

What Are the Costs of Corneal Cross-linking for the Treatment of Progressive Keratoconus?

To the Editor:

Although corneal cross-linking (CXL) for keratoconus is increasingly applied, there is limited evidence on the costs of this treatment. One cost-effectiveness study estimated the costs of the total CXL treatment for one simulated patient as £928 (\$1,392 U.S.).¹ In our study, we assessed the costs of CXL in clinical practice, including preoperative eligibility assessments and 1-year follow-up.

All consecutive patients referred for keratoconus to our tertiary referral center between September 2012 and July 2013 were included. Surgical treatment was performed according to the Dresden protocol (3 mW/cm² irradiation for 30 minutes). Inclusion and exclusion criteria were described previously.² All costs of preoperative consultation, surgical procedure, and postoperative costs during 1 year of follow-up were assessed from the health care perspective, following a microcosting approach in concordance with Dutch guidelines for health economic research.³ Equipment costs were based on purchase value, annual volume, and a 10-year depreciation. Costs of medication were obtained from the Dutch Healthcare Institution.⁴ All costs were converted to 2015 Euros and an exchange rate of 1.10 to U.S. dollars was applied.

A total of 43 patients (86 eyes) were included in this study. Twenty-eight eyes of 20 patients were scheduled for CXL treatment. The mean age of treated patients was 20.2 years and mean uncorrected and corrected visual acuity of treated eyes were 20/100 and 20/29, respectively, with a mean maximum keratometry value of 57.50 diopters. The mean total costs for one eye treated with CXL were €1,754.06 (\pm 177.23) or \$1,929.47 (\pm 194.95). The mean costs of the surgical CXL procedure itself were €719.50 (\pm 18.82) of \$791.45 (\pm 20.70) (Table A, available in the online version of this article). Personnel costs were the main driver, accountable for 88.1% of the total costs. Further cost categories, such as medication, diagnostic procedures, and the ultraviolet-A lamp, were accountable for 4.6%, 4.3%, and 3%, respectively (Figure 1).

Although personnel costs are the main expense in the CXL treatment, it should be taken into account that wages can diverge among organizations and countries. In our institution, the surgical procedure is performed by an optometrist, as are parts of the preoperative and postoperative consultation. The investment of medical specialist time is therefore reduced. If all care would be delivered by an ophthalmologist, the costs of the treatment itself would increase by 23.5% and the overall cost by 20.3% (calculations not shown). Accelerated CXL has been shown to produce similar results with shorter ultraviolet-A radiation times and thus shorter surgical procedure times.⁵ A decreased radiation time from 30 to 5 minutes

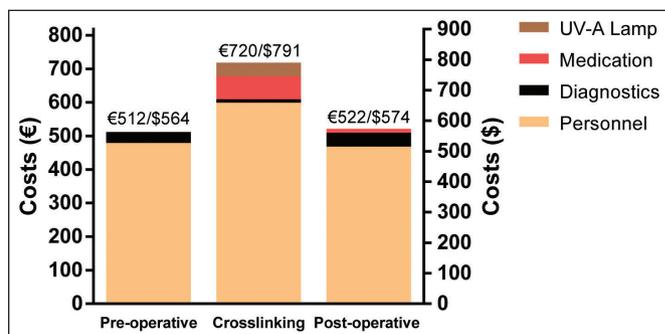


Figure 1. Costs of one eye treated with corneal cross-linking for progressive keratoconus during preoperative consultation, surgical cross-linking procedure, and 1-year postoperative follow-up. The total costs for one eye treated with cross-linking were €1,754.06 or \$1,929.47. UVA = ultraviolet-A

would save €141.09 or \$155.20 (8.0% of total costs and 19.6% of CXL treatment costs). The relatively small decrease is explained by the fact that the majority of costs are incurred during the preoperative consultations and postoperative follow-up period. More detailed insight is provided in Table A. This table can also be used to adjust wages and material costs to local situations.

These results provide insight in the financial side of CXL treatment and can be used in health economic evaluations, procedural pricing, and reimbursement negotiations.

REFERENCES

- Salmon HA, Chalk D, Stein K, et al. Cost effectiveness of collagen crosslinking for progressive keratoconus in the UK NHS. *Eye (Lond)*. 2015;29:1504-1511
- Wisse RP, Godefrooij DA, Soeters N, et al. A multivariate analysis and statistical model for predicting visual acuity and keratometry one year after cross-linking for keratoconus. *Am J Ophthalmol*. 2014;157:519-525.
- Oostenbrink JB, Bouwmans CAM, Koopmanschap MA, et al. *Handleiding voor Kostenonderzoek: Methoden en Standaard Kostprijzen voor Economische Evaluaties in de Gezondheidszorg*. Diemen: College voor Zorgverzekering; 2010.
- Dutch Healthcare Institution. Information about drug costs [article in Dutch]. Available at: <http://www.medicijnkosten.nl>. Accessed: July 10, 2015
- Hashemi H, Fotouhi A, Mirafteb M, et al. Short-term comparison of accelerated and standard methods of corneal collagen crosslinking. *J Cataract Refract Surg*. 2015;41:533-540.

Daniel A. Godefrooij, MD
 Pepijn van Geuns, BSc
 G. Ardine de Wit, PhD
 Robert P. L. Wisse, MD, PhD
 Utrecht, the Netherlands

Supported by unrestricted grants from the Dr. F.P. Fischer Foundation (DG, RW), facilitated by the Foundation Friends from the UMC Utrecht.

The authors have no financial or proprietary interest in the materials presented herein.

doi:10.3928/1081597X-20160318-01

TABLE A
**Costs of Cross-linking Treatment for Keratoconus Including
 Preoperative Assessment and Follow-up During 1 Year**

Parameter	Costs Per Unit (€)	Units of Resource Use (Mean)	Mean Costs (€)
Preoperative costs			
First outpatient visit (20 + 20 minutes)			
Corneal specialist	145.55/visit	1.00	145.55
Optometrist	112.87/visit	1.00	112.87
Diagnostic procedures			
Keratometry	5.72/eye	2.00	11.44
Endothelial cell count	3.68/eye	1.05	3.85
Progression control consultation (15 minutes)			
Corneal specialist	109.16/visit	0.05	5.08
Optometrist	84.66/visit	0.42	35.44
Resident	89.12/visit	0.02	2.07
Nurse practitioner	85.31/visit	0.05	3.97
Diagnostic procedures			
Keratometry	5.72/visit	1.07	6.12
Endothelial cell count	3.68/eye	0.09	0.34
Consultation by telephone (10 minutes)			
Corneal specialist	3.12/call	0.12	2.27
Optometrist	3.12/call	0.12	0.36
Non-patient-related consultation	11.32/patient	0.33	3.69
No shows	12.50/visit	0.05	0.58
Costs per evaluated patient (n = 43)			333.63 ± 123.30
Costs per treated eye (n = 28)			512.36 ± 52.45
Cross-linking treatment			
Procedural costs			
Optometrist (105 minutes)	592.57/visit	1.00	592.57
Abrasion	5.79/abrasion	1.00	5.79
Materials			
UVA lamp	37.01/eye	1.00	37.01
Pachymeter	10.36/eye	1.00	5.79
Bandage contact lens	4.42/eye	1.00	4.42
Medication			
Riboflavin	59.61/eye	1.00	59.61
Hypotone riboflavin	59.61/eye	0.11	6.39
Preoperative eye drops	2.77/eye	1.00	2.77
No shows	16.39/visit	0.04	0.59
Costs of surgical cross-linking procedure (n = 28)			719.50 ± 18.82
Postoperative costs			
Medication			
Postoperative eye drops	11.78/eye	1.00	11.78
Oral medication	0.40/eye	1.00	0.40
Outpatient visit (≤ 1 week, 10 minutes)			
Corneal specialist	72.78/visit	0.25	18.20
Optometrist	56.44/visit	0.64	36.28
Resident	59.42/visit	0.36	21.22
Nurse practitioner	56.87/visit	0.07	4.06
Outpatient visit (> 1 week, 20 minutes)			
Corneal specialist	145.55/visit	0.11	15.59
Optometrist	112.87/visit	2.64	298.30
Resident	118.83/visit	0.18	21.22
Nurse practitioner	113.74/visit	0.29	32.50
Diagnostic procedures			
Keratometry	5.72/eye	6.43	36.77
Endothelial cell count	3.68/eye	1.43	5.25
Emergency outpatient visit (20 minutes)			
Corneal specialist	145.55/visit	0.07	10.40
Optometrist	112.87/visit	0.04	4.03
Resident	118.83/visit	0.04	4.24
Consultation by telephone (10 minutes)			
Corneal specialist	19.53/call	0.07	1.40
Optometrist	3.12/call	0.04	0.11
No shows	3.12/visit	0.14	0.45
Postoperative costs			522.20 ± 164.71
Total costs per cross-linking treatment (€)	Total ± SD		1,754.06 ± 177.23

costs per evaluated patient = average preoperative costs per patient; costs per treated eye = average preoperative costs per treated eye; abrasion = performed by either corneal specialist or resident (weighted average); preoperative eye drops = oxybuprocaine, tetracaine, iodine, and isotonic saline solution 0.9%; postoperative eye drops = chloramphenicol, polyvidon, and fluormetholone; oral medication = paracetamol and diclofenac; outpatient visit (≤ 1 week) = short visit without diagnostic procedures; no shows = patients not attending scheduled appointments