

Recent Advances in Contact Lenses

Essay

*Submitted for Partial Fulfillment of Master
Degree of Ophthalmology*

By

Dr. Amany El Sayed Ahmed El Sabbagh

Under supervision of

Prof. Dr. Magdy Mohammed El Barbary

Professor and head of Ophthalmology department

Faculty of Medicine- Ain-Shams University

Dr. Maged Maher Salib

Lecturer of Ophthalmology

Faculty of Medicine-Ain-Shams University

Faculty of Medicine

Ain-Shams University

Cairo, Egypt

2012

أحدث التطورات في مجال العدسات اللاصقة

رسالة

توطئة للحصول على درجة الماجستير في
طب وجراحة العيون

مقدمة من

الطبيبة / أماني السيد أحمد الصباغ

تحت إشراف

أ.د. / مجدي محمد البربري

أستاذ ورئيس قسم طب و جراحه العيون
كلية الطب- جامعة عين شمس

د. / ماجد ماهر صليب

مدرس طب و جراحه العيون
كلية الطب- جامعه عين شمس

كلية الطب

جامعة عين شمس

القاهرة

٢٠١٢

Contents

	Page
List of Abbreviations.....	I
List of Tables	III
List of Figures.....	IV
Protocol	VIII
Contact Lens materials.....	1
Manufacturing of contact lenses	24
Presbyopic contact lenses.....	34
Toric contact lenses.....	43
Contact lenses used in keratoconus	47
Aspheric contact lenses.....	62
Orthokeratology	67
Therapeutic applications of Contact lenses.....	79
Tinted and prosthetic contact lenses.....	89
Summary.....	100
References	102
Arabic Summary	

List of Abbreviation

AA:	Acuvue A dvance
ACT:	A symmetric C orneal T echnology
AO:	Acuvue O asys
ASD:	A cademic S kills D isorder
AV2:	Acuvue 2
CL:	C ontact L ens
DA:	D iacetone a crylamide
Dk:	Oxygen Permeability
Dk/t:	Oxygen Transmissibility
DMA:	D imethyl a crylamide
E:	Modulus of E lasticity
EDTA:	E thylene d iamine t etra a cetic acid
FDA:	F ood and D rug A ministration
FND:	F ocus N ight and D ay
GVHD:	G raft V ersus H ost D isease
IC:	I rrregular C ornea
LASEK:	L aser A ssisted S ub E pithelial K eratectomy
LASIK:	L aser A ssisted I n S itu K eratome l usis
MAA:	M ethacrylic a cid
MEMS:	M icro-machined E lectro M echanical S ystems
MMA:	M ethyl m ethacrylate
MPa:	M ega P ascal
NCVE:	N - C arboxy v inyl e ster
NVP:	N - V inyl p yrrolidone
OSD:	O cular S urface D isease
OZ:	O ptical Z one
PBVC:	P oly b utanol v inyl c arbamate
PC:	P hosphoryl c holine
PED:	P ersistent E pithelial D efect
pHEMA:	p oly h ydroxyethyl m ethacrylate
PLGA:	P oly l actic-co- g lycolic a cid
PMMA:	P oly m ethyl m ethacrylate
PV:	P ure V ision
PVP:	P oly v inyl p yrrolidone

RGP: **R**igid **G**as **P**ermeable
SiH: **S**ilicone **H**ydrogel
t: **T**hickness of the lens
TPVC: **T**rimethylsiloxysilyl **p**ropyl **v**inyl carbamate
TRIS: **T**rimethyl**S**iloxy silane
USAN: **U**nited **S**tates **A**dopted **N**ame
US FDA: **U**nited **S**tates **F**ood and **D**rug **A**ministration

List of tables

Table number	Contents	Page number
Table 1	Spherical SiH lenses	3
Table 2	Central and peripheral Dk/t values for a range of currently available CLs. Calculation use manufaurers' data for Dk and laboratory values of maximaum peripheral lens thickness.	7
Table 3	Major tear film proteins.	15
Table 4	The United States Food and Drug Administration (FDA) classification of soft CL materials.	18
Table 5	Silicon hydrogel FDA –approved for therapeutic use.	80

List of Figures

Figure Number	Contents	Pagse number
Figure 1	Relationship between water content and oxygen permeability (Dk) for conventional hydrogels.	3
Figure 2	Relationship between water content and oxygen permeability for SiH.	4
Figure 3	Relationship between measures of corneal oxygenation and Dk/t during daily CL wear.	6
Figure 4	Rigid gas permeable (RGP) lens.	10
Figure 5	Methacrylic Acid (MAA).	11
Figure 6	One big difference between soft lenses and RGP lenses is their size: RGP lenses generally have a smaller diameter.	12
Figure 7	Ocular surface-tear film interface.	13
Figure 8	Degree of lysozyme deposition measured on Focus Night & Day (lotrafilcon), PureVision (balafilcon) and Acuvue (etafilcon).	16
Figure 9	Measures of denatured lysozyme (less activity signifies greater levels of denaturation) on a range of CL materials.	17
Figure 10	Degree of lipid deposition measured on Focus Night & Day (lotrafilcon), PureVision (balafilcon) and Acuvue (etafilcon).	20
Figure 11	Lipid caliculi on soft lens surface.	21
Figure 12	Modern precision Lathes, and polishing machine for CLs.	25
Figure 13	Cast molding of CLs.	27
Figure 14	Thermofusion Technology.	28
Figure 15	Vacuum-forming.	28
Figure 16	Injection molding and casting.	29

Figure Number	Contents	Pagse number
Figure 17	Dry cast molding.	31
Figure 18	Wet cast molding.	32
Figure 19	Sandwich color process.	33
Figure 20	Comparison between normal and presbyopic eye.	35
Figure 21	Aspheric multifocal lens.	40
Figure 22	Concentric multifocals lens.	40
Figure 23	Diffractive design.	41
Figure 24	The translating design, the near prescription is on the bottom. The bottom edge is flattened to keep the lens from rotating on eye during blinking.	42
Figure 25	Bifocal hard lens, with a D-shaped segment.	42
Figure 26	Double slab-off (dual thin zone) design.	46
Figure 27	Keratoconus with steepening of cornea.	47
Figure 28	Classic stigmata of keratoconus include Fleischer's ring, Vogt's striae and central scaring.	48
Figure 29	Corneal topography of keratoconic patient.	48
Figure 30	RGP lens with three point touch.	50
Figure 31	GP lens with apical clearance with central fluorescein pooling.	51
Figure 32	GP lens with flat fitting.	52
Figure 33	Fluorescein pattern of CL by Oculus Pentacam.	53
Figure 34	Automated Corneal Topographer Medmont E300.	53
Figure 35	The Medmont topographer's CL module is used to build an initial trial lens for this eye. The second image shows a diagnostic lens with the same parameters on-eye.	54
Figure 36	Piggyback CL.	55
Figure 37	Hybrid lens.	56
Figure 38	ClearKone lens.	56

Figure Number	Contents	Pagse number
Figure 39	Demonstrates the benefits of a smaller optical zone of Rose K lens to fit the cone contour. The design results in little tear pooling at the base of the cone and show an even distribution of tears under the lens.	58
Figure 40	Rose K lens fitted on this asymmetric keratoconic cornea fits well at 3, 9 and 12 o'clock but causes the lower edge to lift off at 6 o'clock.	60
Figure 41	Incorporating ACT into the design significantly improves the fit at 6 o'clock, making the lens more comfortable and stable and providing superior vision.	60
Figure 42	Asymmetric Corneal Technology improves lens performance for the irregular cornea.	61
Figure 43	Spherical aberration: light rays from the periphery are not focused on the retina.	62
Figure 44	Spherical aberrations with plus and minus powered CLs.	64
Figure 45	Reverse-geometry CL used in orthokeratology.	67
Figure 46	Fluorescein pattern of an orthokeratology hyperopic lens.	73
Figure 47	Toric orthokeratology lens on a cornea exhibiting with-the-rule corneal astigmatism.	74
Figure 48	Components of Reverse-geometry CL used in orthokeratology.	77
Figure 49	Fluorescein pattern of an orthokeratology lens.	78
Figure 50	Persistent epithelial defect (PED).	81
Figure 51	Peripheral corneal thinning and secondary wound leak.	82
Figure 52	Bullous keratopathy.	83
Figure 53	Sensimed Triggerfish.	86
Figure 54	Scleral lens over transplanted cornea.	88

Figure Number	Contents	Pagse number
Figure 55	CL with light blue visibility tint.	89
Figure 56	Opaque colored CLs.	90
Figure 57	Light filtering tinted lens.	91
Figure 58	Prosthetic CLs.	92
Figure 59	A patient prior to application of prosthetic CL and the improved cosmetic appearance after lens application.	92
Figure 60	Scleral prosthetic CLs.	94
Figure 61	The X-chrome CL.	96
Figure 62	Magnocellular pathway.	98
Figure 63	ChromaGen lenses.	99



*First and foremost, I thank **Allah**, without his aid this work would not have been.*

*I would like to express my deepest gratitude to **Prof. Dr. Magdy Mohammed El Barbary**, Professor and head of Ophthalmology department, Faculty of Medicine, Ain Shams University, for his kind supervision and continuous encouragement.*

*I would like also to express my special thanks to **Dr. Maged Maher Salib**, Lecturer of Ophthalmology, Faculty of Medicine, Ain Shams University, for his support and great help to complete this work.*

*Last but not least my deepest thanks to **My family** for their support and encouragement.*

Introduction

Contact lenses (CLs) have become an excellent alternative to spectacles. There are two different forms of CLs; soft and rigid. Soft lenses are typically made from the traditional hydrogel. More recently, soft lenses are also being made from the newer silicone hydrogel (SiH) material. A basic knowledge of CL materials is essential in the management of clinical complications frequently seen in practice. The optimal CL material is one that meets or exceeds the oxygen requirements of the cornea. The other form is rigid CL; traditional rigid lenses were made of polymethylmethacrylate (PMMA), but are now more commonly prescribed in one of the many gas permeable (GP) materials (*Jones, 2008*).

Three techniques can be employed to manufacture CLs; lathe cutting, spin casting and cast molding. As CLs rest against the highly sensitive eye ball, CLs need to be of the highest quality (*Hough, 2008*).

Contact lenses are commonly used now for the correction of presbyopia. There are several available options, including single vision CL and spectacle over correction for near, monovision, RGP multifocal and bifocal lens designs and soft bifocal lens designs (*Bennett, 2008*).

Contact lenses correction for astigmatism has made significant toric advances over the last years. There are two types: soft toric and toric RGP CLs which include: Front surface toric, back surface toric and bitoric CLs. Each has its advantage and disadvantage (*Russell and Slonim, 2009*).

Keratoconus is an asymmetric bilateral ectasia and thinning of the cornea resulting in increasing steepening of the cornea. The treatment of keratoconus can be implemented by the use of CL of various kinds such as, piggyback, hybrid, scleral and Rose K CL. depending on the severity of keratoconus, a CL is chosen that will give the best visual acuity and tolerance (*Garcia and Alio, 2007*).

Aspheric CLs were made to correct spherical refractive error and ocular spherical aberration, but many studies found that the fitting of aspheric design soft CL does not result in superior visual acuity or aberration control compared with equivalent spherical design soft CL (*Dietze and Cox, 2006*).

Overnight orthokeratology, or corneal reshaping is utilizing reverse-geometry rigid CL to change the shape of the cornea. This is a temporary, reversible technique. Currently, it is most commonly used to flatten the central corneal curvature temporarily and reduce the corneal eccentricity. So, it is used with myopia and with-the-rule astigmatism. Recently it is also used in treatment of hyperopia (*Barr et al., 2009*).

Contact lenses have a variety of therapeutic applications in the management of corneal diseases. Common indications for use are relief of pain, promotion of corneal healing and control of corneal hydration (*Rubinstein, 2008*).

The majority of ocular medications are delivered to the eye topically in the form of eye drop. CLs could

potentially also be used to deliver medications to the eye. Recently, progress has been made in developing a drug eluting CL (*Ciolino et al., 2009*).

Colored or tinted lenses are very common today. The most common uses of them are for cosmetic purposes, along with vision correction. There are four types of tinted CLs: visibility, enhancement, opaque color and light-filtering tints (*Gerald, 2009*).

Any part of the eye may become disfigured due to trauma, ocular disease or congenital defects. Prosthetic CLs may be used to improve the appearance of a disfigured cornea, sclera or iris. These lenses may also be used to replace an enucleated eye, to patch an eye during vision therapy or to treat binocular diplopia (*Carol et al., 2006*).

Aim of the work

Review of literature concerning the recent modalities and technology in CLs to treat different errors of refraction and other eye diseases.