing countries where preventable causes predominate[3]. Pediatric corneal blindness accounts for approximately 10.26% of childhood blindness, with about 45% being preventable[3-4,6-8]. Improved diagnostics and surgical techniques have increased case identification, though etiological complexity and surgical challenges persist. This study provides foundational data on disease patterns and surgical management in our hospital.

Infectious keratitis (29.5%), corneal dermoids (20.9%), and trauma-related disease (14.4%) were predominant etiologies, consistent with Low *et al*[9]. Wang[3] noted that infectious corneal diseases are the primary cause of corneal blindness in rural areas of Northeast China, often due to poor sanitary conditions and inadequate eye care practices. Conversely, Yu *et al*[6] from Peking University reported congenital corneal opacity as most common of 434 pediatric corneal patients. This is consistent with the findings of Low *et al*[9] from Singapore. It is evident that the etiologies of corneal diseases in children are influenced by regional and economic factors. In developed countries, congenital corneal opacity predominates are more prevalent, while in developing countries, infectious corneal diseases[1,10-11]. Northwestern China's economic constraints, large rural population, limited eye health awareness, and injury risks contribute to high infectious keratitis rates. As emphasized by Wang *et al*[3] minor corneal epithelial injuries often overlooked and not promptly treated in rural areas, can progress to corneal ulcers and ultimately lead to blindness[3]. Therefore, efforts to strengthen health education and improve local sanitary conditions are crucial for reducing the incidence of corneal blindness in Northwest China and other regions with similar economic and health challenges.

Although infectious corneal diseases were the primary etiology in this study, corneal dermoids represented 20.9% of cases (second highest), suggesting that as parents in Northwest China become more aware of pediatric eye diseases, more cases of congenital corneal opacity are being identified and treated promptly, thereby preventing corneal blindness. Reducing preventable blindness remains an ongoing challenge. Corneal trauma is another important cause of avoidable corneal blindness, as it can lead to severe visual impairment and even blindness. In this study, 20 patients (14.4%) suffered from corneal trauma, including 7 cases of mechanical trauma and 13 cases of chemical or thermal burns. Fifteen of these patients were aged 5 y or older. The majority of mechanical eye injuries were caused by sharp objects, such as scissors, books, blocks, and sticks. Many scholars have mentioned in their studies that corneal trauma can lead to severe corneal diseases, which can further cause irreversible visual function damage[6,11]. Preventing and avoiding trauma can significantly reduce the incidence of corneal trauma and, consequently, the rate of corneal blindness.

An analysis of the residential areas of the 139 patients revealed that 73.4% were from Shaanxi Province, particularly Xi'an city, 18.7% were from Gansu Province, and fewer patients were from Qinghai Province and Ningxia Hui Autonomous Region. No patients were from Xinjiang Uygur Autonomous Region. Notably, all patients included in this study were treated at our hospital during 2018-2022. Given that the global COVID-19 pandemic emerged in late 2019, travel restrictions and other logistical constraints likely impeded out-of-region patients from seeking care at our

Table 2 The microbiological culture results of infectious corneal diseases

Organisms	Number of isolates	Percentage (%)
Fungus	4	11.4
Acanthamoeba	2	5.7
Bacteria	5	14.3
Negative	24	68.6

Table 3 Surgical methods analysis of pediatric corneal diseases *n* (%)

Disease	PKP	LKP	AMT	Others
Congenital corneal diseases	39 (75)	11 (21.2)	1 (1.9)	1 (1.9)
Corneal dermoid	29 (100)	0	0	0
Corneal tumors	0	9 (90)	1 (10)	0
Corneal leukoma	10 (83.3)	2 (16.7)	0	0
Corneal dystrophy	0	0	0	1
Acquired traumatic corneal diseases	3 (15)	3 (15)	13 (65)	1 (5)
Mechanical injuries	3 (42.8)	2 (28.6)	2 (28.6)	0
Chemical injuries	0	1 (7.7)	11 (84.6)	1
Acquired non-traumatic corneal diseases	23 (34.3)	20 (29.8)	17 (25.4)	7 (10.5)
Infectious corneal diseases	16 (39)	12 (29.3)	13 (31.7)	0
Keratoconus	6 (50)	6 (50)	0	0
Other non-infectious corneal diseases	1 (7.1)	2 (14.3)	4 (28.6)	7 (50)
All	65 (46.8)	34 (24.4)	31 (22.3)	9 (6.5)

PKP: Penetrating keratoplasty; LKP: Lamellar keratoplasty; AMT: Amniotic membrane transplantation.

institution. This resulted in a more geographically concentrated patient cohort, potentially limiting the study population's representativeness beyond local demographics.

In this study, the rate of corneal transplantation surgery was 71.2%. Among patients with congenital corneal diseases, corneal transplantation accounted for 98.1% of surgeries, whereas in those with acquired non-traumatic corneal diseases, this proportion was 64.1%. These findings align with research conducted by scholars such as Yu *et al*[6], Jin *et al*[8], Low *et al*[9]. Viberg and Byström *et al*[12] provided a detailed analysis of the efficacy of corneal transplantation for infectious corneal diseases, further corroborating the conclusions of our study. Evidently, corneal transplantation plays a crucial role in managing corneal diseases in children and has emerged as a critical and effective treatment modality for pediatric corneal blindness. Among the 20 patients with acquired traumatic corneal diseases, a higher proportion (65%) underwent AMT. This is attributable to the fact that most trauma patients treated at our hospital sustained chemical or thermal burns, and early amniotic membrane surgery provides a foundation for subsequent ocular treatment. Six patients with severe corneal damage from sharp object injuries underwent corneal transplantation. In recent years, leveraging the Shaanxi Eye Bank and its sufficient supply of corneal donors, our hospital has vigorously promoted corneal transplantation surgeries, addressing corneal diseases in children across the Northwest region and thus preventing corneal blindness and avoiding a substantial number of potential childhood blindness cases.

Infectious corneal diseases represent a major cause of blindness, with bacterial infectious corneal ulcers constituting the highest proportion[3,13-16]. The etiological species vary significantly by country and region. Nikolaos from the UK reported that the most prevalent bacteria in bacterial corneal diseases were *Staphylococcus* (25%), *Pseudomonas* (22%), *Streptococcus* (12%), and *Moraxella* (10%)[15]. *Staphylococcus* and *Streptococcus* infections predominantly occur in northern regions worldwide, findings that align with our study results[11]. However, research by Indian scholars revealed notable discrepancies: in central India, *Pseudomonas* was the leading cause of infectious keratitis (14.6%), followed by *Staphylococcus* (11.2%) and *Bacillus* (3.4%)[17].

Most patients with fungal infections were from rural areas and had a history of plant-related trauma, which is consistent with findings reported by previous studies[14]. Therefore, improving sanitary conditions in rural regions and enhancing eye health education may help reduce the incidence of fungal infections to a certain extent.

With the growing prevalence of childhood myopia and the substantial increase in contact lens use, there has been a concomitant rise in patients with *Acanthamoeba* corneal disease in recent years. Most cases are attributed to inadequate contact lens care, particularly improper cleaning and disinfection of lens surfaces[14]. Relevant studies indicate that the incidence of infectious corneal diseases among individuals under 18 years old wearing orthokeratology lenses ranges from 5.3 to 13.9 cases per 10 000[18]. Clinically, such patients are infrequently encountered in our practice. It is worth mentioning that even with active treatment, some patients with severe corneal damage may experience permanent vision loss due to corneal opacity, highlighting the importance of proactive prevention of contact lens-related infectious corneal diseases. Therefore, enhancing the caregiving abilities of children and their guardians, raising health awareness, and seeking timely medical attention are crucial.

As shown in Table 2, the positive rate of microbial culture for infectious corneal diseases remains relatively low, with our hospital's data reporting approximately 31.4%. The causes of this low positivity rate are complex, including specimen contamination during submission, prolonged culture cycles, and pre-collection medication use by patients. Therefore, enhancing relevant technical development will enable rapid and accurate identification of infectious microorganisms in corneal disease patients during clinical practice, providing direct and robust guidance for their treatment. Among patients with infectious corneal diseases in this study, no positive cases were detected vial monoclonal antigen-antibody qualitative detection methods for herpes simplex virus and adenovirus. This might be attributed to our detection approach. Although this method yields a lower positivity rate, it offers distinct advantages of speed and convenience, making it suitable for initial screening. In March 2023, the Ophthalmic Microbiology Laboratory of the Ophthalmic Research Institute in our hospital introduced virus PCR detection. This technique is characterized by high sensitivity, specificity, efficiency, and broad applicability, serving as an invaluable tool for the diagnosis and management of viral infectious corneal diseases. Additionally, our study has several limitations: first, this study is based on single-center data from Shaanxi Province, which is relatively limited and cannot represent the corneal disease composition in a larger geographical region. Second, from 2018 to 2022, the COVID-19 pandemic hindered data acquisition, restricting the generalizability of our conclusions. Further research is needed to validate these findings. Third, the pediatric patient cohort showed low follow-up compliance, leading to insufficient postoperative data. Key metrics (*e.g.*, corneal transplantation recurrence and infection rates) remain incomplete, warranting focused investigations in this area. Finally, current smear and culture data for infectious keratitis are limited, requiring additional validation to strengthen related conclusions.

In summary, infectious corneal diseases, corneal dermoids, and trauma-related diseases constitute the primary etiologies of pediatric corneal diseases treated with surgery in our hospital. Corneal transplantation is fundamental to management and represents an effective treatment for corneal blindness. Preventive strategies, early diagnosis, and timely intervention can significantly reduce preventable childhood blindness.

Conflicts of Interest: Wei PP, None; Wu J, None; Cheng Y, None.

Authors' Contributions: Wei PP collecting patient data, organizing data, participating in all stages of the research process, and drafting the final academic paper; Wu J providing guidance on the research protocol, project design, and project implementation; Cheng Y responsible for project design, guiding project implementation, and revising the academic paper.

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