Types of Multifocal IOLs

**Refractive IOLs**
- are designed with several refractive optical zones on the intraocular lens. These zones provide various focal points, allowing for an improvement in distance, intermediate, and near vision.

**Diffractive IOLs**
- Use diffractive optic principle.
- they have diffractive steps on the intraocular lens and they distribute incoming light rays into two principal foci
- Different technologies (diffractive – refractive; diffractive apodized)
Types of Multifocal IOLs

Segmental Multifocal IOL
- Combines an aspheric, asymmetric distance vision zone with sector-shaped near vision zone of 3.00D
- Two specific surfaces with different radii – one main surface and one embedded surface, to create two defined focal points

Accommodative IOL
- So-called “accommodative” intraocular lenses have one focal point only. Their working principle is based upon a focal shift.
Medicontur approach to Multifocal IOLs

- Multifocal IOLs
  - Diffractive
  - Refractive
  - „Accomodative“
  - Full Optic Diffractive
  - Diffractive central zone/refractive periphery
**Fresnel principle** – The Fresnel lens is a type of lens originally developed by French physicist **Augustin-Jean Fresnel** for lighthouses (1820)

**Fresnel lens**, in general, is a thin **refractive** lens

**Fresnel lens** is constructed by removing the „non-refractive part” of the lens

The size of the lens fragments are not necessarily in the order of lambda

**Fresnel lens** – **refractive monofocal**
A **Diffractive lens** is a *very special* Fresnel lens, where the optical path difference (OPD) through the fragments are integer times the wavelength.

- Image is created in the focal point only if there is a positive interference among the waves from each point of each fragment of the surface.
- The height of the steps is in the order of lambda.

The phase shift is $k \lambda$, where $k$ is integer.
Bifocal refractive + diffractive lens

Diffractive Optical principles

The light intensity is shared between refractive and diffractive focus because:

- The height of the steps is not exactly $k*\lambda(n_2-n_1)$ (intentionally and due to manufacturing precision).
- The diffractive structure is optimal for a specific lambda, and not optimal for other wavelengths.

<table>
<thead>
<tr>
<th>Refractive</th>
<th>Diffractive</th>
<th>Bifocal:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Å base power</td>
<td>Å added power</td>
<td>Å base + added power</td>
</tr>
</tbody>
</table>
Diffraction refers to various phenomena which occur when a wave encounters an obstacle.

- = bending of waves around small obstacles and the spreading out of waves past small openings

- As the waves spread out into each other, constructive and destructive interference occurs
Diffractive Bifocal Lens = refractive lens + diffractive microstructure

- Diffraction effect is caused by a micro-structured surface profile of the lens
- The diffracted light contributes to the near focus and the undiffracted light to the far focus

1st-order near focus

Zero order far focus

www.medicontur.com
The steps width determines the **addition power**.

The steps height determines **the energy repartition** between far and near vision.
The steps height determines **the energy repartition** between far and near vision.

The **same step heights** over the whole optic surface = **the same energy repartition** between far/near vision whatever the pupil diameter.
Decreasing steps height from the center to the periphery = variable repertition of the energy between far and near vision respected pupil diameter = **APODIZATION**
Multifocal Hydrophilic Aspheric Diffractive Apodized IOL
To restore near, intermediate and distance vision

- manufactured by lathe-milling process
- polish free technology for perfect Sharp Edge
- aspheric biconvex optic with neutral approach – to maintain depth of field
- combination of apodized diffractive and refractive zones
- apodized diffractive part
  - to improve image quality
  - to minimize visual disturbances
Bi Flex M

- **Diffractive–Refractive Design Concept**
  - To provide improved control energy distribution

- **7 Diffractive Discontinuities**, or steps, that have been incorporated in the anterior surface of the acrylic optic to provide the diffractive added power

- Central diffractive region directs light into near power

- **Apodized** diffractive optic design

- **Apodization** improves image quality by optimizing light energy delivered to the retina by distributing the appropriate amounts of light to near and distant focal points, regardless of lighting situation.
Apodization

- Gradual reduction or blending of the diffractive step heights

- Apodization describes a change in a property of the lens or its function from center to periphery in a radial fashion.

- The apodization property of the Bi Flex M is defined by the gradual reduction in diffractive step heights from center to periphery.

The term apodization derives from the Greek “cutting off the feet”.

1.4 microns

2.2 microns
Neuron cells 4-100 microns
Rods 15 microns
Cones 50-55 microns (at night)
Neuron cells 4-100 microns
Reticulocytes 8 microns

Diffractive steps
1.4 – 2.2 microns
Bi Flex M Technology

Central 3.1 mm apodized diffractive structure

Step heights decrease peripherally from 2.2 – 1.4 microns

+3.5D at lens plane equaling +2.7D at spectacle plane

Outer refractive zone
Light energy balance
Distance/Near = 60/40

Å Near tasks (reading) – small pupil
   ï Good light
   ï Accommodative reflex

Å Distance – dominant activities – larger pupil
   ï Less light
   ï Without accommodative reflex

![Graph showing relative energy vs pupil diameter for near and distance vision.](https://www.medicontur.com)
Assessment of multifocal optical quality

- The modulation transfer function is a measure of the transfer of modulation (or contrast) from the subject to the image.

- The spatial frequency is a measure of how often sinusoidal components of the structure repeat per unit of distance (lines/mm).
Assessment of multifocal optical quality

MTF means how faithfully the lens reproduces detail from the object to the image produced by the lens.

- Transmitted contrast 100%  \( \text{MTF} = 1 \)
- Transmitted contrast 50%  \( \text{MTF} = 0.5 \)
- Transmitted contrast 2%  \( \text{MTF} = 0.02 \)
Through focus curve - Bi Flex M

Tested at 50 cyc/mm (according ISO norms)
The advantage of the Bi Flex M is that the apodized diffractive portion turns into a pure refractive lens in the periphery, and that tends to suppress halos and glare.

2 primary focal points
- one at distance and the other at near
- the near point is equivalent to approximately a +2.7 D added power in the spectacle plane.

The base lens provides the distance power using its refractive shape.
<table>
<thead>
<tr>
<th></th>
<th>Bi Flex M</th>
<th>ReStor</th>
<th>Tecnis</th>
<th>M Flex</th>
<th>Acrilisa</th>
<th>PY-60MV isert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffractive</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Apodized</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Aspheric</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pupil Independ.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>*MICS</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>**SE 360°</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toric Option</td>
<td>coming soon</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ABBE number</td>
<td>58</td>
<td>37</td>
<td>57</td>
<td>58</td>
<td>58</td>
<td>42</td>
</tr>
<tr>
<td>Chromatic aberration</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

**SE – sharp edge;  *MICS – suitable for „sub 2“ Microincision surgery**
Major assets for Medicontur Bi Flex M

1. Material
2. Design
3. Optic
4. Precision
MATERIAL (BENZ 25)
optimally combining hydrophobic and hydrophilic monomers

- HEMA, highly hydrophilic monomer
  Pure HEMA = 38% water content
  >> BIOCOMPATIBILITY

- EOEMA, hydrophobic monomer
  Approximately 2% water content
  >> ELASTICITY
  >> SOFTNESS
  >> SHAPE MEMORY

A hydrophobic
hydrophilic
25% copolymer

www.medicontur.com
A long chain acts as a « molecular eyelash » to prevent cell adhesion and protein deposit.

**Anti-PCO behaviour**

Our raw material: low adhesion for a low PCO rate.
MATERIAL – BENZ 25
optimally combining hydrophobic and hydrophilic monomers

- LOW Chromatic Abberation
- ABBE number: 58

Excellent optical performance

WHAT IS CHROMATIC ABBERATION?

- Uneven focusing of an optical system which causes wavelengths of light to have different focal points thus decreasing optical performance

Do you know the ABBE number?

The Abbe number - defined by the German physicist Ernst Abbe - is a measure of a transparent material's dispersion in relation to the refractive index. The HIGHER Abbe number the LOWER chromatic aberration

www.medicontur.com
A unique & patented design
with a “Dolphin zone” and double haptics specific design

for REPRODUCIBLE CENTRATION OF THE IOL
for IMMEDIATE & SYMMETRIC UNFOLDING
A unique & patented design
With 180° total contact angle with capsular bag equator

Experimental simulator with a diameter of 9 mm

Medicontur Bi-Flex
Average contact angle: 88.8°

Competitor 1
Average contact Angle: 69°

Competitor 2
Average contact Angle: 64.4°
Measurement of radii of Square Edge (SE) at optic-haptic junction by Scanning Electron Microscopy. The IOLs with discontinuity of SE in optic-haptic junction are not included.

The smaller the radius,

The more effective the square edge effect.

*Comp = Competitor
DESIGN – 360° Square Edge
Comparison of Square Edge of different IOLs at Optic – Haptic Junction

Bi Flex 677ABY
10 microns

Comp 1
35 microns

Comp 2
60 microns

Comp 3
25 microns

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DESIGN – 360° Square Edge
Comparison of Square Edge of different IOLs at Optic – Haptic Junctions

No Square Edge at all at Optic-Haptic Junctions

Bi Flex 677ABY
10 microns

Comp 4
Comp 5
Comp 6
Natural Yellow Filter

- for FILTERING AS MUCH AS NECESSARY
- for PRESERVING AS MUCH AS POSSIBLE

Medicontur natural yellow filter protects the macula against the wavelengths comprised between 390nm and 460nm thus covering the whole most dangerous zone of «blue light» and maintaining scotopic vision (over 460nm)
Simulation of vision without and with yellow filter

IOL
With NO Yellow filter

MEDICONTUR
Natural Yellow filter

IOL
With NON natural Yellow filter
## Bi Flex M characteristics

### SUMMARY

To meet surgeons and their patients requirements

### MATERIAL

- BENZ 25 material (USA)
  - A combination of two monomers (HEMA 34% & OEMA 64%)
  - Low water content
  - Low refractive index (RI)
  - Preventing cells adhesion and protein deposits
  - High ABBE Number (58)
  - Natural Yellow filter (390 – 460 nm)

### OPTIC

- Apodized Diffractive – Refractive design
  - Aspheric (neutral approach)
  - Made with high Precision
  - Optimizing light energy distribution
  - Improving the image quality
  - Supresing halos and glares
  - maintaining depth of field
  - Precise and stable refractive results

### DESIGN

- Å 360° square edge (r=10 microns)
  - Double loop haptic
  - Å PCO prevention
  - Improved axial, radial and rotational stability
  - 180° contact angle
  - Easy implantation through micro incision

### BIOCOMPATIBILITY
- ELASTIC
- SOFT
- SHAPE MEMORY

- Better optical performance
- PCO prevention

- Low chromatic abberation – excellent optical performance
- Blocking the most dangerous light for macula
- Preserving scotopic vision
- Preventing a large shift in color in a „bluish“ direction after cataract surgery

- Optimizing light energy distribution
- Improving the image quality
- Supresing halos and glares
- maintaining depth of field
- Precise and stable refractive results

- Improved axial, radial and rotational stability
- 180° contact angle
- Easy implantation through micro incision

- Better optical performance
Conclusion

**Bi Flex M and its strengths**

- Diffractive – refractive optic
- **Apodized** diffractive central part
- Refractive outer zone
- High Precision
- Suitable for MICS (incision size sub 2)

**Material**
- **BENZ 25**
- Low chromatic aberration
- Natural Yellow filter (390-460 nm)
- PCO prevention
- Refractive Index 1.46

**Design**
- PCO prevention
- 360° Square Edge (r = 10microns)
- material
- Rotation stability - 180° contact angle

www.medicontur.com
<table>
<thead>
<tr>
<th><strong>Bi Flex M</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multifocal Apodized Diffractive Aspheric Hydrophylic Acrylic IOL</strong></td>
<td></td>
</tr>
<tr>
<td>Optic diameter</td>
<td>6.0 mm</td>
</tr>
<tr>
<td>Overall diameter</td>
<td>13.0 mm</td>
</tr>
<tr>
<td>Diffractive zone</td>
<td>Between radius 1 mm - 3.1 mm</td>
</tr>
<tr>
<td>Diffractive discontinuity</td>
<td>7</td>
</tr>
<tr>
<td>Characteristics of steps</td>
<td>Gradually decreasing 2.2 – 1.4 microns</td>
</tr>
<tr>
<td>Addition</td>
<td>+3.5 D</td>
</tr>
<tr>
<td>Optic</td>
<td>Aspheric, Biconvex Apodized Diffractive Optic</td>
</tr>
<tr>
<td>Abbe number</td>
<td>58</td>
</tr>
<tr>
<td>Bi Flex M</td>
<td>Multifocal Apodized Diffractive IOL</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>MTF / light energy distribution</strong></td>
<td><strong>Dependance of Pupille Diameter</strong></td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.46</td>
</tr>
<tr>
<td>Estimated A -const</td>
<td>118.0</td>
</tr>
<tr>
<td>injector</td>
<td>MedJet MB</td>
</tr>
<tr>
<td>Estimated incision size</td>
<td>1.8-2.2 mm</td>
</tr>
<tr>
<td>PCO prevention</td>
<td>360° square edge</td>
</tr>
<tr>
<td>Natural Yellow Filter (covalent bound)</td>
<td>390-460nm</td>
</tr>
<tr>
<td>Temperature</td>
<td>(20-25°)</td>
</tr>
<tr>
<td>Shelf Life</td>
<td>5 years</td>
</tr>
</tbody>
</table>

**Website:** [www.medicontur.com](http://www.medicontur.com)
Dr Assouline’s Results

Presented at the SFO (Société Française d’Ophtalmologie) May 2013
- French National Congress
Defocus Curve

Pseudophake solutions for intermediary vision

Medicontur 677MY (n=9), Lentis M+ (n=19) Finevision (n=16) ATLisa-Trifocal (n=3) ATLisa-Bifocal (n=38) Restor (n=6)
Binocular Defocus Curve

Mix & Match

Lentis + Medicontur 677MY (n=6), Lentis M+ Finevision (n=11) ATLisa-Trifocal + Finevision (n=3)

Dr Assouline (Paris, France)
Visual Acuity & Preferences

Preliminary data (8 paired eyes)

Decimal scale (1 to 12) for distance (higher score = better)
Parinaud scale (P14 to P1.5) for near (lower score = better)
Preference (number of eyes)

Dr Assouline (Paris, France)