Principles of Projection Geometry. Neill Serman. August 2000
W&P Chapter 5

A radiograph is a 2 dimensional image of a three dimensional object. When looking at a radiograph one is looking at the **images** of the structures radiographed, but the third dimension of the object is lost. One should be able to reconstruct the third dimension. To obtain the maximum information from the radiograph, it is essential that the images are very clear (definition) and have minimal (or no) distortion. The images can be changed as shown below but ideally should have the same shape and relationship as exists in the mouth.

When radiographing the lower jaw one is utilizing a **negative** angulation, and a **positive** angulation for the upper jaw. Foreshortening of the image results in an angulation that is **too great** and elongation, an angulation that is **too small** or shallow. With **elongation** the apices of the teeth are often not seen radiographically. With **foreshortening** too much alveolar bone is seen apical to the tooth. With overlapping of teeth the horizontal angulation is incorrect.

Sharpness, detail - measures how well the boundary between two areas of differing density is revealed. OR **clarity of the outline of the image** on the radiograph.

Resolution - measures how well small objects next to each other can be seen/visualized.

Distortion / magnification - is the increase in size of the image compared to the object due to divergent path of the photons producing the image.

This lecture applies what has been learned regarding the **Rules for Accurate Image Formation** OR **The Principles of Shadow Casting.** Namely -

1. Small focal spot size.
2. large focal - object distance.
3. small object - film distance.
4. film parallel to object.
5. central beam at ninety degrees to the object (and therefore the film)

Except for item # 1, these are also the **Principles of the paralleling technique**, (Board question) and aligning instruments are utilized to enable the operator to obtain these results consistently.

1. Small focal spot size.

One has a choice of focal spot size **only** at the time of purchasing the machine. Dental X-ray machines should have a focal spot size of 1.00mm or less. The smaller the focal spot the greater / better the **detail / sharpness / resolution.**

Detail / sharpness - defined as the clarity of outline of the image on a radiograph.

Resolution - able to see the difference in densities of adjacent structures

The larger the focal spot the greater the **penumbra** and this **detracts** from the detail because the outline of the images become blurred. The size of the effective focal spot is a function of the angulation. (See Line Focus Principle, W&P. pages 8 and 9). To an extent, the long cone reduces the size of the penumbra by limiting the size of the beam.

2. Large focal - object distance.

Within reason, the greater the focal - object distance the less the magnification (distortion) as the rays of photons travel a more parallel course. (Collimation has removed the more diverging rays.) Thus one utilizes the **long cone**. The short cone permits the rays to diverge more, thus also exposing a larger area (volume) of tissue to the ionizing radiation. (More ionizing radiation exposure to the patient). Further, the long rectangular cone reduces the diameter of the beam **50%** compared to the long round cone.

Whenever, there is magnification there is some loss of detail.

3. Small object - film distance.

The closer the film is placed to the object (teeth), the better the detail / definition. This is due to **less magnification** and a **smaller penumbra**. In the upper jaw, because of the angulation of the palate, one is not able to place the film as close to the teeth as one would desire. The fact that one is utilizing a long cone, with the rays almost parallel, compensates for this - common Board question. This also applies in the mandibular anterior region. Although one moves the film further from the object, the film and the object must remain parallel to each other.

4. Film parallel to object.

One should attempt to place the film as close to the object as possible, place the film and the **long axis** of the tooth as close together provided that parallelism is being maintained. One compensates by using a long cone in those cases where the film has to be moved further from the object in order to obtain parallelism. Board question. Image shape distortion is minimized when the long axes of the teeth and the film are parallel.
Incorrect vertical angulation will result in either **elongation** or **foreshortening**.

5. Central beam at ninety degrees to the object.

If one does not maintain the central beam at ninety degrees to the object, the resultant image will be either **foreshortened** or **elongated**. This relationship can only be consistently obtained with aligning instruments. If the film and the tooth are not parallel to each other this elongation or foreshortening is exaggerated.

Image Size Distortion.

1. film and object not parallel to each other
2. smaller focal - object distance. (use of short cone)
3. central beam not at ninety degrees to object.

Bisecting-the-angle technique.

Most dentists utilize the bisecting technique because they have not mastered the parallel technique and are under the mistaken impression that the bisecting technique utilizes less time. Once one has mastered the parallel technique, both the techniques take an equal amount of time. The parallel techniques results in more consistent and predictable results.

One is often forced to use the bisecting technique in very small mouths, very flat palates, and with endodontic treatment or where the tooth is too tender to bite on the bite block of the aligning instrument. With this system one attempts mentally to bisect the angle made, where the teeth and film meet. One then has to position the central beam so that it meets this imaginary line at right angles - not at all easy. Also this results in uneven magnification. The further the object and film are apart (at the tooth apex especially) the greater the distortion. It is customary to use the short cone with this technique to ensure that one has more chance of seeing the image and this adds to the distortion.

The Clark's Rule. (SL OB Rule)

Where one needs to determine whether a structure, (supernumary tooth etc.) found radiographically, is lying lingual / palatal or buccal / facial to the other teeth, one can take a second radiograph. In the second radiograph **only the horizontal angulation** is changed. This can only be achieved where the parallel technique (aligning instruments) was used in the initial radiograph. The object being examined will move only a few millimeters in relation to the other anatomic structures. If the object moved in the **same direction** as the tube was moved, it is lying **lingually** and if in the **opposite direction** to the tube movement it is situated buccally.

Same - **L**INGUAL **O**PPOSITE - **B**UCCAL = SLOB

This change is made in the **vertical** where one requires to know how close the mandibular canal is to the apex of a third molar or the relationship of the mental foramen (or pathology) to the apex of a premolar tooth.

Buccal Object Rule.

Most textbooks (including G & W) do not distinguish between this rule and the above rule. The subtle difference in this rule is that when the second radiograph is taken the object situated buccally will appear to move **more.**

These rules can both be used to determine whether a periapical lucency in the mandibular premolar area is the mental foramen or periapical pathology. However, there is no need to take a second radiograph where the tooth clinically tests vital and where the periodontal ligament space and the lamina dura can be followed around the apex of the affected tooth.