Brien Holden Vision Institute

INTRODUCTION TO REFRACTION

THINK

An artist comes to you for an eye examination. She tells you that she sometimes has trouble seeing clearly.

You take a complete case history from her, and measure her visual acuity and pinhole visual acuity.

You think that she has a refractive error – but what sort of refractive error does she have and how can you measure it?

AIM

This unit introduces you to the different ways of measuring refractive error and the goals of a refraction examination.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain the purpose of a refraction examination
- list objective and subjective refraction techniques
- explain the advantages and disadvantages of different refraction techniques
- identify the goals of a refraction examination
- predict the amount and type of refractive error based on case history and visual acuity
- describe the basic refraction examination procedure.

REVIEW: INTRODUCTION TO REFRACTION

WHAT IS REFRACTIVE ERROR?	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • The amount of refractive error an eye has depends on: - the curvature of the cornea, and/or - the curvature of the crystalline lens, and/or - the length of the eyeball. • A person with a refractive error may have eyes that look normal, but they will not see well. • An eye examination that tests for refractive error is called a refraction.
WHAT IS ACCOMMODATION?	• Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker) and more curved. • This changes the optical focus of the eye so that close objects can be seen clearly. • When accommodation is relaxed in a normal eye (an eye without refractive error), objects in the distance are seen clearly. • Presbyopia is the natural aging change in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as easily as a younger person. • All people will get presbyopia when they get older. It is impossible for a child or a young adult in their 20s to have presbyopia.
WHAT IS VISUAL ACUITY?	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Common causes of poor VA are: - refractive error (this person needs spectacles to see clearly) - eye health problem (this person has a health problem with their eyes).

CLINICAL REFRACTION

Refraction is the clinical technique for measuring refractive error. A refraction tells you:

- the type of refractive error that a person has (hyperopia, myopia, astigmatism or presbyopia)
- how much refractive error a person has.

REFRACTION OF LIGHT	In optics, refraction refers to the way light is bent by a lens or a prism.
REFRACTION OF THE EYES	In eye care, refraction refers to the clinical technique used to measure a person's refractive error.

MEASURING REFRACTIVE ERROR

There are several ways to measure refractive error.
These different ways can be divided into objective and subjective tests.

Objective test results are not dependant on what a person says to the examiner.
Objective findings can be seen or measured without needing the person's opinion.

Subjective test results depend on what a person tells the examiner.

Objective refraction methods include:

- Retinoscopy
- Auto-refraction.

Subjective refraction methods include:

- Best vision sphere refraction
- Sphero-cylindrical refraction
- Near refraction.

Because both objective methods and subjective methods have advantages and disadvantages, a combination of these methods is usually used when performing a refraction.

OBJECTIVE REFRACTION METHODS

RETINOSCOPY
Retinoscopy is a good objective way to estimate the refractive error of an eye. A piece of equipment called a retinoscope is used to examine the optical properties of an eye when different trial lenses are held in front of the eye.

It is good to do retinoscopy before you do a subjective refraction because it gives you a starting point and will make your refraction faster.

Figure 15.1: *Using retinoscopy to estimate the refractive error of a person's eye*

ADVANTAGES OF RETINOSCOPY
- Fast estimation of a person's refractive error.
- Easier to control a person's accommodation than auto-refraction.
- Other eye problems (such as cataract or corneal scars) can be detected at the same time.
- Excellent method for estimating refractive error of children and people who cannot communicate with you (such as people who speak a different language).
- Small and portable (easy to transport).

DISADVANTAGES OF RETINOSCOPY
- Accurate measurements require training and practice.
- Difficult to do on people with small pupils.

OBJECTIVE REFRACTION METHODS (cont.)

AUTO-REFRACTION

An auto-refractor is a machine that is used to estimate the refractive error of an eye objectively.

Figure 15.2: *An auto-refractor*

- **Advantages of an auto-refractor:**

  The measurement can be taken by someone who has minimal eye care training.

- **Disadvantages of an auto-refractor:**
  - Auto-refractors often over-estimate myopia and under-estimate hyperopia (especially for young people).
  - A trained eye care worker is needed to interpret the results correctly.
  - A trained eye care worker is needed to refine the results (make them more accurate).
  - Auto-refractors are expensive.
  - Auto-refractors are usually not portable (cannot be taken on outreach).

You should never prescribe spectacles just from an auto-refractor reading.

If you do, the person can have problems wearing their new spectacles.

Their eyes may not feel comfortable looking through the spectacle lenses.

An auto-refractor can be useful to give a starting point for a subjective refraction, but it is not necessary to have this type of equipment.

SUBJECTIVE REFRACTION METHODS

Subjective refraction is usually performed using trial lenses (from a trial lens set) which are put into a trial frame that is worn by the person being examined.

BEST VISION SPHERE (BVS) REFRACTION	A BVS refraction is a subjective technique that is used to accurately measure myopia and hyperopia. The BVS is measured by asking a person what they can see on a VA chart when spherical trial lenses of different powers are put in front of their eyes.  ***Figure 15.3:*** *In subjective refraction a person is asked what they can see on a VA chart when trial lenses are put in front of their eyes* Because BVS refraction only uses spherical trial lenses (plus and minus lenses), it can only measure spherical refractive errors. A BVS refraction cannot measure astigmatic refractive errors.
SPHERO-CYLINDRICAL REFRACTION	A sphero-cylindrical refraction accurately measures hyperopia, myopia and astigmatism subjectively. A sphero-cylindrical refraction begins with a BVS refraction and then uses cylindrical lenses to measure any astigmatism that a person might have. This is the best way to measure refractive error, but it takes training and practice to become good at this technique.  ***Figure 15.4:*** *Both spherical and cylindrical trial lenses are used in a sphero-cylindrical refraction to measure a person's refractive error – including astigmatism*

SUBJECTIVE REFRACTION METHODS (cont.)

SPHERO-CYLINDRICAL REFRACTION (cont.)	Sometimes, instead of using a trial frame and a trial lens set, a phoropter is used. A phoropter (also called a refractor head) is a special machine that is used for subjective refraction. Inside the phoropter are all the lens powers and accessory lenses that you can find in a trial lens set. The person looks through the eyepieces of the phoropter and the examiner turns the dials to change the lens power in front of the person's eyes.  ***Figure 15.5:*** *A phoropter can be used instead of a trial lens set and trial frame* A phoropter is heavy, fragile and expensive and it cannot be used for outreach clinics. Usually it is easier to use a trial frame and a trial lens set to do a refraction.
NEAR REFRACTION	Presbyopic people need to have a subjective near refraction examination as well as a subjective distance refraction examination. A near refraction measures how much presbyopia a person has. A near refraction begins with a BVS (or sphero-cylindrical) refraction, and then the person looks at a near VA chart (or reading card) for a near refraction. Only spherical lenses and a trial frame are used for a near refraction.

GOALS OF REFRACTION

GOALS OF REFRACTION

A refraction is performed to find the power of the spectacle lens that a person needs to correct their refractive error. A good refraction lets a person see clearly and comfortably with the spectacles that are made for them.

The goals of refraction are to find:

- the lens (or lenses) that gives the person the clearest vision; and
- the lens (or lenses) that gives the person the most comfortable vision.

→ Both of these goals are equally important.

If you give a person too much minus power you will make the person uncomfortable → this is because you are making the person accommodate to see clearly.

If you give a person too much plus power you will make the person's vision blurry.

The examiner must find the one lens that gives the person clear vision and minimises their accommodation (makes the person comfortable).

CLEAR VISION

Often there are several lenses that will give a person good vision on the VA chart.

→ Not all these lenses will be comfortable for the person to wear as spectacles.

COMFORTABLE VISION

There will only be one lens that gives a person the most comfortable and clear vision.

→ This is the lens that will minimise the amount of accommodation the person needs to use.

The lens that gives the most comfortable vision is always the lens that has the least amount of minus power (or the most amount of plus power)

→ but still gives the best VA.

Accommodation will be minimised if the least minus (or most plus) lens is used.

PREDICTING REFRACTIVE ERROR – KNOWING WHAT TO EXPECT

Before you start a refraction, you should already have an expectation of the amount and type of refractive error that the person has. This expectation is based on:

- **Case history:** The person's visual symptoms → at what distance is the vision blurry?
  The person's age → could the person have presbyopia?
- **Visual acuity:** Unaided VA → how bad is their distance and near vision?
  Pinhole VA → is the poor VA caused by refractive error?

Usually a person's distance VA will get worse by one line on the VA chart for every 0.25 D of spherical refractive error.

→ This works best on a VA chart that has rows of characters that are these sizes:

6/6 6/7.5 6/9 6/12 6/15 6/18 6/24 6/36 6/48 6/60

Table 15.1: *Predicting spherical refractive error from unaided VA*

UNAIDED VA	EXPECTED REFRACTIVE ERROR (+ OR –)
6/6	0.25
6/7.5	0.50
6/9	0.75
6/12	1.00
6/15	1.25
6/18	1.50
6/24	1.75
6/36	2.00
6/48	2.25
6/60	2.50
< 6/60	> 2.50

Each 0.25 D of refractive error reduces VA by about one line.

But! This estimation will only work if:

- the person has no astigmatism (or only a little)
  → astigmatism affects a person's VA in a different way.
- the person is not using any accommodation
  → young hyperopes can have good VA because they can accommodate.
- the person has no eye health problem
  → some eye health problems can make the person's VA worse than expected.
- the person has a refractive error less than 2.50 D
  → refractive errors that are higher than 2.50 D do not always follow this rule.

THE ART OF REFRACTION

The theory of refraction can be taught, but the practise of refraction requires an understanding that can only be learnt from experience. This is why refraction is sometimes called an art, not just a science.

WE ALL MAKE MISTAKES

Just like you will sometimes make mistakes, the person that you refract will sometimes make a mistake and tell you something that can confuse you. This may cause you to make a mistake in your refraction. This is particularly the case with people who are having their eyes examined for the first time, and with elderly people and young children.

Good communication will help the person to understand you, and for you to understand them.

When you are learning to refract a person, refraction can take you a long time. If you take too long to do your refraction the person can get tired and bored. If this happens, the person's responses will become more unreliable.

You need to learn to do a reasonably fast refraction so that the person is alert and concentrating during the whole examination. This will make your refraction more accurate.

Children need to be kept busy and entertained during an eye exam or they will lose interest and become unhelpful.

Elderly people will get tired if the refraction takes too long. If this happens you must give them a rest or ask them to come back on another day.

CONTROLLING ACCOMMODATION

Vision is a complicated process. An especially complicated part of vision is accommodation. If a person has very active accommodation you can have difficulty controlling it, unless you are extremely careful. A person who has uncontrolled accommodation will tell you that sometimes the VA chart looks clear and sometimes it looks blurry - even if they are looking through the same lens and at the same letter!

A person who has poorly controlled accommodation will give you unexpected results. If you do not control accommodation, your refraction will probably be incorrect.

Most people cannot control their own accommodation. In fact, most people do not even realise that they are accommodating.

If accommodation is poorly controlled it is not the fault of the person being examined. Accommodation must be controlled by the examiner.

KNOWING WHAT TO EXPECT

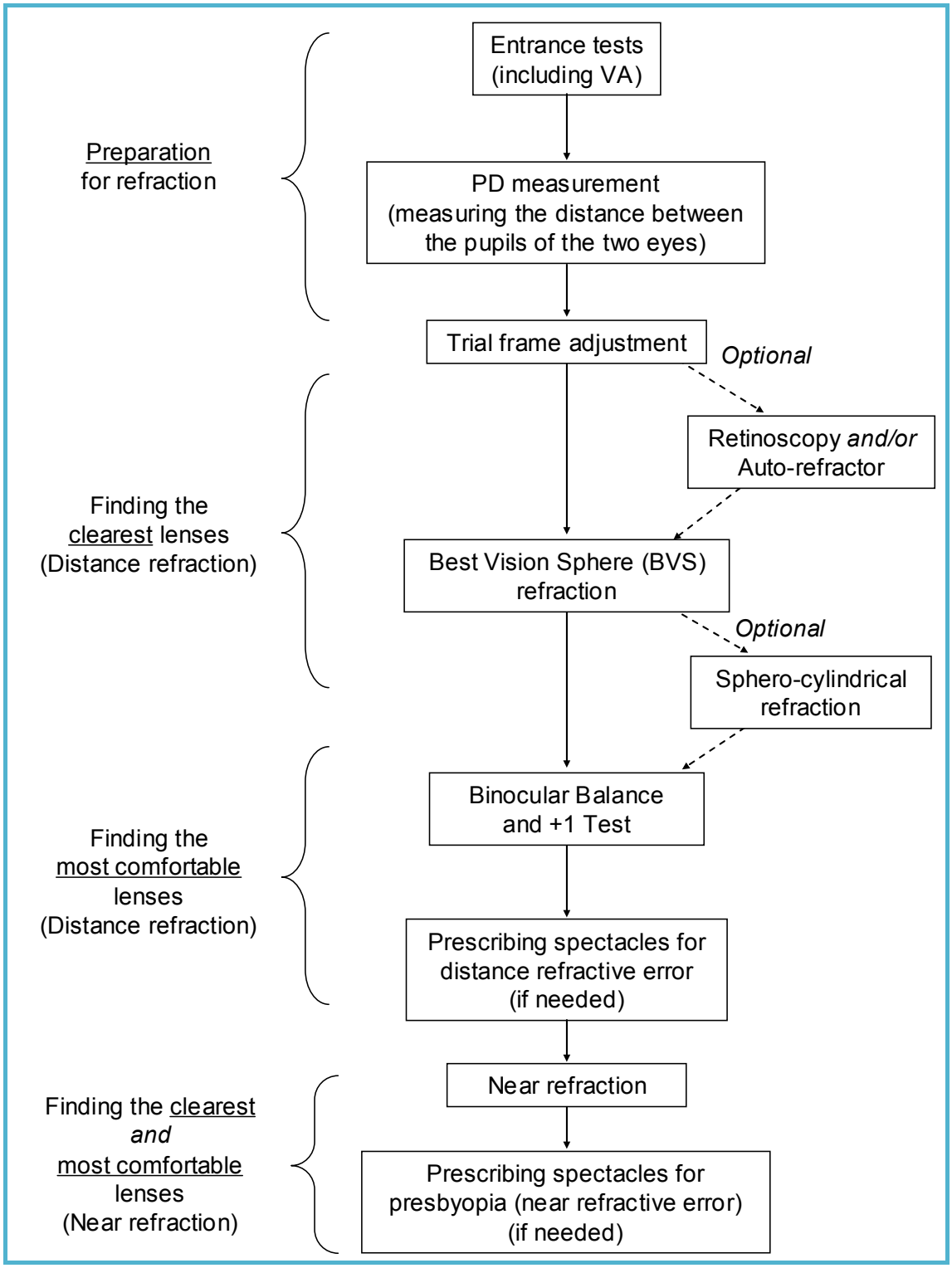
A good examiner listens to a person's symptoms when taking their case history and starts to think about what the person's problem might be. The VA and pinhole VA will give more information about how much refractive error a person has.

Before the examiner starts the refraction, they know what refractive error to expect and can estimate how much refractive error there will be.

If the person being refracted gives answers that are surprising, a good examiner will know that the person's accommodation is not well controlled – or that the person is confused or tired – and they will know what to do about it.

THE REFRACTION PROCEDURE

There is the basic order that refraction tests are performed in. This order is summarised in the flow chart below.



SUMMARY: INTRODUCTION TO REFRACTION

CLINICAL REFRACTION

- Refraction is a clinical technique for measuring refractive error.

- A refraction tells you
  - the type of refractive error that a person has
  - how much refractive error a person has.

MEASURING REFRACTIVE ERROR

- Objective refraction methods include:
  - retinoscopy
  - auto-refraction.

- Subjective refraction methods include:
  - best vision sphere (BVS) refraction
  - sphero-cylindrical refraction
  - near refraction.

OBJECTIVE REFRACTION METHODS

- Retinoscopy:
  - A retinoscope and a trial lens set are used to determine the refractive error of the eye objectively
  - Good to do before a subjective refraction to use as a starting point.

- Auto-refraction:
  - An auto-refractor is used to estimate the refractive error of the eye
  - Must do a subjective refraction after auto-refraction as it is not accurate enough to prescribe spectacles from.

SUBJECT REFRACTION METHODS

- BVS refraction:
  - Measures the amount of hyperopia or myopia present.

- Sphero-cylindrical refraction:
  - Accurate measure of hyperopia, myopia and astigmatism
  - Begins with a BVS refraction
  - Best way to measure refractive error.

- Near refraction:
  - Measures how much presbyopia a person has
  - Begins with a BVS (or sphero-cylindrical) refraction
  - The person looks at a reading card or near visual acuity (VA) chart and a trial frame and spherical lenses are used to measure near refractive error.

SUMMARY: INTRODUCTION TO REFRACTION (cont.)

GOALS OF REFRACTION

- A refraction must find:
  – the lens that gives the person the clearest vision, **and**
  – the lens that gives the person the most comfortable vision.

- The clearest and most comfortable lens is always the lens that has the least amount of minus power (or most amount of plus power) but still gives the best VA.

- Ambyopia is a diagnosis of exclusion
  → This means that you can only say that a person has amblyopia if all other possible reasons for poor vision have been excluded (ruled out).

ESTIMATING REFRACTIVE ERROR – KNOWING WHAT TO EXPECT

- Case history and VA will give you clues as to what sort of refractive error a person probably has.

- Case history:
  – the person's visual symptoms
  – the person's age.

- VA:
  – unaided and pinhole VA
  – the amount of spherical refractive error can be predicted by looking at the unaided VA
  (every 0.25 D refractive error = approx. one line of VA)

  But only if:
  → the person has no astigmatism
  → the person is not accommodating
  → the person has no eye health problem.

THE ART OF REFRACTION

- People can sometimes tell you the wrong thing by accident
  – especially if they are tired, bored or have trouble understanding you.

- Uncontrolled accommodation can give you the wrong results
  – be especially careful when you are refracting young people with active accommodation.

- If you know what to expect (from the case history and VA) you will recognise when the refraction is giving unusual results.

TEST YOURSELF QUESTIONS

1. **What is the difference between subjective and objective refraction tests?**

_____

_____

2. a) **What are the advantages of objective refraction tests?**

_____

b) **What are the advantages of subjective refraction tests?**

_____

3. **What is the difference between a best vision sphere refraction and a sphero-cylindrical refraction?**

_____

_____

4. **What are the two main goals of refraction?**

_____

_____

5. **What information will help you estimate a person's refractive error before you start your refraction?**

_____

_____

6. **How can you use visual acuity to estimate a person's refractive error?**

_____

_____

7. **How can you help a person give you good answers during a subjective refraction?**

_____

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NOTES