Panorama of the Treatment of Keratoconus in 2020

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Keratoconus has always been a challenge both in its early diagnosis and integral treatment. When we began this book project, we considered making an updated panorama of the diagnosis and treatment of the keratoconus. We believe the keratoconus has been and still remains one of the pathologies whose treatment has been benefited most over the last two decades.

Beginning with the diagnosis, we have made greater in the early detection helped by the new keratoconus indices, among which we can highlight Belin-Ambrosio ones. We have been also helped by the improvement and new technologies which have contributed to the early detection of such disease. In this book, we have included a handful of chapters related to the diagnosis of keratoconus. Looking forward, we believe the gene therapy will not only be the future but it will intervene in the diagnosis and treatment of the disease as well [1, 2].

There is no doubt the corneal crosslinking becomes an important procedure when it comes to both stopping the progression of the *novo keratoconus* and being used in personalized refractive treatments in an adjunct way (Fig. 1). As a results, having a more stable cornea by using crosslinking has allowed us to correct these patients in a refractive way to improve their visual quality, and in most cases, we obtained the non-use of contact lenses or glasses. We have been given the opportunity to fine-tune the target of the treatments to be able to correct refractive defects [3].

It is important to consider the inflammatory component as the essential basis for the keratoconus. This has opened a wide range of possibilities of understanding its clinical ongoing process and performing different, anticipatory and more appropriate treatments avoiding advanced stages of the disease. Patients with advanced stages prevent us from using more rigid chances aimed at therapeutic strategies, and as a consequence, we are only able to perform a keratoplasty.

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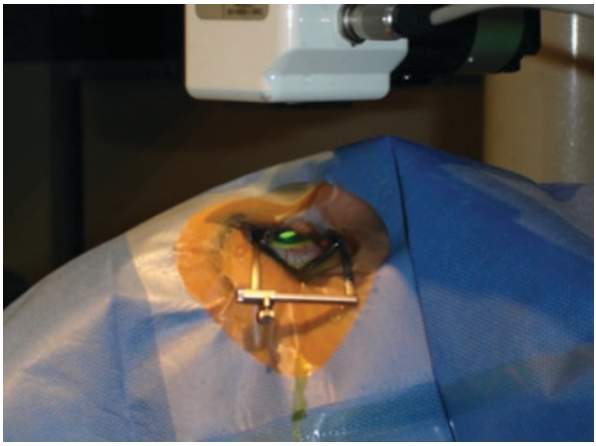

Fig. 1 Corneal crosslinking

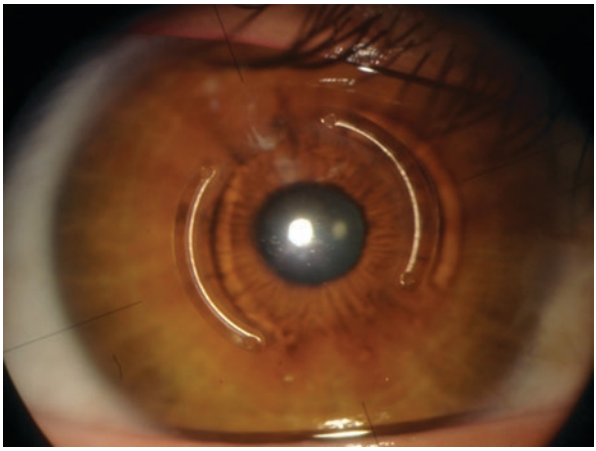

Fig. 2 Intracorneal rings

The intracorneal ring implantation has also been an alternative to correct irregular astigmatism, which is an unfortunate characteristic of the keratoconus (Fig. 2) [4, 5]. Likewise, we found the great alternative to compensate the ametropia of this type of patients either in a refractive way by means of phakic lens implantation or with the use of excimer laser by performing a photorefractive surgery. In chapters 7 and 8, the obtained results and our remarks on the best indications are shown. The use of excimer laser in patients with keratoconus is limited to a very specific segment of patients, and unfortunately the use of such laser cannot be broadly applied because it works in the corneal plane, which is the visibly affected tissue in the keratoconus [6, 7]. However, the phakic lens implantation allows correcting high ametropies, which often occur in patients with keratoconus, with really promising results (Fig. 3) [8, 9, 10]. Once these chapters have been read, we have no doubts that our readers will find the necessary grounds to count on both tools to correct these patients in a refractive way.

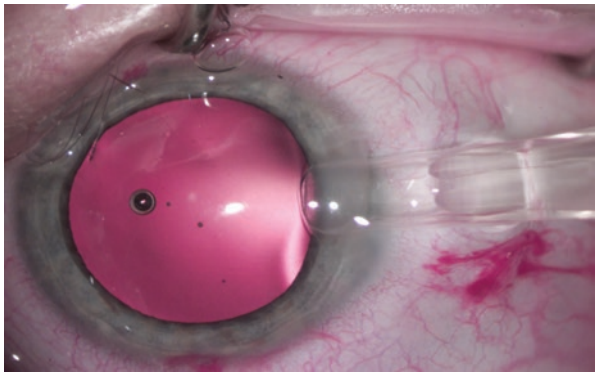

Fig. 3 Posterior chamber phakic intraocular lens

In the treatment options, we will observe that each treatment has a different biomechanical behaviour. The corneal flattening of crosslinking is due to the contraction of the stromal lamellae. This allows the stroma to become more rigid, and in many cases, a slight flattening is produced. The corneal flattening obtained after corneal crosslinking is due to the contractions of the stromal lamellae.

When we talk about corneal refractive correction, especially with laser, its biomechanical behaviour obeys Dr. José Ignacio Barraquer's law of thickness, which tells us: "If we remove tissue in the periphery or add it in the centre, we bend the cornea" and, on the contrary, "If we remove tissue in the centre or add it in the periphery, we flatten the cornea". This is a way of "carving or sculpting" the anterior structure of the cornea.

However, Barraquer's studies and findings were based on healthy corneas which he planned to modify its anterior face in order to be refractive. Therefore, this thickness law does not apply to all keratoconus corneas. Unstable and/or weak corneas do not obey this law. What must be done? How do we calculate? How do we predict their behaviour? [11].

Such is the case of corneal rings, which do not respond in essence to Dr. Barraquer's law. In the case of intracorneal ring implantation, there is no corneal carving. In these cases, the cornea is not carved, the intracorneal rings produce a "tension" generated in the posterior stroma and a consequent flattening in the anterior layers of the cornea.

A great panorama is opened with the new therapeutic alternatives to treat keratoconus. We can say that they are not palliative and compensatory; they are more radical, if the term is allowed. This type of treatment, unimaginable at the end of the twentieth century, contributes to creating a cornea with coefficients closer to normal tissue. Stromal regeneration therapy has shown very good results in that way too, and we believe it will be a solid treatment alternative, which will be consolidated in the near future. This is expressed in one of our chapters [12, 13].

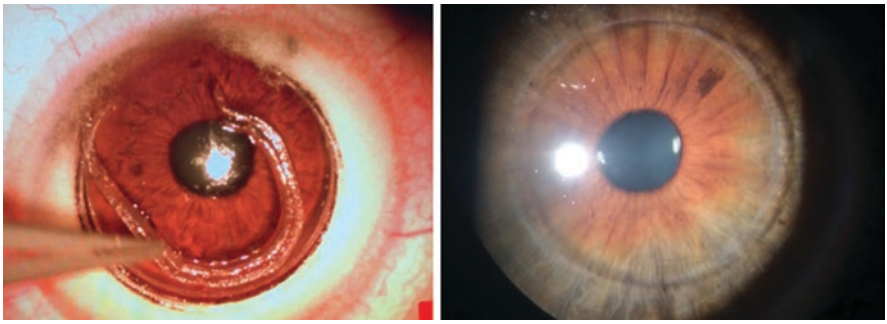

Fig. 4 Corneal remodelling

Talking about keratoconus without mentioning the concepts of corneal biomechanics is impossible. We address new concepts on this topic that will allow us to lead the analysis from a new approach. We would like to specially highlight a new surgical alternative to treat corneal ectasia, which we have called "corneal remodelling" (Fig. 4) [14, 15]. This technique is a new concept that moves away from the conceptual bases of "laminar contraction", observed in corneal crosslinking; it also differs from the one observed in the Thickness Law, "carved or sculpted" and it is also far from the concept of "tense deformation", presented in intracorneal rings. Since resistance is the keyword suffered by corneas with keratoconus, with this new concept, we introduce ourselves into the generation of a new limbo, resistant, which generates a physiological corneal profile. This new concept is based on "corneal stretching", which is the essence of the procedure. The results observed encourage us to think that it becomes a valid alternative procedure between the tools of the present and the future, at least until other superior technologies appear. This new therapeutic instrument is efficient in the optical and refractive management of keratoconus. One of its great advantages is the wide and clear optical zone, which allows optical aberrations to be modified and aims at the recovery of visual quality.

We have not included in the content of the book the alternative of performing keratoplasty, as it is our goal to give a great panorama of the immediate future that is foreseen regarding the most effective treatments for corneas with keratoconus. We believe that well-understood medicine is more corrective and less palliative.

To conclude this brief introduction, we should not take each technique as an isolated or separate treatment entity, but rather as a combinable and elastic whole, capable of being coupled in one or several procedures. One, two or more of these alternatives may be indicated simultaneously or in a deferred form. In our experience, the result of the combination of therapies is usually very positive not only in the optical and biostructural treatment of keratoconus but also in the refractive improvement of our patients.

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