Paediatric Keratoconus: An ERN-EYE Clinical Consensus Statement on Diagnosis, Treatment, and Follow-Up Care

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Supplemental Data

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Expert Characteristics

Name	Country	Role	Areas of expertise
Boehringer, Daniel	Germany	• Ophthalmologist	• Cornea • Anterior segment
Bourges, Jean-Louis	France	• Ophthalmologist • Surgeon	• Cornea • Refractive surgery • Anterior segment
Bremond-Gignac, Dominique	France	• Paediatric ophthalmologist • Surgeon	• Paediatric eye disease • Corneal transplantation • Myopia
Buzzonetti, Luca	Italy	• Paediatric ophthalmologist • Surgeon	• Cornea • Refractive surgery • Keratoconus
Cocho, Lidia	Spain	• Ophthalmologist	• Uveitis • Anterior segment
Iester, Michele	Italy	• Ophthalmologist • Surgeon	• Glaucoma • Neuro-ophthalmology • Cataract • Retina
Liskova, Petra	Czech Republic	• Ophthalmologist	• Corneal dystrophies • Ocular genetics
Mazzotta, Cosimo	Italy	• Ophthalmologist • Surgeon	• Cornea • Keratoconus • Corneal cross-linking
Monterosso, Cristina	Italy	• Ophthalmologist • Surgeon	• Cornea • Anterior segment • Vitreoretinal surgery
Pauklin, Mikk	Estonia	• Ophthalmologist	• Cornea • Ocular surface
Studeny, Pavel	Czech Republic	• Ophthalmologist • Surgeon	• Cornea • Corneal transplantation
Tekavcic Pompe, Manca	Slovenia	• Paediatric ophthalmologist • Surgeon	• Paediatric eye disease • Cataract surgery
Vannucchi, Martino	Italy	• Paediatric ophthalmologist • Surgeon	• Paediatric eye disease • Refractive surgery
Zemaitiene, Reda	Lithuania	• Ophthalmologist • Surgeon	• Cataract • Glaucoma • Cornea • Uveitis

I. Genetics and Pathogenesis Working Group

I.1. Questions

Q1. What are the known pathways in keratoconus development?

Q2. Which monogenic conditions are associated with keratoconus development?

Q3. What are the incidence and prevalence of paediatric keratoconus?

Q4. Are there any geographical differences in prevalence?

Q5. To what extent do genetic factors influence keratoconus development?

Q6. How predictive can genetic testing be?

Q7. Is it worth performing genetic testing in the diagnostic settings?

Q8. Are there any factors that can predict a keratoconus in children?

Q9. What factors can be associated to paediatric keratoconus onset and progression (inflammatory, mechanical, CHAR (chronic habit of abnormal rubbing), hormonal, rubbing)?

Q10. Are there any environmental factors (e.g., near work, light setting, outdoor activity) that could reduce keratoconus incidence?

Q11. What is the chance for a dizygotic twin of keratoconus patient to manifest the disease?

Q12. What is the chance for a monozygotic twin of keratoconus patient to manifest the disease?

Q13. Can keratoconus associated with monogenic conditions be regarded as true keratoconus or should it be regarded as a different entity?

I.2. Keywords

For the Genetics and Pathogenesis working group, keywords included: keratoconus, corneal ectasia, paediatric/pediatric keratoconus, child, genetic factors, consanguinity, HLA, haplotype, autosomal dominant/recessive, etiopathogenesis, familial history, multifactorial disease, biomechanical factors, eye rubbing, inflammatory markers, cytokines, ocular/systemic disease, Down syndrome, Ehlers-Danlos syndrome, atopy, hormonal factors, BMI, male predominance, and early-onset rapid progression.

I.3. Voting Results

(n = 4)

Question	Voting average	Decision
Q1	81.25	Accepted
Q2	75.00	Accepted
Q3	87.50	Accepted
Q4	93.75	Accepted
Q5	81.25	Accepted
Q6	81.25	Accepted
Q7	75.00	Accepted
Q8	81.25	Accepted
Q9	87.50	Accepted
Q10	93.75	Accepted
Q11	75.00	Accepted
Q12	93.75	Accepted
Q13	100.00	Accepted

II. Clinical Features and Diagnosis Working Group

II. 1. Questions

Q1. What is its natural history?

Q2. When do the ophthalmologist start having some doubts about the possibility that the patient has a keratoconus?

Q3. Which examinations (clinical and instrumental) do the patients need for diagnosis?

Q4. Which examinations (clinical and instrumental) are mandatory to assess keratoconus progression?

Q5. What are the devices used for keratoconus assessment (diagnosis and progression)?

Q6. What is the mean corneal curvature measure to consider for a keratoconus suspicion?

Q7. What are the typical keratoconus patterns on corneal topography and tomography?

Q8. If one family member is affected, should other family members be examined and, if yes, what would be the recommended age for first examination and what would be the recommended monitoring?

Q9. Is keratoconus more common in children developing progressive ametropia first?

Q10. What are the risk factors for keratoconus development and keratoconus progression?

Q11. What are the best monitoring time points, according to progression, age group (paediatrics and young adults)?

Q12. What are examination indices and indexes that would best reflect the progression of keratoconus?

II. 2. Keywords

For the Clinical Features and Diagnosis group, keywords included: bilateral manifestation, posterior ectasia, forme fruste keratoconus, corneal thinning, abnormal corneal thickness, pachimetry, maximum keratometry, Vogt striae, Fleischer ring, stromal oedema, Bowman's layer opacity, associated syndromes, scarring, irregular astigmatism, myopia, BSCVA, Scheimpflug imaging, OCT, topographic/tomographic/biomechanical indices, IOP, and follow-up intervals.

II. 3. Voting Results

(n = 4)

Question	Voting average	Decision
Q1	93.8	Accepted
Q2	81.3	Accepted
Q3	100.0	Accepted
Q4	81.3	Accepted
Q5	100.0	Accepted
Q6	81.3	Accepted
Q7	93.8	Accepted
Q8	87.5	Accepted
Q9	93.8	Accepted
Q10	100.0	Accepted
Q11	93.8	Accepted
Q12	93.8	Accepted

III. Management and Treatment Working Group

III.1. Questions

Q1. What classifications are relevant to manage keratoconus patients?

Q2. What are the steps of keratoconus management?

Q3. Should cross-linking be considered for any kind of keratoconus progression?

Q4. Should cross-linking be considered without any progression?

Q5. What are the recommended cross-linking protocol, according to corneal parameters and patient age?

Q6. Can cross-linking be repeated, when, and following which modalities?

Q7. What other surgical options could be combined with cross-linking?

Q9. When is keratoplasty indicated, and which kind of technique?

Q10. Should corneal surgery be considered in keratoconus patients with contact lenses intolerance or should it be considered independently?

Q11. What should be relevant information and recommended behaviours for keratoconus patients and their family?

Q12. What treatments can be associated to manage other conditions linked to keratoconus?

III.2. Keywords

For the Management and Treatment group, keywords included: contact lenses (rigid, hybrid, scleral, soft keratoconus design), topical antiallergics, lubricants, eye rubbing education, family screening, phototherapeutic keratectomy, phakic IOLs, ICRS, CAIRS, corneal cross-linking (epi-off, epi-on, high fluence, combined), keratoplasty (DALK, PK), femtosecond-assisted transplantation, and Bowman layer transplantation.

III.3. Voting Results

(n = 6)

Question	Voting average	Decision
Q1	100.0	Accepted
Q2	100.0	Accepted
Q3	79.2	Accepted
Q4	100.0	Accepted
Q5	95.8	Accepted
Q6	100.0	Accepted
Q7	83.3	Accepted
Q8	87.5	Accepted
Q9	100.0	Accepted
Q10	95.8	Accepted
Q11	95.8	Accepted
Q12	100.0	Accepted