Clinical profile and demographic distribution of band shaped keratopathy in India: A study of 8801 patients

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Purpose: To describe the clinical profile and demographic distribution of band-shaped keratopathy (BSK) in patients presenting to a multitiern ophthalmology hospital network in India. Methods: This cross-sectional hospital-based study included 2,664,906 new patients presenting between January 2011 and January 2021 (10-year period). Patients with a clinical diagnosis of BSK in at least one eye were included as cases. The data were collected using an electronic medical record system. Results: Overall, 8801 (0.33%) patients were diagnosed with BSK. The prevalence rates were 0.47% in children (age: <16 years) and 0.31% in adults. The majority of patients were males (62.87%) with unilateral affliction (85.21%). The mean age of the patients was 40.43 ± 23.14 years. The majority (16.93%) of the patients were in the age bracket of 11–20 years. A larger proportion of the patients were from higher socioeconomic status (60.46%) and the urban region (45.9%). Of the 10,103 eyes affected with BSK, the common ocular comorbidities were status post-vitrectominal surgery (20.55%) and uveitis (12.7%) in children and corneal scar (41.23%) and spheroideal degeneration (13.7%) in adults. Most of the eyes had mild or no visual impairment (24.74%). Among the eyes that needed surgical intervention, chelation with ethylenediaminetetraacetic acid (EDTA) was the most performed surgical procedure (1.68%) along with phototherapeutic keratectomy (0.32%). Conclusion: BSK commonly affects adult males and is unilateral in nature. The majority of the patients in this cohort belonged to higher socioeconomic strata and urban geography. At initial presentation, visual impairment was mild to moderate in a vast majority of the patients, and the most common surgical intervention performed was chelation with EDTA during the study period.

Key words: Band-shaped keratopathy, big data, electronic medical records, India

Band-shaped keratopathy (BSK) is a chronic corneal degenerative condition characterized by a development of grey opacification of the superficial cornea and was first described by Dixon (1848) and Bowman (1849).1,2 The calcium deposited in the cornea gives the “Swiss cheese” appearance due to dispersed holes and is often associated with chronic ocular conditions such as uveitis and systemic diseases such as hypercalcemia associated with nephrocalcinosis; nephrolithiasis leads to severe renal damage due to high intake of calcium.2,3 This condition is asymptomatic in the initial stage of disease; however, with disease progression, the patient becomes symptomatic with irritation and deterioration of vision due to disruption of corneal epithelium.4,5 The deposition of calcium is found in the interpalpebral region of the cornea due to the evaporation of tears, changes in pH of the ocular surface, and the breakdown of phosphates.3,6 BSK is a condition with an accumulation of calcium deposits that leads to corneal degeneration, which deteriorates corneal transparency and eventually decreases visual performance in patients. Intraocular forward scattering plays a key role in visual loss.6 The condition of BSK is treated with phototherapeutic keratectomy (PTK) and chelation with EDTA to improve the corneal surface and provide visual rehabilitation.3,7 Some studies have reported that corneal degeneration and necrosis from chronic inflammation related to iridocyclitis leads to an unknown mechanism of calcium-phosphate precipitation.8,9 There are few studies on the prevalence and demographic distribution of BSK in the Indian population.10 The aim of the authors in this study is to present the clinical profile and demographic distribution of BSK at a large multitier ophthalmology network in India by using electronic medical record-driven analytics.

Methods

Study design, period, location, and approval

This cross-sectional observational hospital-based study included all patients presenting between January 2011 and January 2021 to an ophthalmology network spread across four adjacent neighboring states (Telangana, Andhra Pradesh, Odisha, and Karnataka) of India.11 A standard consent form for electronic data sharing was filled by the patient or the parents or guardians of the patient at the time of registration. None of the data that were used for analysis had identifiable parameters or guardians.

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of the patient. The study adhered to the Declaration of Helsinki and was approved by the institute’s ethics committee. The clinical data of each patient who underwent a comprehensive ophthalmic examination using a standardized template was entered into a browser-based electronic medical records system (eyeSmart EMR) by uniformly trained ophthalmic personnel and supervised by an ophthalmologist.[12]

Cases
A total of 2,664,906 patients of all ages presented to the tertiary and secondary centers of the network during the study period. The eyeSmart EMR was initially screened for patients with a final ocular diagnosis of BSK in one or both eyes made by an ophthalmologist. A total of 8801 patient records were identified who had symptoms, signs, visual acuity, clinical impression, and plan of management that corroborated with a diagnosis of BSK and were labeled as cases.

Data retrieval and processing
The data of 10,103 eyes of 8801 patients included in this study were retrieved from the electronic medical record database and segregated in a single Excel sheet. The columns included the data on demographics, clinical presentation, visual acuity, ocular diagnosis, and surgical treatment and were exported for analysis. The Excel sheet with the required data was then used for analysis using the appropriate statistical software. Standardized definitions were used for occupation, socioeconomic status, and geographic categorization.[13] The visual acuity was classified according to the WHO guidelines.[14]

Statistical analysis
Descriptive statistics using mean ± standard deviation and median with interquartile range (IQR) were used to elucidate the demographic data. Chi-square test (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP) was used for univariate analysis to detect significant differences in the distribution of demographics features between patients with BSK and the overall population.

Results
Prevalence
Of the 2,664,906 unique patients who presented across the eye care network during the study period, 8801 patients were diagnosed with BSK in at least one eye, translating into a prevalence rate of 0.33% (95% CI: ±0.0033%) or 3302/million population seen across the network.

Age
The mean age of the patients with BSK was 40.43 ± 23.14 years, while the median age was 37 (IQR: 20–61) years. The overall prevalence was 0.47% (1712/365,520) in children (≤16 years) and 0.31% (7089/2,299,386) in adults (>16 years). The frequency distribution of BSK showed an increase between 11 and 20 years of age (16.93%) and another peak between 61 and 70 years of age (15.31%), followed by a gradual decline from 71 to 80 years of age (9.24%) in the subsequent decades. The decade-wise distribution of the patients is detailed in Fig. 1.

Sex
There were 5533 (62.87%) male and 3268 (37.13%) female patients with BSK. The overall prevalence of BSK was significantly greater (P < 0.00001) in males (0.38%; 5533/1,439,162) as compared to females (0.27%; 3268/1,225,744). Among the patients with BSK, the mean and median age were 39.2 ± 23.09 and 34 (IQR: 19–61) years for men and 42.51 ± 23.09 and 45 (IQR: 21–62) years for women, respectively. The overall mode was 66 years and 66 years for men and 61 years for women.

Rural-urban-metropolitan distribution
There were 4040 (45.9%) patients with BSK from urban districts, 3900 (44.31%) from rural districts, and 861 (9.78%) from metropolitan regions. The overall prevalence of BSK was not statistically significant (P = 0.382005) in urban community (0.34%; 4040/1,185,192) as compared to the rural (0.33%; 3900/1,166,834) or metropolitan community (0.28%; 861/312,880).

Socioeconomic status
There were 3480 (39.54%) patients with BSK from the lower socioeconomic class, 4936 (56.08%) from the lower-middle class, 272 (3.09%) from the upper-middle class, and 113 (1.28%) from the upper class. The overall prevalence of BSK was significantly higher (P < 0.00001) in the lower socioeconomic strata (0.53%; 3480/651,035) as compared to higher socioeconomic strata (0.26%; 5321/2,013,871) among the patients seen in the hospital.

Occupation
Of the 8801 patients with BSK, 2378 (27.02%) were students, 1666 (18.93%) were professionals, 1368 (15.54%) were homemakers, 812 (9.23%) were agriculture related, 659 (7.49%) were manual laborers, 482 (5.48%) retired from employment, and 1436 (16.32%) were those for whom the occupational category was not available/applicable. The overall prevalence of BSK in students (0.53%, 2378/446,698) was significantly higher (P < 0.00001) in comparison to other professions.

Laterality: BSK was diagnosed unilaterally (either in right or left eye) in 7499 (85.21%) cases and bilaterally (both right and left) in 1302 (14.79%) cases. The right eye was affected unilaterally in 3483 (43.67%) cases and the left eye in 3656 (41.54%) cases.

Presenting visual acuity
Among the 10,103 eyes, mild or no visual impairment (20/20 to 20/70) was seen in 2499 (24.74%) eyes, moderate visual impairment (20/70 to 20/200) in 1081 (10.7%) eyes, severe visual impairment (20/200 to 20/400) in 401 (3.97%) eyes, blindness 3 (>20/400 to 20/1200) in 1883 (18.64%) eyes, blindness 4 (>20/1200 to perception of light) in 1554 (15.38%) eyes, blindness 5 (no perception of light) in 2515 (24.89%) eyes, and undetermined or unspecified in 170 (1.68%) eyes.

Ocular associations
Among the 10,103 eyes, the primary diagnosis was corneal scar in 4019 (39.78%) eyes, cataract in 2235 (22.12%) eyes, phthisis bulbi in 1601 (15.85%) eyes, glaucoma in 1212 (12%) eyes, and spheroidal degeneration in 1150 (11.38%) eyes. The detailed list of ocular comorbidities is described in Table 1. The most common associated corneal dystrophy was macular dystrophy in 19 (33.93%) eyes followed by lattice dystrophy in 13 (23.21%) eyes and endothelial dystrophy in 5 (8.93%) eyes. The common ocular comorbidities were status post-vitrectorretinal surgery (20.55%) and uveitis (12.7%) in children and corneal scar (41.23%) and spheroidal degeneration (13.7%) in adults. Fig. 2 illustrates representative clinical slit-lamp photographs of some patients.
Systemic disease associations
Of the 8801 patients with BSK, 438 (4.98%) had associated hypertension, 332 (3.77%) had diabetes mellitus, 63 (0.72%) had arthritis, 59 (0.67%) had coronary heart disease, and 23 (0.26%) had a history of renal disease.

Surgical management
A significant percentage of the 9783 (96.83%) eyes did not require surgical management. The most common surgical procedure performed was chelation with ethylenediaminetetraacetic acid (EDTA) in 170 (1.68%) eyes, phototherapeutic keratectomy in 32 (0.32%) eyes, superficial keratectomy in 28 (0.28%) eyes, and debridement in 10 (0.10%) eyes.

Discussion
This study sought to describe the clinical profile and demographic distribution of BSK in a large cohort of patients presenting to a multitier hospital network in India by using electronic medical records-driven big data analytics. The primary purpose of the study was to determine the relative proportion and demographic profile of the BSK in the clinical care setup.

In this study, the overall prevalence of BSK was 0.33% of all eye diseases diagnosed between 2011 and 2021 (10-year period). The condition was predominantly unilateral and more commonly seen in males. The overall prevalence of the condition was higher in the lower socioeconomic strata, age <16 years, and those presenting from the urban region among the patients presenting to the hospital. Surgical intervention was performed in a small percentage of eyes. The most likely reason is the sparing of the visual axis as the visual impairment was mild to moderate in a large majority of eyes.

Weng et al.\textsuperscript{[14]} conducted a cohort study in Taiwan to evaluate the relationship between BSK with end-stage renal disease (ESRD) and non-end-stage renal diseases (non-ESRD) and found that the incidence rate of BSK in ESRD was 12.21 times more than in the non-ESRD group and the relative risk of BSK with ESRD was 11.56 times higher in the whole cohort after adjusting for age, sex, sarcoidosis, hyperthyroidism, iridocyclitis and, phthisis bulbi. They also observed that BSK was higher in the younger group of ESRD patients than the elderly group (>65 years), which exhibited lower incidence rate. This study found that iridocyclitis and phthisis bulbi were associated with a higher risk for BSK in ESRD patients. In our study, the most common systemic

Table 1: Ocular comorbidities in patients with band-shaped keratopathy

| Ocular Comorbidities                          | Eyes | %     |
|----------------------------------------------|------|-------|
| Corneal Scar                                 | 4019 | 39.78%|
| Cataract                                     | 2235 | 22.12%|
| Phthisis Bulbi                               | 1601 | 15.85%|
| Glaucoma                                     | 1212 | 12.00%|
| Spheroidal degeneration                      | 1150 | 11.38%|
| S/p Vitreoretinal Surgery                    | 984  | 9.74% |
| Uveitis                                      | 696  | 6.89% |
| Retinal Detachment                           | 683  | 6.76% |
| Corneal Trauma                               | 170  | 1.68% |
| Retinopathy of Prematurity                   | 150  | 1.48% |
| Staphyloma                                   | 138  | 1.37% |
| Status/post Corneal Surgery                  | 126  | 1.25% |
| Corneal Dystrophy                            | 56   | 0.55% |
| Keratoconjunctivitis Sicca                   | 25   | 0.25% |
| Xeroderma Pigmentosum                        | 10   | 0.10% |
| Irido-Corneal Endothelial Syndrome           | 8    | 0.08% |

Figure 1: Decade-wise distribution of band-shaped keratopathy

Figure 2: Representative slit-lamp photographs showing band-shaped keratopathy. (a) 15-year-old patient with juvenile idiopathic arthritis; (b) Right eye of a patient following vitreoretinal surgery; (c) A 45-year-old patient with chronic anterior uveitis; (d) Post trauma eye showing dense scarring and deposits; (e) Chronic focal corneal edema secondary to PCiol haptic touch on the endothelial surface; (f) Anterior segment optical coherence tomography of the image (e) showing deposits in the superficial cornea.
disease noted was hypertension, followed by diabetes. Renal disease was documented in a smaller percentage (0.26%) of patients.

A retrospective study conducted by Yang et al.\textsuperscript{15} assessed the incidence of BSK clinical features and Vogt–Koyanagi–Harada (VKH) syndrome in Chinese patients. Although VKH syndrome is very rare in the population, it was associated with BSK in both genders equally, and the results revealed that this condition was predominantly seen in patients with prolonged course of treatment for recurrent chronic intraocular inflammation, complicated cataract, and secondary glaucoma. This study concluded that early control of intraocular inflammation may prevent BSK. Uveitis was the seventh common cause of BSK in our study.

A retrospective study by AAI-Hity et al.\textsuperscript{16} identified that the majority of the BSK needing EDTA treatment had no underlying causes (36%) and the most frequent cause identified for BSK was chronic topical glaucoma treatment (27%) due to the long-term usage of topical drops. Visual performance was seen to be improved or be maintained in a majority (79.8%) of cases. The outcome of chelation with EDTA was found to be successful in 97.8% with a moderate recurrence rate (28.1%) and need for retreatment (4.5% overall).

A study conducted in Wills Eye Hospital, Philadelphia, USA in 2004 reported that the most frequent cause of BSK was chronic corneal edema in 28%, followed by idiopathic in 25.9% and phthisis bulbi in 16.4% of cases. This study result demonstrates that chelation with EDTA is a safe and effective procedure that helps in improving a patient’s vision and symptoms.\textsuperscript{17} A small percentage (3.17%) of eyes underwent surgical intervention in our cohort. This is likely because the intervention is usually performed to improve visual functions. As a majority of the eyes in the study had a good visual acuity, surgical intervention may have been deferred.

**Conclusion**

In conclusion, this study aimed to describe the epidemiology and clinical presentation of BSK in 2.7 million new patients presenting to a multtier ophthalmology hospital network in India. The findings show that BSK commonly affects adult males and is unilateral in nature. The disease is more prevalent in the lower socioeconomic strata. At initial presentation, visual impairment was mild to moderate in a vast majority of the patients and the most common surgical intervention performed was chelation with EDTA during the study period.

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**Conflicts of interest**

There are no conflicts of interest.

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