

# Corneal and Scleral Elevation Topography Changes After Corneal Hydrops in Keratoconus Cases

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## Background

A recent case was reported where collagen crosslinking not only substantially changed the cornea but also the scleral shape necessitating a remake to the previously well-fitting scleral lens<sup>1</sup>. It was unclear whether this scleral shape change occurred directly because of selective areas of stiffening of the sclera based upon riboflavin accumulation and UV light exposure or indirectly due to transmitted stress or tightening from the cornea. Consejo and Rozema<sup>2</sup> have argued against an indirect effect since the stiffness of the sclera is higher than the cornea making it more difficult for the cornea to deform the sclera.

DeNaeyer G, Sanders DR van der Worp, E, et.al. described the use of circumferential scleral plots (Figure 1) to characterize scleral surface patterns. These plots can be generated for any radius from the corneal center and thus can be used to compare corneal and scleral changes after hydrops or other pathology or procedures affecting ocular surface shape.

This report summarizes 4 cases of corneal hydrops where Corneo-scleral topography using the sMap3D instrument (Precision Ocular Metrology, Los Angeles, CA) was performed prior to and 3-5 months post the hydrops event. Since hydrops only affects the cornea, any effect on the sclera should be indirect due to corneal changes.

## Case 1 (YM) 28 y/o ♀

This 28 year old female Keratoconus patient developed Hydrops in March 2016. The corneal elevation and sagittal height (SAG) maps pre and 5-months post hydrops showed a regularization of the surface and a less prominent kono after hydrops (Figure 2). The corneal shape plot through the apex of the kono and the scleral shape plot at a 16mm diameter from the corneal center showed a decrease in the mean SAG value in both plots of 253µ post hydrops; the general shape of the corneal and scleral maps remained unchanged (Figure 3).

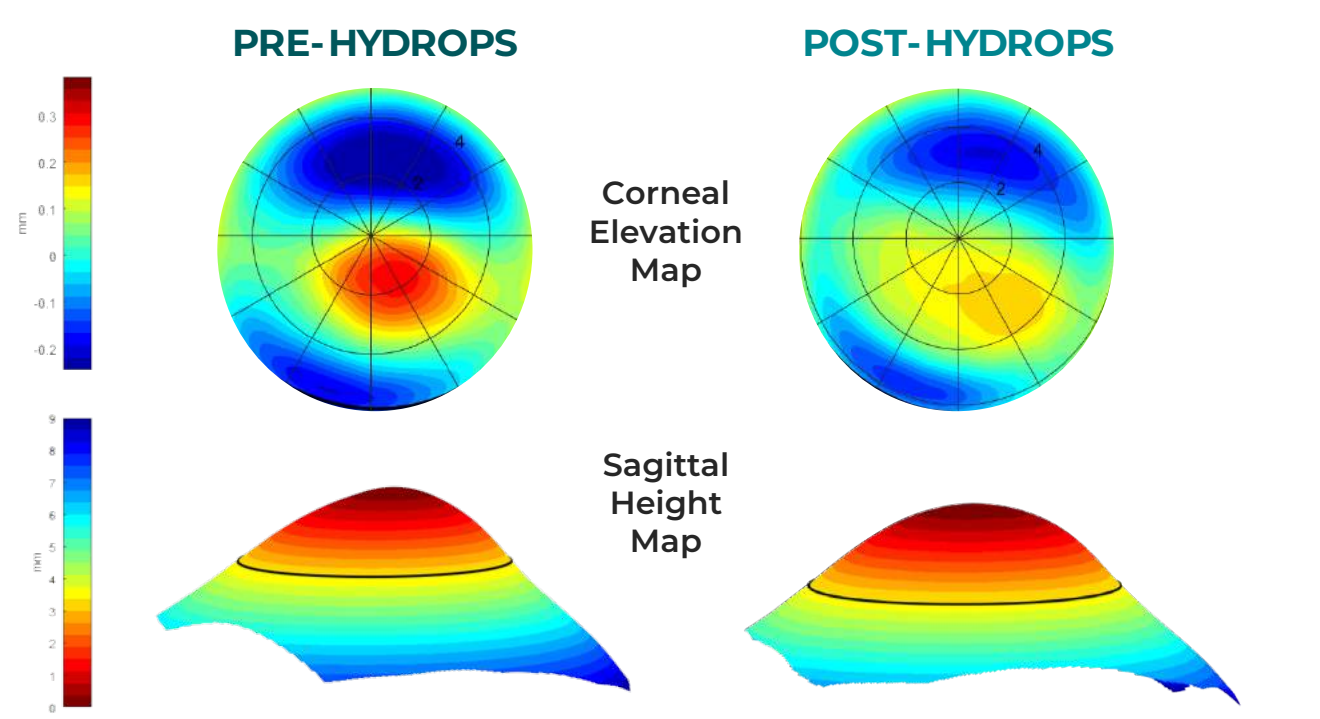


Figure 2 Corneal elevation (Top) and sagittal height (Bottom) maps demonstrated a regularization of the cornea and a less prominent kono post hydrops.

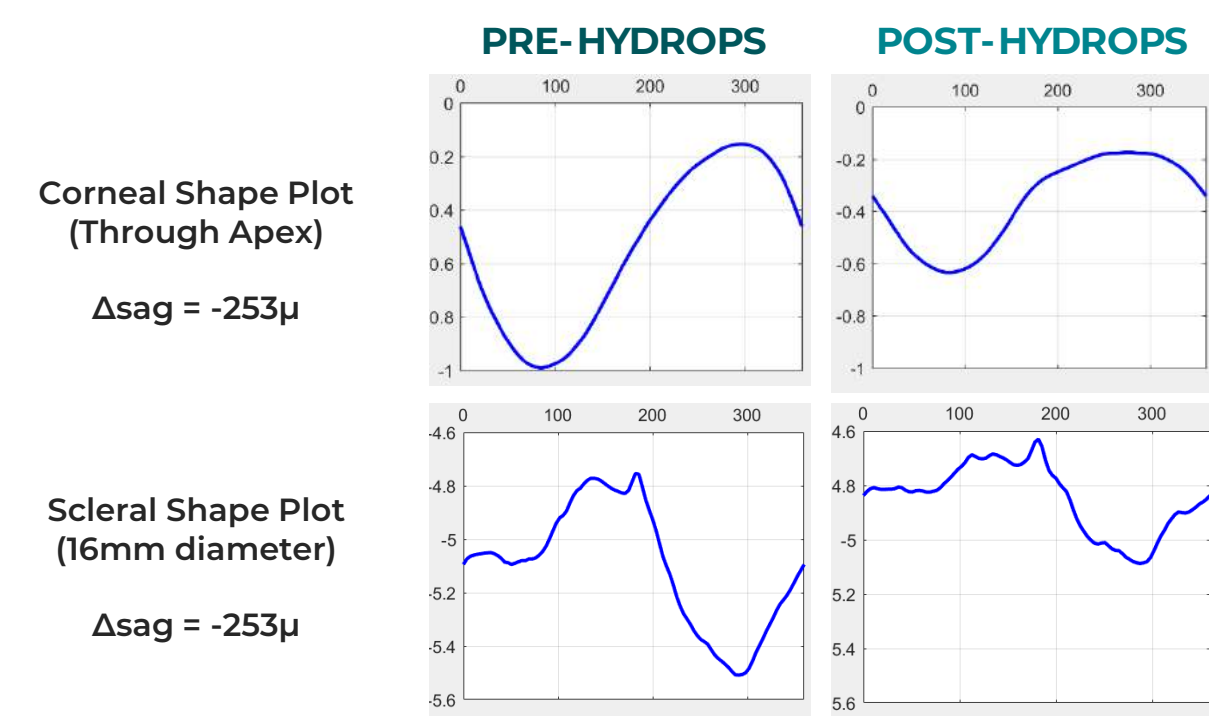


Figure 3 The corneal shape plots through the apex of the kono and the scleral shape plots at the 16mm diameter from the corneal center both showed a narrowing of the excursion from highest point to lowest point on the shape plots as well as a decrease in the average SAG value of 253µ for both post hydrops. The general shape of the corneal and scleral maps remained unchanged post hydrops.

## Case 3 (KJ) 49 y/o ♀

This 49 year old female Keratoconus patient was fit with a Europa lens using sMap3D data in October 2016 and developed Hydrops in March 2018. The corneal elevation and sagittal height maps pre and 3-month post hydrops showed a progression of the kono after hydrops (Figure 6). The corneal shape plot through the apex of the kono showed an increase in the mean SAG value of 92µ and the scleral shape plot at a 16mm diameter from the corneal center showed an increase in the mean SAG value of 442µ; the scleral shape plot showed only mild changes, becoming more toric (Figure 7).

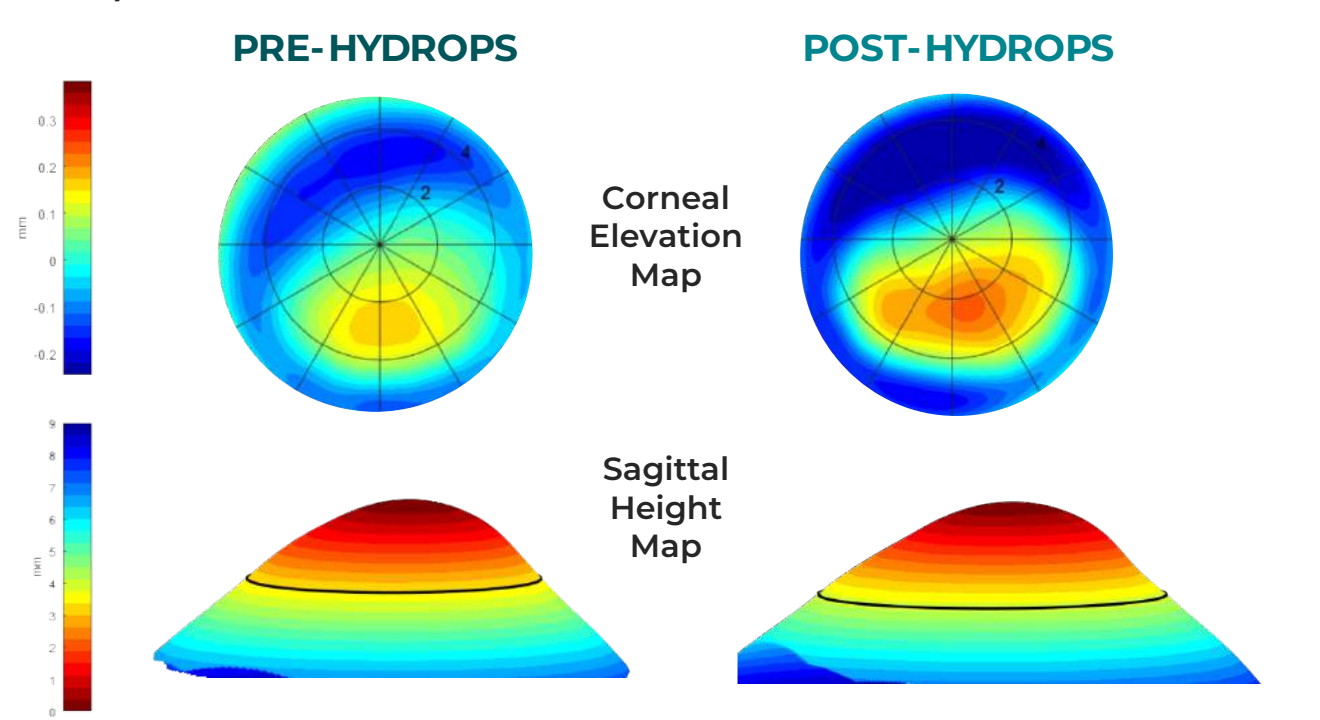


Figure 6 Corneal elevation (Top) and sagittal height (Bottom) maps demonstrated progression of the irregularity of the cornea and a more prominent kono post hydrops.

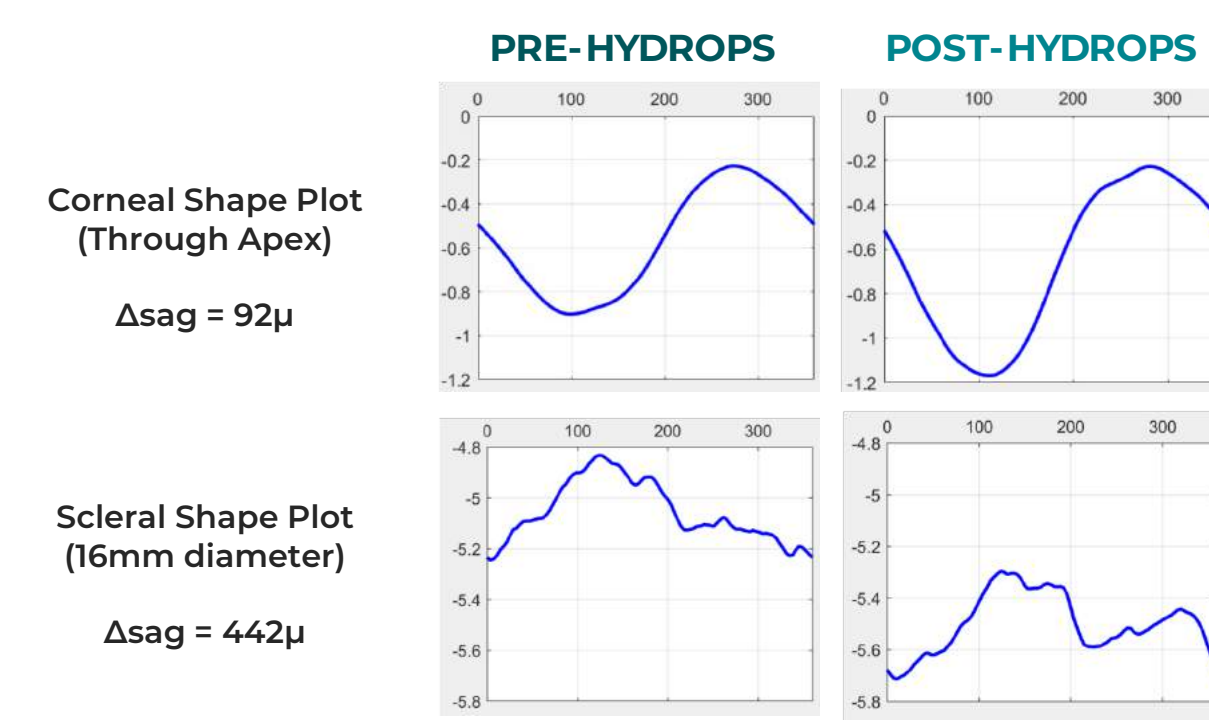


Figure 7 The corneal shape plot through the apex of the kono showed a widening of the excursion from highest point to lowest point post hydrops while the scleral shape plot at the 16mm diameter from the corneal center showed little changes in excursion and mild shape changes; there was an increase in the average SAG value of 92µ in the cornea and 442µ in the sclera.

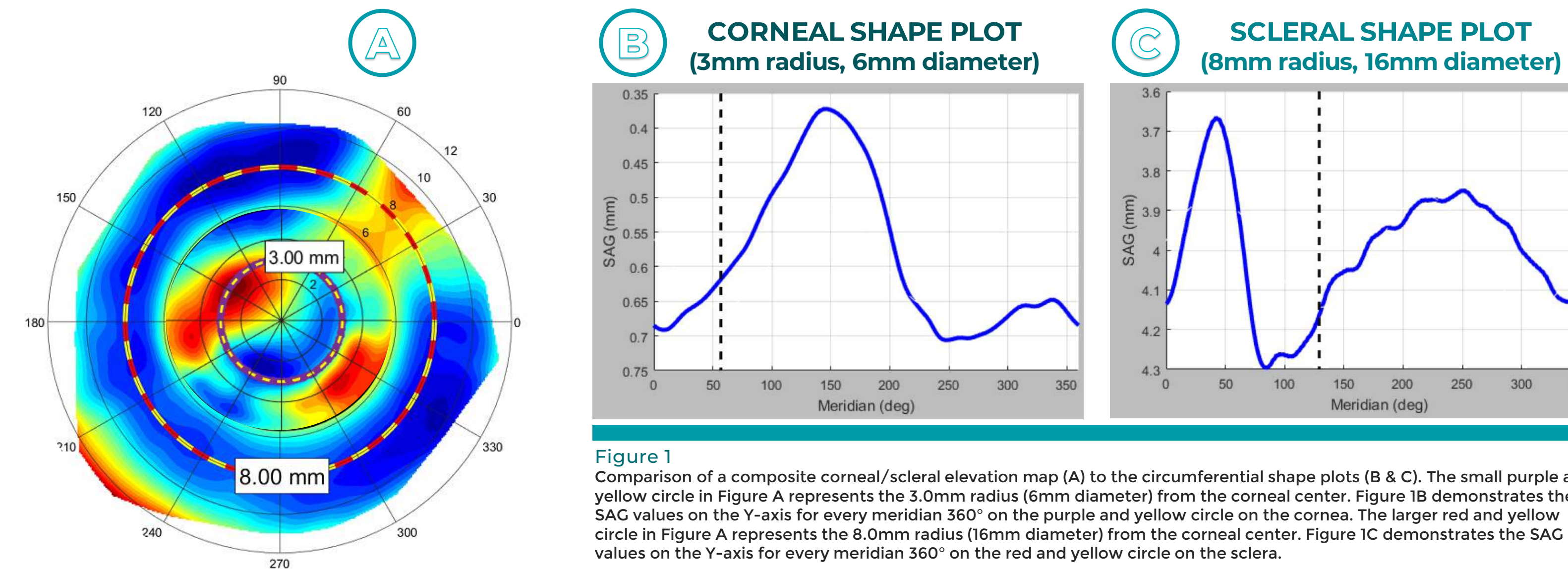


Figure 1 Comparison of a composite corneal/scleral elevation map (A) to the circumferential shape plots (B & C). The small purple and yellow circle in Figure A represents the 3.0mm radius (6mm diameter) from the corneal center. Figure 1B demonstrates the SAG values on the Y-axis for every meridian 360° on the purple and yellow circle on the cornea. The larger red and yellow circle in Figure A represents the 8.0mm radius (16mm diameter) from the corneal center. Figure 1C demonstrates the SAG values on the Y-axis for every meridian 360° on the red and yellow circle on the sclera.

## Case 2 (MC) 26 y/o ♂

This 26 year old male Keratoconus patient developed Hydrops in November 2014. The patient was fit with a Europa lens using sMap3D data in August 2016. In September 2017, the patient had a second hydrops event. The corneal elevation and sagittal height maps pre and 4-month post the second hydrops event again showed a regularization of the surface and a less prominent kono after hydrops (Figure 4). The corneal shape plot through the apex of the kono showed a decrease in the mean SAG value in of 207µ and the scleral shape plot at a 16mm diameter from the corneal center showed a decrease in the mean SAG value of 224µ; general shape of the corneal and scleral maps remained unchanged (Figure 5).

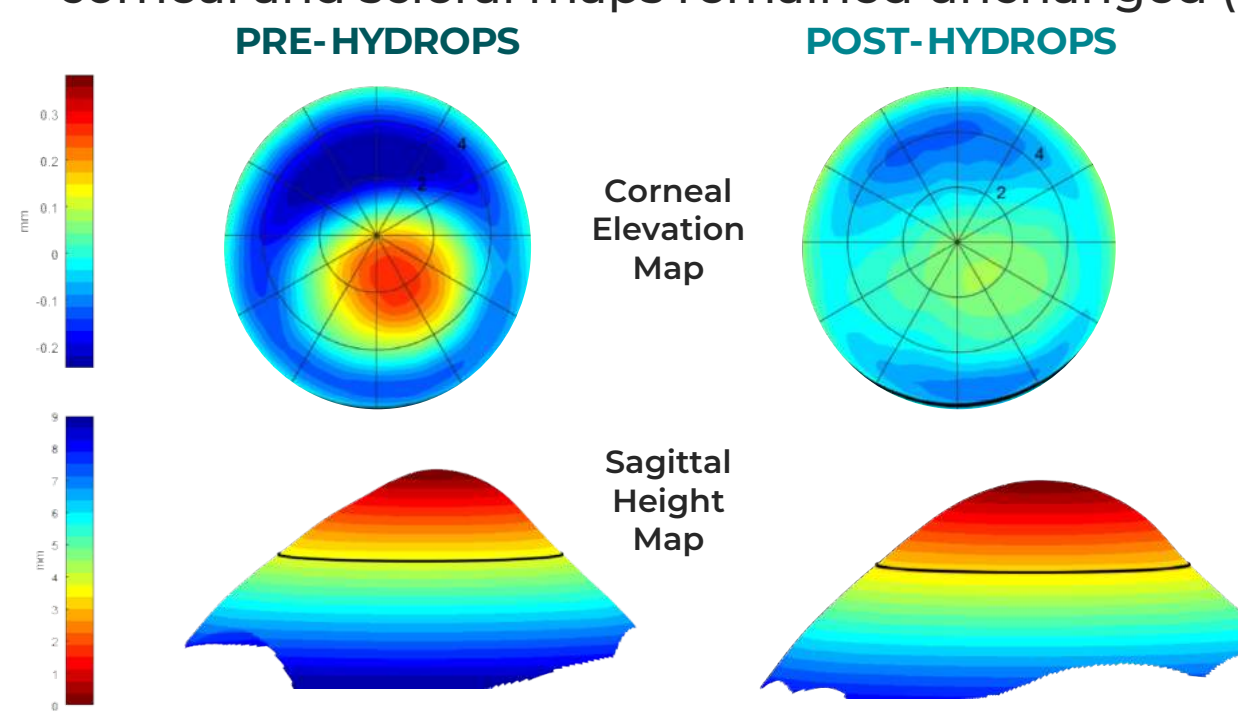


Figure 4 Corneal elevation (Top) and sagittal height (Bottom) maps demonstrated a regularization of the cornea and a less prominent kono post hydrops.

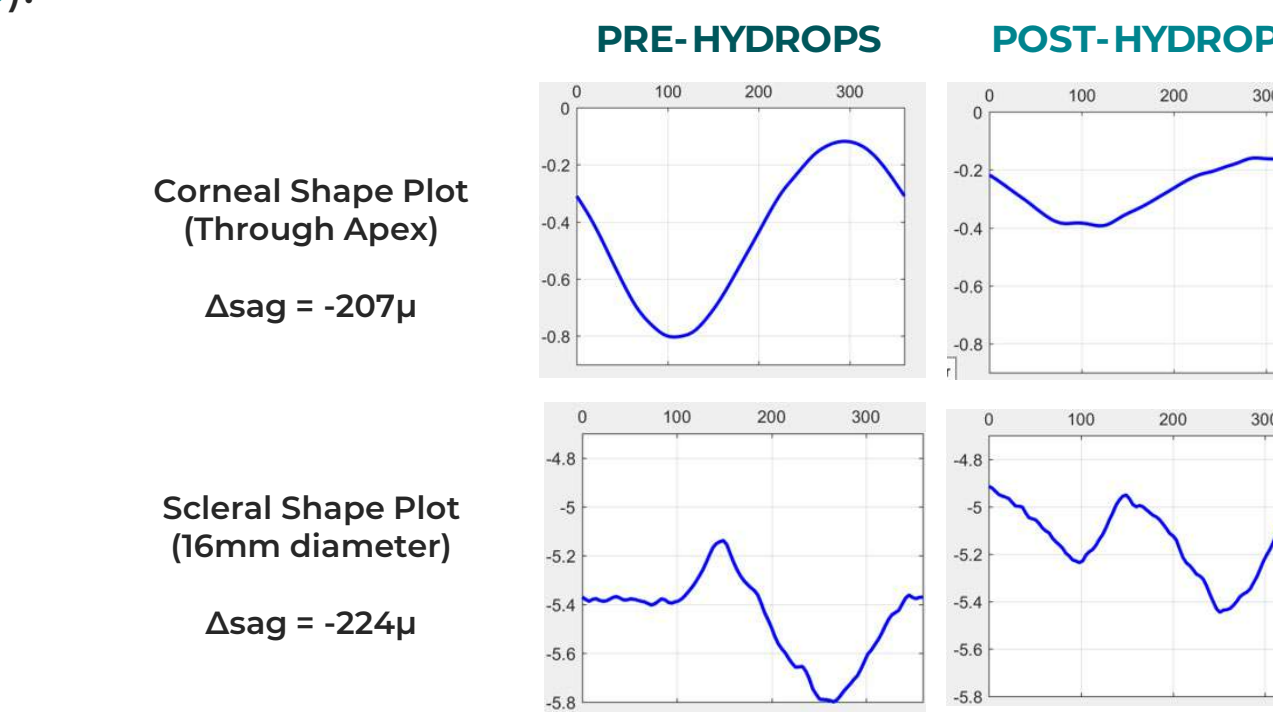


Figure 5 The corneal shape plots through the apex of the kono and the scleral shape plots at the 16mm diameter from the corneal center both showed a narrowing of the excursion from highest point to lowest point on the shape plots; there was a decrease in the average SAG value of 207µ in the cornea and 224µ in the sclera.

## Case 4 (JE) 45 y/o ♂

This 45 year old male Keratoconus patient was fit with a Europa lens using sMap3D data in June 2016 and developed Hydrops in December 2017. The corneal elevation and sagittal height maps pre and 4-month post hydrops showed a progression of the kono after hydrops (Figure 8). The corneal shape plot through the apex of the kono showed an increase in the mean SAG value in of 169µ and the scleral shape plot at a 16mm diameter from the corneal center showed an increase in the mean SAG value of 286µ; the scleral shape plot became less toric and more asymmetric with an inferior depression of approximately 850µ (Figure 9).

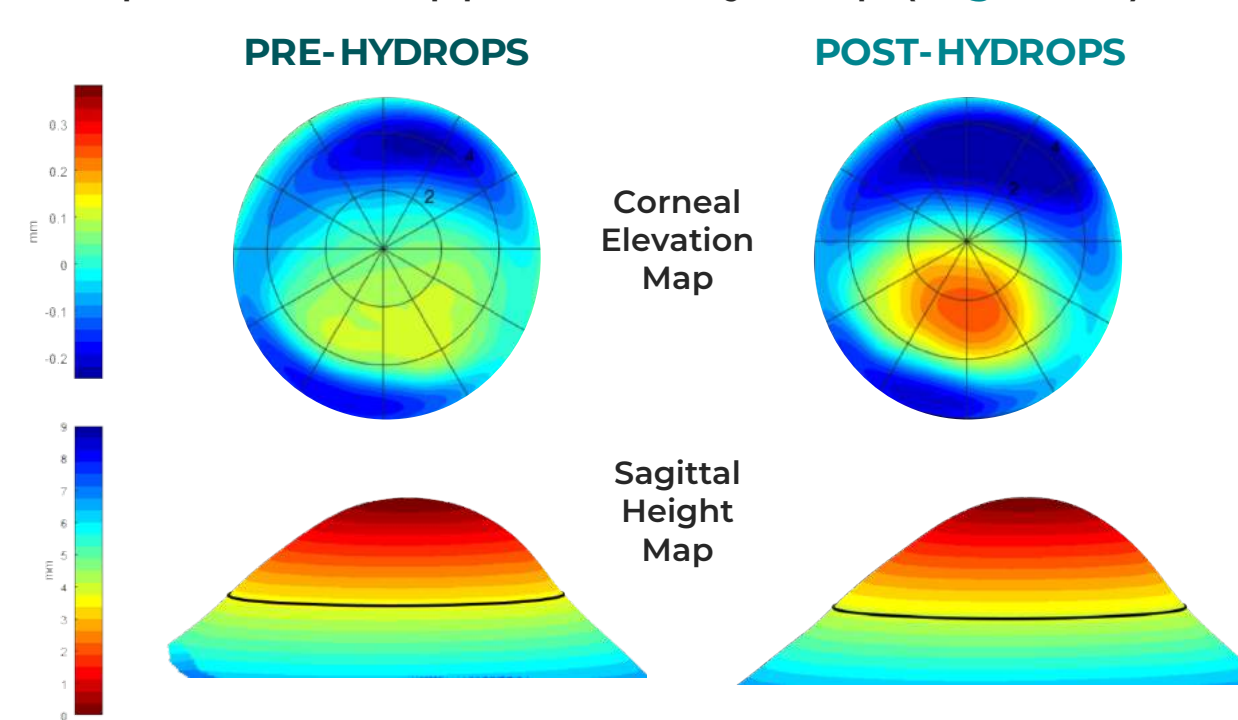


Figure 8 Corneal elevation (Top) and sagittal height (Bottom) maps demonstrated progression of the irregularity of the cornea and a more prominent kono post hydrops.

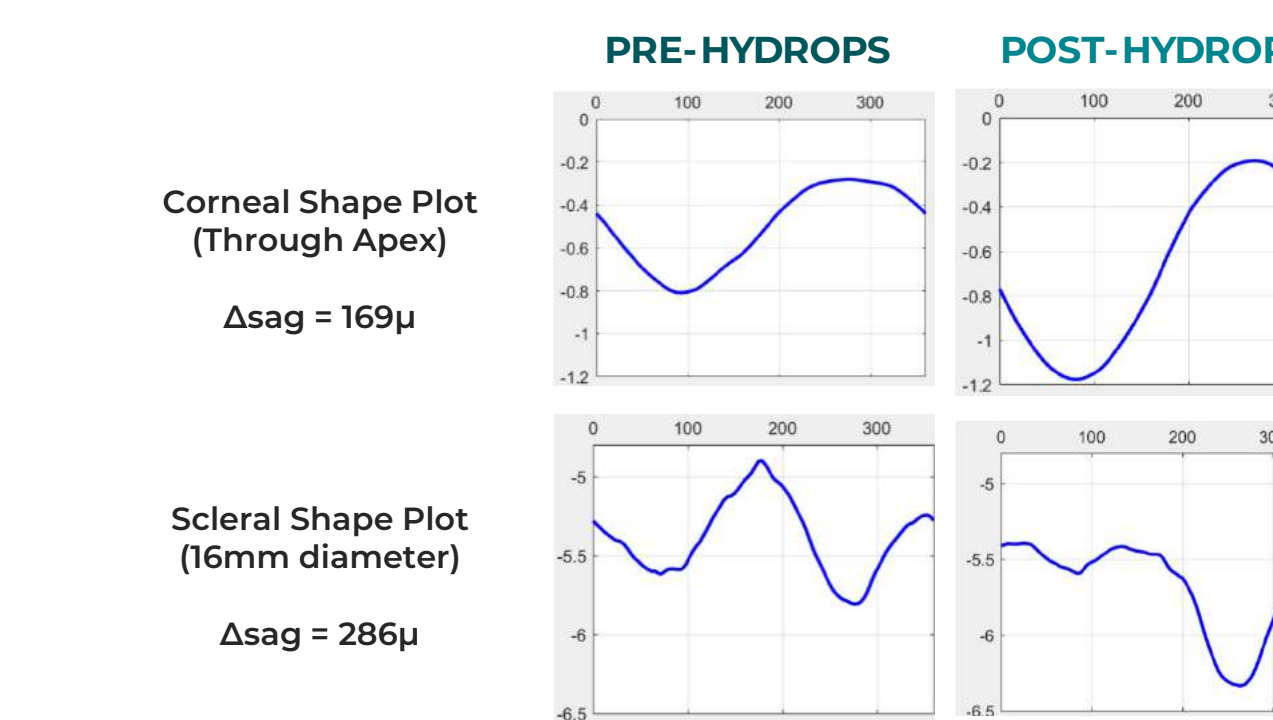


Figure 9 The corneal shape plot through the apex of the kono showed a widening of the excursion from highest point to lowest point post hydrops while the scleral shape plot at the 16mm diameter from the corneal center showed little change in excursion however the general shape of the curve became less toric and more asymmetric; there was an increase in the average SAG value of 169µ in the cornea and 286µ in the sclera.

## Discussion

In the 2 youngest patients (26-28 years old), the findings were very similar; the corneal shape became more regular and the mean sagittal height (SAG) at a diameter of 1.75-2.0mm (through the center of the kono) decreased by 207 to 253µ. The scleral shape plots at a diameter of 16mm showed little change in the actual configuration but there was an overall decrease in the average SAG of between 224 and 253µ, paralleling the decreased SAG of the cornea. In one 49 year old, the corneal shape became less regular and the mean sagittal height at a diameter of 2.5mm increased by 93µ while the scleral shape plot at a diameter of 16mm showed only slight change in the actual configuration but there was a large overall increase in the average SAG of 442µ. In the 4<sup>th</sup> patient, a 45 year old, the corneal shape became less regular and the mean sagittal height at a diameter of 2.4mm increased by 169µ and increased by 286µ at a 16mm diameter. The scleral shape pattern at a 16mm diameter substantially changed from a fairly regular toric shape before hydrops to an approximately 850µ inferior depression.

## Conclusion

The corneal response to hydrops was variable, with two corneas becoming more regular and two becoming less. In those becoming more regular the mean SAG at the diameter of the kono decreased while it increased in those cases becoming more irregular.

In all cases the change in mean SAG pre to post hydrops was in the same direction on the cornea and sclera. In 3 of the 4 cases the scleral shape pattern remained similar pre and post hydrops and in one case where the cornea became more irregular, the scleral pattern changed substantially, becoming more irregular.

These cases demonstrate that the development of corneal hydrops, a disease process thought to be restricted to the cornea, can affect the scleral SAG and shape configuration.

## References

- DeNaeyer, G, Sanders, DR, Collagen crosslinking for keratoconus can change scleral shape. Cont Lens Res Sci Vol 2(1);e15-e21; March 23, 2018.
- Consejo A, Rozema JJ, Scleral Shape and Its Correlations With Corneal Astigmatism. Cornea. 2018 Aug;37(8):1047-1052
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## Disclosures

Dr. DeNaeyer and Sanders and Mr. Farajian are shareholders in Precision Ocular Metrology, the manufacturer of the sMap3D® instrument. Dr. Sanders is a shareholder of and Dr. DeNaeyer is a consultant to Visionary Optics, distributor of the sMap3D and manufacturer of the Europa Scleral lens.