

1 **Keratoconus Plus (KC-Plus): A New Term Proposed**
2 **by an Egyptian Research Team for use in Relation to**
3 **Keratoconus, with coexisting Cataracts**

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25

26 ABSTRACT

27 **Purpose:** To establish a consensus in the Egyptian literature on the management of keratoconus
28 (KC) and cataracts in the same eye.

29 **Methods:** An Egyptian research team, including 42 KC experts, met to develop a protocol for the
30 management of KC in Egypt. In three scientific meetings, the Egyptian Protocol for Keratoconus
31 (EPK) group focused on the diagnosis and treatment of KC in Egypt. In panels and debates, they
32 discussed procedures to treat coexisting cataracts and KC in the same eye. Many experts in the EPK
33 group agreed on the term KC-Plus to refer to KC and cataracts in the same eye. The experts then
34 participated in Delphi-style rounds of questionnaires to define this new term.

35 **Results:** Thirty-two (76.2%) of the 42 participants who participated in the Delphi-style rounds of
36 questionnaires agreed on the definition of KC-Plus as a term that described the coexistence of
37 cataracts and KC in the one eye. The participants agreed on the need for a fourth face-to-face
38 meeting of the EPK group.

39 **Conclusion:** Cataracts and KC in one eye represent a visual, refractive and corneal dilemma. A
40 solidly designed protocol is needed to guide ophthalmologists in the diagnosis and treatment of
41 patients with coexisting cataracts and KC in the same eye. The protocol should address various
42 issues under debate, such as whether the cataract or KC should be treated first. It should also
43 address patient selection, intraocular lens (IOL) selection and optimum biometry formulae. A new
44 term (i.e. KC-Plus) is needed to describe the existence of KC and cataracts in the same eye.

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51 1. Introduction

52 Keratoconus (KC) is a non-inflammatory ectatic corneal disease, which is characterized by
53 progressive weakening of the corneal stroma, with apical protrusion. Patients with KC complain of
54 progressive diminution of vision, which necessitates the wearing of spectacles. KC is usually

55 associated with progressive myopia and astigmatism, both of which greatly reduce visual acuity and
56 have a negative impact on vision quality [1,2].

57 In the last two decades, there have been major advances in operative techniques to treat KC. Prior to
58 these advances, among available procedures, corneal collagen cross-linking (CXL) was the only
59 procedure proven to halt KC progression. All other procedures aimed only to correct the refractive
60 status of the keratoconic eye. The emergence of many new terms in the last decade has made it
61 difficult to draw comparisons between different research outcomes worldwide, with each research
62 team devising its own terminology and abbreviations [1-3].

63 Recently, Randleman et al. [1] stated the importance of standardizing CXL terminology. They
64 suggested the use of fixed general terms to describe different CXL procedures, thus facilitating
65 comparisons of topographic, refractive and visual outcomes of different research studies worldwide.
66 They recommended the following four terms: CXL, CXL-Plus, prophylactic CXL and PACK-CXL
67 (photo-activated chromophores for keratitis). They proposed the use of the term CXL for the treatment
68 of corneal ectasia and suggested the use of the term CXL-Plus for therapeutic CXL combined with
69 another refractive procedure. They recommended the use of the term prophylactic CXL for non-ectatic
70 corneas when CXL was used in conjunction with refractive surgery and the use of the term PACK-
71 CXL for the treatment of infectious keratitis. They recommended using the acronyms S-CXL and A-
72 CXL for standard (Dresden protocol) and accelerated CXL, respectively [1,3].

73 CXL-Plus has two major objectives: CXL aims to halt KC progression, while a refractive procedure is
74 performed to correct the myopic and/or astigmatic components of KC. In CXL-Plus, different
75 procedures are used in conjunction with CXL. These procedures are non-topography guided
76 photorefractive keratectomy (PRK), wave-front guided PRK (WFG PRK), implantation of continuous or
77 segmented intra-corneal ring segments (ICRSs), implantation of a phakic intraocular lens (IOL) and
78 implantation of a toric implantable collamer lens. Implantation of a toric intraocular lens, together with
79 refractive lens surgery, is also used [4-20].

80 Many researchers have evaluated several IOL power calculation formulas, including SRK, SRK-T and
81 SRKII. They have also evaluated post-operative visual and refractive outcomes, including biometry
82 prediction errors, and the need for post-operative spectacles or rigid gas permeable contact lens.

83 Some researchers have recommended the use of toric IOL implantation in keratoconic eyes and
84 reported that a toric IOL was a good refractive tool to correct refractive outcomes of a keratoconic

85 eye. They also concluded that the grade or stage of KC was vital in surgical decision making
86 regarding each keratoconic eye.

87 When treating cataracts and KC together, the most important factors that control post-operative visual
88 and refractive results are as follows: IOL formula, IOL selection, patient education (i.e. ensuring that
89 the patient has good understanding of the nature of the disease), the patient's age, counselling of
90 parents of KC patients, grade of KC, stability or progression of KCs and surgical planning (i.e.
91 whether KC or the cataract should be treated first) [10-20].

92 Two years ago, an Egyptian research team, known as the Egyptian Protocol for Keratoconus (EPK)
93 group, was established to consider the management of KC in conjunction with cataracts in the same
94 eye. The EPK group includes professors from many Egyptian universities. The team followed the
95 Delphi method to define a new term to describe KC and cataracts in the same eye. Herein, we share
96 the recommendations of the EPK group.

97 **2. METHODS**

98 The team took part in three Delphi-style rounds of questionnaires according to established scientific
99 approaches. The three questionnaire rounds included 12–13 questions of high reliability and validity in
100 each round (Figs. 1, 2 and 3). Forty-two professional KC experts participated in the Delphi methods
101 and answered 38 questions in the three rounds. The result of each round was announced to the
102 participants before launching the next round.

103 In February, March and November 2017, the EPK group attended three major scientific conferences
104 in Luxor and Zagazig in Egypt. These conferences focused mainly on the treatment of KC. At these
105 scientific meetings, several panels and debates discussed in detail issues giving rise to controversies
106 regarding the management of KC in conjunction with cataracts. The panel focused on determining the
107 best treatment strategies to manage both cataracts and KC with respect to the patient's age, KC
108 grade, final visual acuity and quality outcomes. The panel gave due consideration to patients'
109 professions, expectations and lifestyles. At the second scientific meeting in March 2017 in Luxor,
110 Egypt, the EPK group proposed a new term for KC coexisting with cataracts: KC-Plus. Following three
111 Delphi-style rounds of questionnaires, the team attended a face-to-face meeting this year to discuss
112 the results of the Delphi method and to vote on the use of the proposed term (KC-Plus) in Egypt.

Data collected from the corneal experts during the various Delphi-style rounds were collated using Microsoft Excel (Microsoft Office 2010) and analysed using the Statistical Package for the Social Sciences, version 22 (SPSS for Windows).

#EPK_KCPLUS_Delphi_Round 1_Questionnaire

Prof Name:

University:

1- In your practice, the existence of KC and Cataract together is :			
Common	Uncommon	Not rare	Rare
2- Have you ever treated KC with Cataract at the same time ?			
Yes		No	
3- Do you prefer using Toric IOLs in treating Cataract in Keratoconic patients ?			
Yes		No	
4- In managing KC with Cataract, if PK / DALK not indicated, I prefer to start treating :			
KC		Cataract	
5- Do you agree that our priorities in treating KC with Cataract vary in adults from children ?			
Yes		No	
6- Do you agree that the difficulty in managing KC with Cataract arises from the difficulty in IOL calculation ?			
Yes		No	
7- Do you agree that there is no one perfect formula for IOL power calculation in KC with Cataract ?			
Yes		No	
8- Do you agree that we should flatten the cornea before measuring IOL power ?			
Yes		No	
9- Do you agree that ICRS implantation is necessary before measuring IOL power ?			
Yes	No	May be	
10- Do you agree that the coexistence of KC with Cataract is an interesting condition ?			
Yes	No	May be	
11- Did you notice that all previous 10 questions included KC with Cataract ?			
Yes		No	
12- Do you agree that we should use a specific term to describe KC with Cataract ?			
Yes		No	
13- Do you agree to use the new term KC PLUS from the EPK GROUP to describe KC with Cataract ?			
Yes		No	

Signature

Fig. 1. Delphi method round 1

#EPK_KCPLUS_Delphi_Round 2_Questionnaire

Prof Name:

University:

1- Have you ever operated a cataract case and then postoperatively you discovered accidentally that the patient had undiagnosed KC ?	
Yes	No
2- Some colleagues prefer start treating cataract first before KC, while other colleagues prefer to treat KC first before cataract. In a cataract case with KC with 51/56 D Ks, 400 um at thinnest location, you prefer start treating :	
KC	Cataract
3- In the previous example, do you agree that we can never accurately calculate the IOL power unless we flatten the cornea first ?	
Yes	No
4- In the previous example, do you agree that CXL alone is not enough to flatten the cornea and we need ICRS implantation ?	
Yes	No
5- Do you agree that the recent advances in KC diagnostic tools have increased the rate of KC diagnosis in the last decade ?	
Yes	No
6- Do you agree that the number of patients that received KC treatment in the last decade is many times more than the previous decades ?	
Yes	No
7- Do you agree that most of these patients are teens and twenties ?	
Yes	No
8- Do you agree that even the highly specialized KC surgeons are not alike regarding their own KC protocol management strategies ?	
Yes	No
9- Do you agree that one day senile cataract will affect most of keratoconic eyes that you are treating now ?	
Yes	No
10- Do you agree that most of KC patients treated in the last decade will need further surgical interference for senile cataract in the next 3-4 decades ?	
Yes	No
11- Do you agree that with the new 1 in 375 population KC prevalence we should expect more patients presented with both KC and cataract in the future ?	
Yes	No
12- Do you agree that we have to design a special protocol using a specific term, describing the existence of KC with cataract, regarding how can we treat cataract in already fully, partially or never treated KC patients ?	
Yes	No

Signature

Fig. 2. Delphi method round 2

#EPK_KCPLUS_ Delphi_ Round 3_ Questionnaire

Prof Name: _____ University: _____

1- In adults presenting with KC and cataract, you prefer to start treating:						
KC			Cataract			
2- If you started treatment of KC in adults before cataract, do you agree that CXL is mandatory ?						
Yes			No			
3- If you started treatment of KC in adults before cataract, what is your sharp K2 reading that makes you do ICRS with CXL to flatten the cornea before cataract ?						
48 D	49 D	50 D	51 D	52 D	53 D	≥ 54 D
4- If you started treatment of KC in adults before cataract, what is your sharp astigmatic reading that makes you do ICRS with CXL to flatten the cornea before cataract ?						
3 D		4 D		5 D		≥ 6 D
5- If you started treatment of KC in adults before cataract, do you agree that CXL alone is enough before cataract if K2 < 50 D and astigmatism < 4 D ?						
Yes			No			
6- In the previous example (No 5), do you agree that CXL alone is enough because toric IOL is sufficient to correct the corneal astigmatism ?						
Yes			No			
7- In children presenting with KC and visually SIGNIFICANT cataract, you prefer to start treating:						
KC			Cataract			
8- In the previous example (No 7) and if you choose to start treating cataract first, do you agree to leave the eye aphakic then to treat KC followed by 2ry IOL implantation ?						
Yes			No			
9- In the previous example (No 7), is the answer "Yes" in (No 8) applicable for unilateral visually SIGNIFICANT cataract with KC ?						
Yes			No			
10- In children presenting with KC and visually INSIGNIFICANT cataract, you prefer to start treating:						
KC			Cataract			
11- In the previous example (No 10) and if you choose to start treating KC first, do you agree that we deal in this situation like adults ?						
Yes			No			
12- In the previous example (No 10) and if you choose to start treating cataract first, do you agree to leave the eye aphakic then to treat KC followed by 2ry IOL implantation ?						
Yes			No			
13- In adults with KC and cataract requiring DALK/PKP, do you agree that it's better to leave the eye aphakic and then to do 2ry IOL implantation later ?						
Yes			No			

Signature _____

Fig. 3. Delphi method round 3

3. RESULTS and DISCUSSION

The three scientific meetings yielded many results and recommendations regarding the treatment of KC and cataracts in the same eye, including which should be treated first (i.e. KC or the cataract). The main conclusion of these meetings was that surgeons are dealing with an unstable unpredictable refractive situation, which needs to be studied in detail, and that a good surgical plan needs to be put in place for KC-Plus. The most important outcome of the meeting was that 32 (76.2%) of the EPK participants voted to accept the new term KC-Plus to describe the medical condition of cataracts consisting with KC. Detailed results will be announced after a fourth face-to-face meeting of the EPK group this summer.

The panel confirmed that the treatment of keratoconic eyes presenting with cataracts poses a major visual, refractive and corneal dilemma. For example, IOL calculation formulas are not 100% accurate in keratoconic eyes. To improve post-operative visual outcomes, prior to calculation of IOL power in keratoconic corneas, surface corneal irregularities must be treated, and high order aberrations must be decreased. Questions surround the best possible procedures to flatten the corneal surface, eliminate anterior corneal surface irregularities or even customize CXL to treat localized ectatic corneal areas before calculating the IOL power for cataract surgery. Taking into consideration that many young keratoconic patients treated today will be liable to develop senile cataracts after the age of 50 years, it may be that KC treatment should take place at a young age to correct anterior corneal surface irregularities and reduce the astigmatic component of KC. If these patients develop cataracts in the future, accurate IOL calculations needed for cataract surgery will be easier.

The panel reached a consensus that correcting anterior corneal surface irregularities before cataract surgery was important for both accurate IOL biometry calculations and decreasing the cylinder that needed to be corrected in toric IOL implantation. The panel also reached an agreement that WFG PRK or custom PRK was an ideal operative tool to correct anterior corneal surface irregularities and minimize high order aberrations. They concluded that these steps improved the anterior corneal surface, with a much lower cylinder, thereby allowing more accurate IOL power calculations and improved post-operative visual quality outcomes.

Most of the panellists accepted that it was necessary to flatten the anterior corneal surface using ICRSs, mainly the segmented type. Some KC specialists on the panel refuted the idea of implementing ICRS prior to cataract surgery. They preferred WFG PRK over segmented ICRS and

164 claimed that ICRS would adversely affect post-operative corneal refractive stability and definitely have
165 a negative impact on cataract surgery, long-term refractive outcomes and vision quality outcomes in
166 the long term. Corneal experts who refuted the idea of implanting ICRS before cataract surgery
167 stressed that allergic conjunctivitis was common in Egypt, especially in rural regions. Chronic eye
168 rubbing is a major contributor to distorting the stability of the ICRS within the corneal stoma. In severe
169 cases, it can culminate in ICRS explanation. If this happens after the IOL had been implanted,
170 recorrecting the refractive and corneal dilemma will be a major challenge. The aforementioned factors
171 explain why some panellists were not in favour of the inclusion of ICRS as part of the therapeutic plan
172 in KC-Plus.

173 All the panellists reached a consensus that corneal CXL was mandatory for all keratoconic eyes up to
174 the age of 30 years. However, there was great debate among the panellists as to whether S-CXL or
175 A-CXL should be selected. There was also a major debate about whether WFG PRK and CXL (CXL-
176 Plus) should be performed simultaneously or sequentially.

177 The panellists agreed that refractive correction in KC-Plus was multifactorial. They stated that visual
178 rehabilitation included both corneal and lens levels. The panellists also confirmed the importance of
179 correcting the highest possible cylinder dioptric power at the corneal level, thus facilitating correction
180 of the remaining cylinder dioptric power by toric IOL. The need for further post-operative optical
181 rehabilitation following both corneal and lens surgeries was considered optional. The panel reached a
182 consensus that additional optical correction could be undertaken to improve both acuity and quality of
183 vision. They added that a variety of optical aids, such as spectacles, soft conventional or toric contact
184 lenses, rigid gas permeable contact lenses and scleral contact lenses, could be used.

185 CONCLUSION

186 The final results of the Delphi rounds regarding the Egyptian consensus on the proposed term KC-
187 Plus and outcomes of the fourth face-to-face meeting of the EPK group scheduled to take place this
188 summer will be published later.

189 Consent Disclaimer:

190 As per international standard or university standard written patient consent has been collected and
191 preserved by the authors.

192 **Ethical approval: NA**

193

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Competing Interests:

The authors declare that they have no interests.

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