Case Studies: Fitting Keratoconus with Use of VKE to determine BOZD/LD of Contact Lenses

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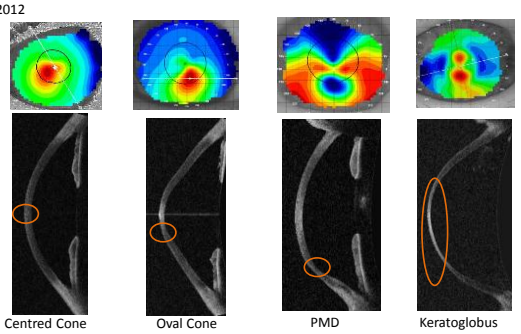
No conflicts or disclosures with any lenses or instruments

Understanding corneal shapes

GSLS 2012

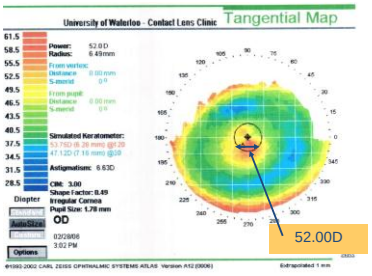


Centred Cone | Oval Cone | PMD | Keratoglobus

Case 1: Centred Cone-Late

- History
- Physical Measurements
- Biomicroscopy and tear assessment
- Topography
  - Determine cone type (nipple, oval, globus, PMD)
  - Simulated K readings
  - Corneal astigmatism
  - Steepest cone diameter
  - Overall cone diameter
  - E-values

Case 1 : Centred Cone: Late



Choosing BOZD/LD

Simulated K readings (D, mm)	47.12 (7.16)@030/53.75 (6.28)@120
Corneal Astigmatism (D)	-6.63 x 026
Average K reading (D, mm)	50.43 (6.69)
Steepest K reading (D)	61.50
Steepest Cone diameter (mm)	1
Overall Cone diameter (mm)	2.5
Q, e and p values*	0.49,0.7,0.51

*Q (asphericity) = e^2, e = eccentricity, p (shape factor) = 1-Q

Cone type	Cone diameters	BOZD ranges	LD ranges	Lens Examples
Centred Cone:				**Floating:** Rose K, Rose K2, Dyna Z Dyna Z Cone Plus
Early	**4.0 to 5.0 mm**	**7.4 to 8.1 mm**	**9.4 to 9.6 mm**	
Mod	**2.8 to 3.9 mm**	**5.0 to 7.3 mm**	**8.8 to 9.3 mm**	
Severe	**2.0 to 2.7 mm**	**3.0 to 4.9 mm**	**8.0 to 8.7 mm**	

Cone type	Cone diameter	BOZD	LD	Lens Examples
Centered Cone:				Rose K, Rose K2, Dyna Z Dyna Z Cone Plus
Severe	2.5mm	3.0 to 4.9mm	8.7mm	

Choose a FLOATING BOZD/lens type to fit the centred cone, since as it progresses, the cone becomes smaller and steeper, as does the lens parameters, in order to maintain centration.

Choosing BOZR based on BOZD/LD

1. Start with standard rule for 9.4mm LD with a 7.4mm BOZD (Calculated K)
2. Then adjust either steeper (if BOZD is smaller) or flatter (if BOZD is larger)

ΔK (D)	Calc BOZR (D) (9.4LD)
-0.25D to -3.75D	Flat K (D) +0.609x(ΔK)
-4.00D to –7.50D	Flat K (D) +0.491x(ΔK)**
-7.75D to –16.75D	Flat K (D) +0.354x(ΔK)

**** Average K for 7.4mm BOZD/9.4 LD**

Floating BOZD	Adjusted BOZR (mm)
3.0-3.7mm	Calculated K(mm) – 0.4mm
3.8-4.9mm	Calculated K(mm) – 0.35mm
5.0-6.1mm	Calculated K(mm) - 0.3mm
6.2-7.3mm	Calculated K(mm) - 0.2mm
7.4-8.0mm	Calculated K(mm)
>8.1BOZD	Calculated K(mm) + 0.2mm

ΔK (D)	Calc BOZR (D) (9.4LD/7.4 BOZD)	BOZR adjusted
6.63D	**Calculated K = 50.43D (6.69mm)**	**Calculated K – 0.35mm (6.69-0.35) = 6.34mm**

Sample Trial Lens Set

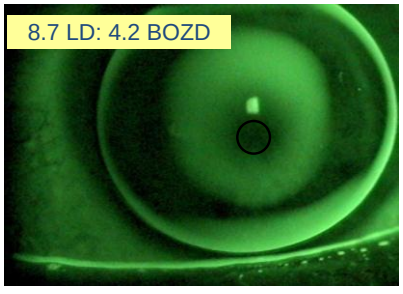
8.7 TD																	
BOZR	7.18	7.11	7.03	6.96	6.89	6.82	6.75	6.68	6.62	6.55	6.49	6.37	6.25	6.14	6.03	5.92	5.82	5.72
BOZD	**5.60**	**5.50**	**5.40**	**5.30**	**5.20**	**5.10**	**5.00**	**4.90**	**4.80**	**4.60**	**4.40**	**4.20**	**4.00**	**3.80**	**3.60**	**3.40**	**3.20**	**3.00**
SC1	7.98	7.91	7.83	7.76	7.69	7.62	7.55	7.48	7.42	7.50	7.40	7.30	7.25	7.20	7.15	7.00	6.90	6.80
SCW1	5.60	5.60	5.50	5.50	5.40	5.40	5.30	5.20	5.10	5.00	4.90	4.80	4.70	4.60	4.50	4.50	4.50	4.50
SC2	8.98	8.91	8.83	8.76	8.69	8.62	8.55	8.48	8.42	8.55	8.40	8.30	8.25	8.20	8.15	8.00	7.90	7.80
SCW2	6.20	6.00	5.90	5.90	5.80	5.80	5.70	5.60	5.50	5.40	5.30	5.20	5.10	5.00	4.90	4.90	4.90	4.90
SC3	10.18	10.11	10.03	9.96	9.89	9.82	9.75	9.68	9.62	9.65	9.55	9.35	9.35	9.25	9.25	9.15	9.00	8.90
SCW3	6.90	6.70	6.60	6.50	6.40	6.40	6.30	6.20	6.10	6.00	5.90	5.80	5.70	5.60	5.50	5.50	5.50	5.50
PC	11.68	11.61	11.53	11.46	11.39	11.32	11.25	11.18	11.12	11.00	11.00	10.85	10.80	10.75	10.65	10.50	10.35	10.25
PCW	7.70	7.50	7.40	7.30	7.20	7.10	7.00	6.90	6.80	6.70	6.60	6.50	6.40	6.30	6.20	6.20	6.20	6.20
PC	12.25	12.20	12.10	12.00	11.90	11.80	11.70	11.60	11.50	11.40	11.30	11.20	11.10	11.00	10.90	10.80	10.70	10.60
PCW	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70	8.70
AEL	0.37	0.39	0.41	0.42	0.44	0.46	0.48	0.50	0.52	0.55	0.57	0.61	0.65	0.70	0.74	0.78	0.82	0.86

Closest Adjusted K with BOZD between 3.8 to 4.9mm

Apply trial lens and assess fit

- Central Fit
  - Adjust BOZR first until gentle 3-pt-touch achieved
- Peripheral Fit
  - Do not adjust until central fit is correct
  - When flatter/steeper periphery needed, adjustments to the BOZR and power are made due to SMALL optic zones
  - Flatter periphery will result in less sagittal depth and so lens will be steepened and more minus added and visa versa (by approx. 0.50D)

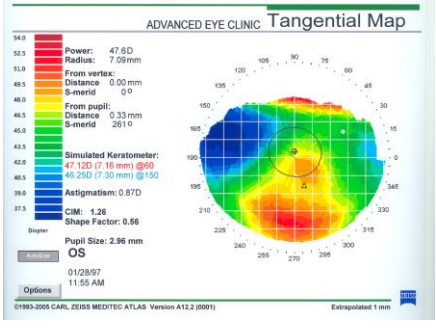
Centred Cone: Late



Case 2: Oval Cone: Moderate

- History
- Physical Measurements
- Biomicroscopy and tear assessment
- Topography
  - Determine cone type (nipple, oval, globus, PMD)
  - Simulated K readings
  - Corneal astigmatism
  - Steepest cone diameter
  - Overall cone diameter
  - E-values

Case 2: Oval Moderate



Choosing BOZD/LD

Simulated K readings (D, mm)	46.25 (7.3)@150/47.12 (7.16)@060
Corneal Astigmatism (D)	-0.87 x 150
Average K reading (D, mm)	46.68 (7.23)
Steepest K reading (D)	54.00
Steepest Cone diameter (mm)	4
Overall Cone diameter (mm)	5
Q, e and p values	0.56, 0.75, 0.44

*Q (asphericity) = e^2, e = eccentricity, p (shape factor) = 1-Q

Cone type	Cone diameters	BOZD ranges	LD ranges	Lens Examples
Oval Cone:				**(Fixed)**
Early	**2.0 to 4.0 mm**	**5.25 to 7.50mm**	**8.5 to 9.6 mm**	**CentraCone**
Moderate	**4.2 to 5.0 mm**	**7.60 to 8.10mm**	**9.8 to 10.1mm**	**Centra PGA,KBA,**
Severe	**5.2 to 7.0 mm**	**8.20 to 9.40mm**	**10.2 to 11.4mm**	**Irregular Cornea**
Globus Cone	**>7.0 mm**	**9.20 to 9.60mm**	**10.2 to 11.4mm OR semi-scleral**	

Cone type	Cone diameters	BOZD	LD	Lens Examples
Oval Cone: Mild Moderate Severe	5.0 mm	7.6 to 8.1mm	9.8mm	CentraCone Centra PGA Rose K Post Graft KBA

Choose a FIXED BOZD/lens type to fit the oval cone, since as it progresses, the cone becomes larger, so increase the BOZD along with the LD in order to maintain centration

Choosing BOZR based on BOZD/LD

- Start with standard rule for 9.4mm LD with a 7.4mm BOZD
- Then adjust either steeper (if BOZD/LD is smaller) or flatter (if BOZD/LD is larger)

ΔK (D)	Calc BOZR (D) (9.4LD)
-0.25D to -3.75D	Flat K (D) +0.609x(ΔK)
-4.00D to –7.50D	Flat K (D) +0.491x(ΔK)**
-7.75D to –16.75D	Flat K (D) +0.354x(ΔK)

**** Average K for 7.4mm BOZD/9.4 LD**

Fixed BOZD/LD	BOZR (mm)
5.25-6.5/8.5-9.0mm	Calculated K(mm) – 0.2mm
7.2-7.5/9.2-9.6mm	Calculated K(mm)
7.6-8.1/9.8-10.1mm	Calculated K(mm) + 0.15mm
8.2-8.6/10.2-10.6	Calculated K(mm) + 0.2 to 0.3mm
8.7-9.4/10.8-11.4	Calculated K(mm) + 0.4mm

ΔK (D)	Calc. BOZR (D) (9.4LD/7.4 BOZD)	BOZR adjusted
0.87D	Flat K + 0.61 X (0.87) = 46.75D (7.22mm)	Calc K + 0.15mm (7.22+0.15) = 7.37mm

Sample Trial Lens Set

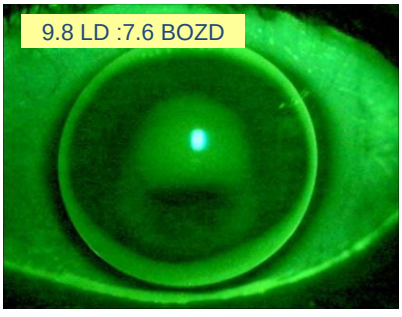
9.8-10.2 TD																		
BOZR	8.33	8.13	7.94	7.76	7.58	7.42	7.18	7.11	7.03	6.96	6.89	6.82	6.75	6.68	6.62	6.55	6.49	6.37
BOZD	**7.60**	**7.60**	**7.60**	**7.60**	**7.60**	**7.60**	**7.80**	**7.80**	**7.80**	**7.80**	**7.80**	**7.80**	**7.80**	**8.00**	**8.00**	**8.00**	**8.00**	**8.00**
SC1	9.33	9.13	8.94	8.76	8.58	8.42	7.98	7.91	7.83	7.76	7.69	7.62	7.55	7.48	7.42	7.50	7.40	7.30
SCW1	8.00	8.00	8.00	8.00	8.00	8.00	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.40	8.40	8.40	8.40	8.40
SC2	10.33	10.20	10.15	10.10	10.00	9.80	8.98	8.91	8.83	8.76	8.69	8.62	8.55	8.48	8.42	8.55	8.40	8.30
SCW2	8.60	8.60	8.60	8.60	8.60	8.60	8.80	8.80	8.80	8.80	8.80	8.80	8.80	9.00	9.00	9.00	9.00	9.00
SC3	11.33	11.50	11.50	11.40	11.30	11.00	10.18	10.11	10.03	9.96	9.89	9.82	9.75	9.68	9.62	9.65	9.55	9.35
SCW3	9.20	9.20	9.20	9.20	9.20	9.20	9.40	9.40	9.40	9.40	9.40	9.40	9.40	9.60	9.60	9.60	9.60	9.60
PC	12.35	12.25	12.15	12.15	12.10	12.00	11.68	11.61	11.53	11.46	11.39	11.32	11.25	11.18	11.12	11.00	11.00	10.85
PCW	9.80	9.80	9.80	9.80	9.80	9.80	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.20	10.20	10.20	10.20	10.20
AEL	0.200	0.220	0.239	0.259	0.280	0.294	0.312	0.321	0.332	0.342	0.353	0.364	0.376	0.413	0.426	0.453	0.464	0.495

Closest to the Adjusted K result with the 7.6BOZD

Apply trial lens and assess fit

- Central Fit
  - Adjust first until gentle 3-pt-touch achieved
- Peripheral Fit
  - Do not adjust until central fit is correct
  - When flatter/steeper periphery needed, adjustments to the BOZR and power may NOT be made due to LARGE optic zones

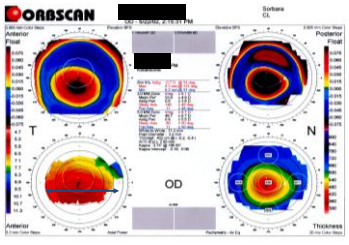
Oval Cone: Moderate



Case 3: Oval Cone: Globus

- History
- Physical Measurements
- Biomicroscopy and tear assessment
- Topography
  - Determine cone type (nipple, oval, globus, PMD)
  - Simulated K readings
  - Corneal astigmatism
  - Steepest cone diameter
  - Overall cone diameter
  - E-values

Case 3: Oval Cone: Globus



Choosing BOZD/LD

Simulated K readings (D, mm)	54.43 (6.2)@031/55.13 (6.12)@121
Corneal Astigmatism (D)	-0.70 x 031
Average K reading (D, mm)	54.78 (6.16)
Steepest K reading (D)	71.80
Steepest Cone diameter (mm)	7
Overall Cone diameter (mm)	7.5
Q, e and p values	0.45, 0.67, 0.55

*Q (asphericity) = e^2, e = eccentricity, p (shape factor) = 1-Q

Cone type	Cone diameters	BOZD ranges	LD ranges	Lens Examples
Globus Cone	**>7.0 mm**	**9.20 to 9.60mm**	**10.2 to 11 4mm OR semi-scleral**	Dyna Intralimbal Rose K Irregular Cornea Semi-Scleral, MSD

Cone type	Cone diameters	BOZD	LD	Lens Examples
Globus Cone	7.5mm	9.2 to 9.6	11.2mm	Dyna Intralimbal Rose K Irregular Cornea Semi-Scleral, MSD

Choose a FIXED BOZD/lens type to fit the oval cone, since as it progresses, the cone becomes larger, so increase the BOZD along with the LD in order to maintain centration

Choosing BOZR based on BOZD/LD

- Start with standard rule for 9.4mm LD with a 7.4mm BOZD
- Then adjust either steeper (if BOZD/LD is smaller) or flatter (if BOZD/LD is larger)

ΔK (D)	BOZR (D) (9.4LD)
-0.25D to -3.75D	Flat K (D) +0.609x(ΔK)
-4.00D to –7.50D	Flat K (D) +0.491x(ΔK)**
-7.75D to –16.75D	Flat K (D) +0.354x(ΔK)

**** Average K for 7.4mm BOZD/9.4 LD**

Fixed BOZD/LD	BOZR (mm)
5.25-6.5/8.5-9.0mm	Calculated K(mm) – 0.2mm
7.2-7.5/9.2-9.6mm	Calculated K(mm)
7.6-8.1/9.8-10.1mm	Calculated K(mm) + 0.15mm
8.2-8.6/10.2-10.6	Calculated K(mm) + 0.2 to 0.3mm
8.7-9.4/10.8-11.4	Calculated K(mm) + 0.4mm

ΔK (D)	Calc BOZR (D) (9.4LD/7.4 BOZD)	BOZR adjusted
0.70D	**Flat K +0.61 X (0.70) = 54.86D (6.15mm)**	**K + 0.4mm (6.15+0.4) = 6.55mm**

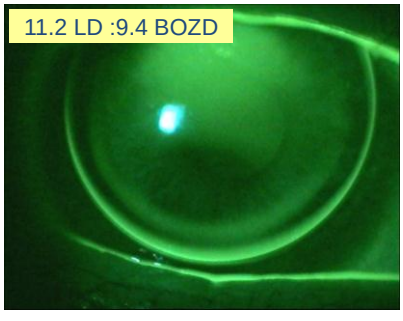
Sample Trial Lens Set

11.2 TD																	
BOZR	8.54	8.33	8.13	7.94	7.76	7.58	7.42	7.18	7.11	6.96	6.89	6.82	6.75	6.62	6.55	6.49	6.37	6.27
BOZD	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**	**9.40**
SC1	9.73	9.53	9.33	9.14	8.96	8.78	8.62	8.40	8.30	8.10	8.00	7.90	7.80	7.50	7.40	7.30	7.20	7.10
SCW1	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80	9.80
SC2	11.20	11.00	10.90	10.80	10.70	10.60	10.50	10.40	10.20	10.00	9.90	9.85	9.80	9.70	9.65	9.60	9.55	9.45
SCW2	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20	10.20
SC3	12.20	12.00	11.90	11.80	11.70	11.60	11.50	11.40	11.30	11.20	11.15	11.10	11.05	10.95	10.90	10.85	10.80	10.70
SCW3	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60
PC	13.65	13.50	13.35	13.25	13.15	13.00	12.95	12.85	12.75	12.65	12.60	12.55	12.50	12.40	12.35	12.30	12.25	12.00
POW	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20	11.20
AEL	0.245	0.263	0.285	0.309	0.334	0.362	0.391	0.442	0.454	0.490	0.508	0.528	0.549	0.590	0.617	0.641	0.703	0.758

Apply trial lens and assess fit

- Central Fit
  - Adjust first until gentle 3-pt-touch achieved
- Peripheral Fit
  - Do not adjust until central fit is correct
  - When flatter/steeper periphery needed, adjustments to the BOZR and power may NOT be made due to LARGE optic zones

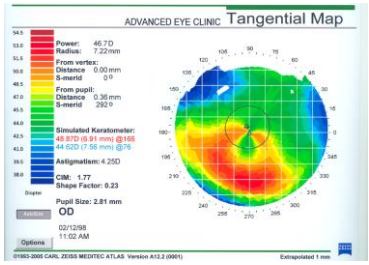
Oval Cone: Globus



Case 4: PMD: Late

- History
- Physical Measurements
- Biomicroscopy and tear assessment
- Topography
  - Determine cone type (nipple, oval, globus, PMD)
  - Simulated K readings
  - Corneal astigmatism
  - Steepest cone diameter
  - Overall cone diameter
  - E-values

Case 4: PMD (late)



Choosing BOZD/LD

Simulated K readings (D, mm)	44.62 (7.56)@076/48.87 (6.91)@166
Corneal Astigmatism (D)	-4.25 x 076
Average K reading (D, mm)	46.75 (7.3)
Steepest K reading (D)	54.50
Steepest Cone diameter (mm)	6
Overall Cone diameter (mm)	**8.5**
Q, e and p values	0.23, 0.48, 0.77

*Q (asphericity) = e^2, e = eccentricity, p (shape factor) = 1-Q

Cone type	Cone diameters	BOZD ranges	LD ranges	Lens Examples
PMD:				**(Fixed)**
Early	**5.0 to 7.0 mm**	**8.2 to 9.4mm**	**10.2 to 11.4mm**	**Dyna Intralimbal**
Late	**7.2 to 9.0 mm**	**9.4 to 10.5mm**	**11.4 to 18.2mm**	**Irregular Cornea**
				Semi-Scleral, MSD

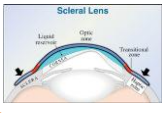
Cone type	Cone diameters	BOZD	LD	Lens Examples
PMD				Dyna Intralimbal Rose K Irregular Cornea Semi-Scleral,
Late	**8.5mm**	**9.4 to 10.5mm**	**13.5mm**	

Choose a FIXED BOZD/lens type to fit the oval cone, since as it progresses, the cone becomes larger, so increase the BOZD along with the LD in order to maintain centration

Choosing BOZR based on BOZD/LD

- Start with standard rule as recommended by manufacturer (14 LD)
- Then adjust either steeper (if BOZD/LD is smaller) or flatter (if BOZD/LD is larger)

ΔK (D)	BOZR (D) (14.0 LD)
-0.25D to -1.00D	Flat K (D)
-1.00D to –2.00D	Flat K (D) + 0.50D steeper
-2.25D and up	Flat K (D) + 0.30x(ΔK)

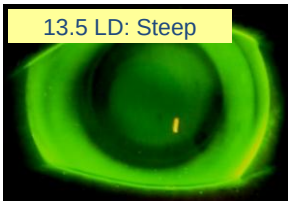


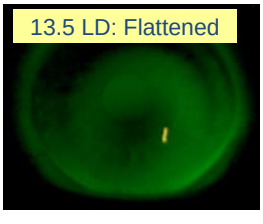
ΔK (D)	BOZR (D) (14.0 LD)	BOZR adjusted (13.5 LD)
4.25D	Flat K + 0.3(ΔK)= 44.62 + 0.3(4.25) =45.89D (7.34mm)	45.89D + 0.25D=46.25D (7.30mm)

Apply trial lens and assess fit

- Central Fit
  - Adjust first until very gentle 3-pt-touch achieved if LD is 14.0 mm or LESS
  - Otherwise, clear the apex of the cone, completely
  - Remember that the lens will settle back! So wait!
- Mid-Peripheral Fit
  - Ensure that there is clearance over the limbus
- Peripheral Fit
  - Ensure that there is NO blanching of the blood vessels and conj moves freely beneath the lens edge

PMD: Late





If area of touch is too harsh with PMD- late, then try a *reverse geometry type design*, where the central portion is flatter reducing the central clearance and the mid-periphery is steeper allowing more clearance over the inferiorly displaced cone.

Current technology to help with peripheral fit

- OCT technology

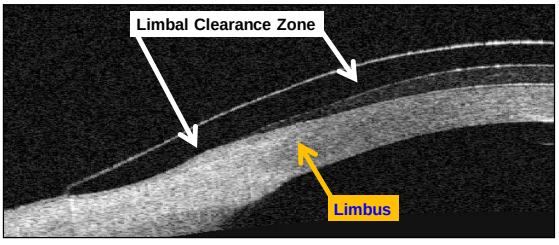


Photo: Randy Kojima

References

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Thank you for your attention!
Questions?