Evaluation of rare earth intensifying screens in cephalometric radiography

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The unique information available only from dental radiographs has made them an indisputable part of dentistry for many years. The cephalometric radiograph, introduced by orthodontists but widely used in many phases of dentistry, is a specialized dentofacial document which permits quanitification of changes due to treatment or growth.

While recognizing the value of radiographs, awareness of health hazards of radiation is a valid concern. Reduction of the radiation needed to produce images of diagnostic quality is an important goal, and the introduction of "rare earth" methods of image intensification in radiography has made this possible. There has been some reluctance, however, in changing to this method because clinicians are concerned that the diagnostic quality of the films may be reduced.

This study was undertaken to evaluate the reliability of locating cephalometric landmarks on films taken with "rare earth" methods compared to those taken with standard intensifying screens.

Somatic effects of radiation

Radiation from any source can cause genetic and somatic biologic effects. Genetic alterations result from fragmentation and destruction of chromosomes or from point mutations on genes of the germ cells in the reproductive system.[1] The information available at present suggests that the dose required to double the human mutation rate lies between 20-250mrem[1-3] and dental diagnostic procedures contribute less than 0.1mrem.[1] Animal experiments show a decrease in mutation rate with a decrease in dose-rate but these results cannot necessarily be extrapolated to human beings.

The somatic effects are primarily cancer, including leukemia. Cancer was not regarded as a major population risk from sublethal radiation doses until excess leukemia began to appear in

Abstract

Accuracy of cephalometric landmark location was determined in 20 pairs of headfilms, measuring differences in 18 points in two planes of each, using five independent observers. Each pair had one film taken with a conventional (calcium tungstate) intensifying screen system and one taken with a rare earth system. Statistically significant differences in accuracy were found in only six of the 36 measurements. Three of the differences favored the accuracy of the rare earth system (Pogonion Y, S Pogonion X and Y), while the other three favored the conventional system (ANS-X, Nasion-Y, Pt. A-Y). The least reproducible point in both systems in the horizontal axis was condylion. Since these findings showed no landmark accuracy preference of one screen system over the other, the 96 percent reduction in patient radiation with the rare earth system would mandate this be used in cephalometric radiography.

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Key Words

Cephalometric • Radiation • Rare earth screen • Landmark location

the Japanese atomic-bomb survivors in the late forties. A large scale retrospective epidemiologic study in England demonstrated a significant association between in utero exposure to diagnostic levels of x-rays and leukemia.[4] The same study concluded that six percent of childhood malignancies resulted from whole body exposure of the fetus to diagnostic radiation. In adults, eight percent of leukemias other than lymphatic leukemias were caused by diagnostic x-rays and a further 3.6 percent by therapeutic x-ray.[2]

Considering the fact that immature, undifferentiated and rapidly dividing cells are highly sensitive to radiation, it is not surprising the embryonic and fetal tissues are readily damaged by relatively low doses of radiation. Although the specific type of damage is related to the dose and to the stage of pregnancy during which irradiation takes place, the very earliest stages of gestation are more radiosensitive. Possible carcinogenic mechanisms proposed are activation of a latent carcinogenic virus, chromosome damage,[5] mutations in somatic cells and formation of free radicals.[2] Dental radiation as applied in the critical areas of the head-neck region may result in some detrimental biologic effects. Cataract formation requires 200R for single exposure and 550R for multiple exposures.[1] Thyroid gland cancer seems related to exposures of 200-800R. Lastly, active bone marrow of the mandible is considered radiosensitive but for doses well above the modern diagnostic x-rays.[1,6]

Recently the idea that no dose of radiation is without some carcinogenic risk has been investigated. It is believed that the incidence of cancers might increase as a lineal nonthreshold function of the dose.[3,7]

A recent Tri-State survey[8] on men exposed to ordinary diagnostic radiation suggests that the estimates previously obtained by extrapolation from high dosage levels to low dose levels underestimates the actual hazards. The same survey indicates that the incidence of leukemia increases as the radiation increases from 0.1 to 10 rem. The new dosage response curve which is suggested indicates that lineal extrapolation fails because it disregards subgroups in the general population that are particularly vulnerable to x-ray.[9]

The health professions are responsible for making every reasonable effort to reduce any unnecessary radiation to patients, while continuing to obtain the absolutely essential benefits to health derived from diagnostic x-rays. Direct exposure of the film used routinely in dental radiology relies on the amount of x-ray energy needed to obtain an image, a technique which would be unacceptable for a cephalometric film.

Intensifying screens

Intensifying screens are the most commonly used devices for improving the efficiency of cephalometric radiography. Intensifying screens are thin fluorescent sheets held in close contact on each side of the film by a spring-loaded metal cassette. The reduction in patient exposure is on the order of 85 percent to 90 percent. The advantage of the screens is that much of the x-ray energy is converted into light energy. The light-emitting phosphor of these screens has been calcium tungstate ($CaWO_4$) in most applications, although lead activated barium sulfate ($BaSO_4$:Pb) and strontium/europium activated barium sulfate ($BaSO_4$:SrEu) have been used.[5] The calcium tungstate phosphors show good stability under constant irradiation and they fluoresce immediately upon radiation, emitting light in the blue and violet region of the spectrum. This matches well with the sensitivity of conventional films in the same range.[10,11]

The speed at which intensifying screens can convert x-ray energy to light energy depends on the physical properties of the phosphors. Speed is proportional to the size and number of phosphor particles. The calcium tungstate screens can be made faster by increasing the thickness of the phosphor layer, but this is attended by a significant degradation in image quality. The type of phosphor is critical because of the ability to absorb x-ray energy. The spectrum of light emitted when the phosphor is irradiated is also characteristic for the chemical composition of the phosphor. Calcium tungstate has a relatively high x-ray absorption coefficient but conversion efficiency to light is poor, typically three percent to five percent. Limitations of $CaWO_4$ and its substitutes, particularly in the last characteristic, have prevented major advances in the design of intensifying screens. Until the last decade, 96 percent of the dental schools in the United States were using conventional screens.[13]

To maximize the absorption of x-ray photons, intensifying screens should be composed of constituents of high atomic number which can be packed to a high density within the screen emulsion. These constituents should be selected so that the binding energy or ionization potential K-electrons in the screen components closely match the spectral distribution of atypical diagnostic x-ray beam after transmission through the patient.[14]

Rare earth screens

Recently, research on the fluorescent characteristics of various phosphors has led to the development of new screens, generally referred to as rare earth screens. The new phosphors are derived from the rare earth elements of the lanthanide series and are : terbium-activated gadolinium oxysulfide (Gd_20_2S:Tb), terbium-activated lanthanum oxysulphide (La_20_2S:Tb), Thulium and terbium-activated lanthanum oxybromide (LaOBr:Tm and LAOBr:Tb respectively) and europium activated barium fluorochloride.[7,10] The most noteworthy characteristics of these phosphors are their unusually high x-ray absorption coefficients, especially above the K-edge of the particular host metal ion, and their high x-ray-to-light convention efficiencies of 13 percent and 18 percent respectively. These new phosphors are chemically stable except for LaOBr which is hygroscopic and must be "stabilized" in order not to deteriorate.[7] The light emitted from Gd_20_2S:Tb snf La_20_2S:Tb produced by the terbium ion with a strong peak at 5540A is green, while Y_20_2S:Tb and LaOBr emit a significant fraction of light in the blue region of the visible spectrum.[10,11,14]

Since the calcium tungstate intensifying screens emit in the blue range, the classical silver bromide emulsion which absorbs up to about 5000A has been satisfactory. However, this is not true for the rare earth screens, since terbium ion, which is the active emitting ion, has a very strong peak at 5440A in the green with less intense emission peaks in the blue, blue-green, yellow, and red. The degree of exposure of blue-sensitive x-ray film by the oxysulfide screens depends strongly on the proportion of this relatively weak blue emission in the total output spectrum.

The efficiency of the rare earth screens relies structurally on the incorporation of elements with lower atomic numbers than tungsten (z=39-64, compared to 74 for tungsten) and therefore lower K-edge absorption energies (17.0-50.2 KeV vs. 69.5KeV for tungsten). Because x-ray absorption increases once the K-edge energy level is exceeded, most new screens absorb more energy. From 50 to 70 KeV Cd_20_2S:Tb has an advantage of four to five times over $CaW0_4$. Lanthanum oxysulfide has a factor of two advantages over $CaW0_4$ between 38 and 70 KeV.[12] Data from the literature show that about 21 percent of the total number of the incoming photons interact with the conventional screen, while for the rare earth screens it is 40 percent to 50 percent. From the above numbers a reduction of two to two and one-half times can be reached.[15] The above rare earth elements have both also higher conversion efficiency of x-ray energy to light. Yttrium oxysulfide has an absorption efficiency similar to calcium tungstate over most of the diagnostic x-ray energy range but has a greater amplification.

Most of the rare earth screen/film combinations exhibited higher sensitivity at 80KVp than at 60KVp. Above the 80KVp the sensitivity did not exhibit a similar rise.[14,16] Wagner and Weaver in 1976[15] compared the physical characteristics of three conventional calcium tungstate screen film systems and six rare earth systems. From measurements of screen film sensitometry, Wiener spectra, and x-ray spectra they assessed that rare earth medium speed screens can reduce exposure by an order of magnitude without decreased resolution or increased mottle. These systems offer exposure reduction of from two, to tenfold over conventional screens.

Rossi et al in 1976 evaluated and compared the physical and imaging characteristics of a number of commercially available rare earth screen/film combinations over the calcium tungstate/x-Omat RP-14 systems. All systems were evaluated for base-plus-fog density, relative speed, resolution, noise and overall performance. The results indicate that despite certain limitations, rare earth screen/film combinations offer acceptable retention of detail and image noise and thus offer significant advantage over conventional $CaW0_4$ systems.

Reiskin et al in 1977[11] studied the performance of nine screen/film combinations in a test target standing in air, enclosed in a plastic scatter-producing container, or in a tissue-equivalent phantom of a human head. Exposures were also made with conventional and vacuum cassettes with phantom heads as well as combinations of rare earth film/screen and conventional on patients. They found that by visual assessment, rare earth systems appear to have slightly less contrast than their conventional counterparts while showing less evidence of recording scatter from the patient. However, the most significant advantage of the rare earth imaging system is the dramatic reduction in patient dose which will result from their improved efficiency and also due to the fact that there was no need for grids or other devices to eliminate scatter.

Halse and Hedin in 1978[17] evaluated five fast screen/film combinations. A phantom head was radiographed using different tube voltages. Four angles and one linear distance were measured on films with the same density by two observers. All the rare earth combinations were subjectively judged to be qualitatively inferior to the reference system. The loss in definition however, had little influence on the reliability of the cephalometric measurement as estimated from duplicate reading on identical films.

Figure 1

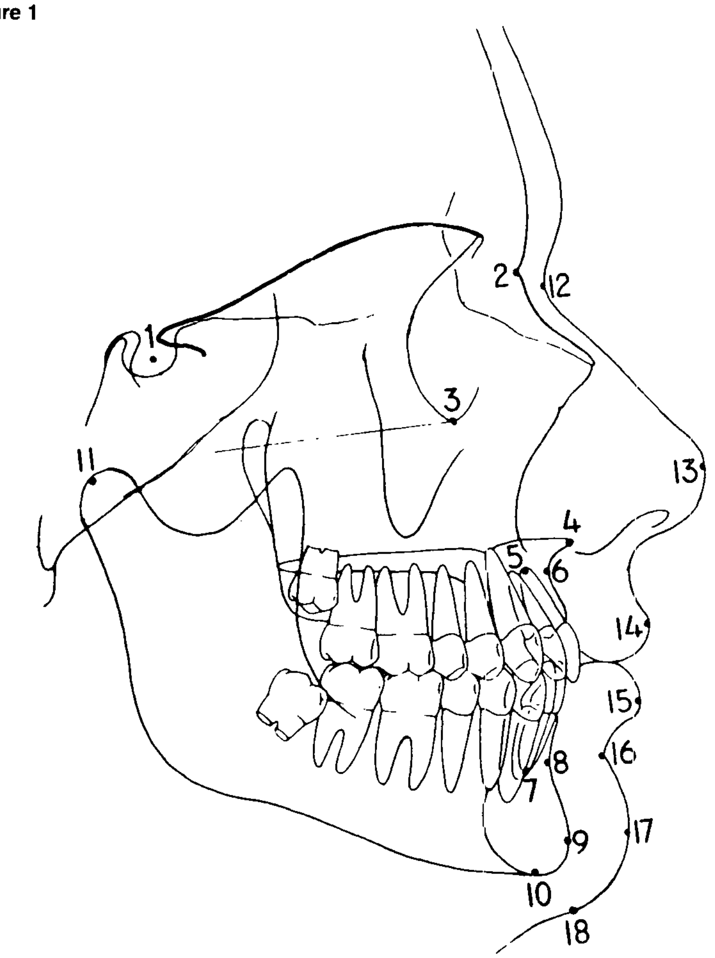

Figure 1
The 18 landmarks located in 40 lateral headfilms.

Verema in 1979[7] compared seven rare earth screens and two conventional screens. Measurements were performed at different energies of the photon fraction interacting in the screens, and energy losses due to escape of K-fluorescent radiations were calculated. The results show that rare earth screens absorb a maximum of 1.5 times as much energy and emit twice as much light as comparable calcium tungstate screens. The speed of the screens was dependent on the energy, primarily due to the fact that x-ray absorption is dependent on energy. However, reabsorbed K-fluorescent radiations might contribute to image unsharpness in the rare earth screens.

In 1981, Hurlburt[18] used four kinds of screen/film combinations among which one was a rare earth screen. Lateral cephalometric radiographs of a human skull embedded in isocyanate rubber were taken and compared by seven orthodontists. The radiographs were viewed separately to identify eight selected landmarks and determine the adequacy of their radiographic images. The results showed that, either for landmark visualization or for overall value, there was little difference in ratings.

Kaugers and Fatouros in 1982[19] undertook a clinical evaluation comparing cephalometric and posterioanterior radiographs taken with conventional ($CaWO_4$) and rare earth screens. The study was done on 130 patients: half had their radiographs taken with $CaWO_4$ system and the other half with the rare earth systems. The results showed that the diagnostic quality of radiographs taken with either system roughly comparable, while rare earth systems reduce patient exposure. A large percentage of rare earth systems (81 percent) were viewed as normal in density as compared to the calcium tungstate (69 percent). Approximately 10 percent of the calcium tungstate systems were judged to exhibit poor contrast and none of the rare earth radiographs were perceived as poor. Concerning the landmark identification, rare earth systems were at least comparable, if not slightly superior to the conventional systems.

Hurlburt et al in 1984[16] compared six panoramic radiographs. Two combinations used calcium tungstate screens (par speed and a high speed), three used rare earth screen systems four times faster than the par-speed, and one combination consisted of a single rare earth screen plus a single coated detail film. The radiographs produced by the faster rare earth screen/film combinations were found to be similar in quality to those produced by calcium tungstate screens, while reducing patient exposure.

Alvi in 1984[10] using four cadavers studied six screen/film combinations. One was a conventional screen/film system and five were rare earth systems. The cadavers were exposed to all combinations and the accuracy of landmark identification on the various films was evaluated. No significant differences were found while radiation was reduced 50 percent to 65 percent.

In the majority of the studies mentioned above it is a common finding that the rare earth systems generally show less contrast, which may not affect diagnostic information, and less image sharpness. Density was comparable while radiation exposure was dramatically reduced. Therefore, there is agreement in the usefulness of rare earth screens in clinical practice, though most studies used a phantom head.

Materials and methods

Twenty orthodontic patient files were selected at random, the criteria being that they include two cephalometric films; one taken with conventional calcium tungstate and the other with rare earth screen system. The conventional screen was Cronex* and the compatible film was SB-5.** The rare earth combination was the Curix*** MR 800 screen, and Curix MR-4-PE-NIF film, manufactured by Agfa-Gevaert. All films were exposed using optimum settings for each patient.

Landmarks were identified and digitized following the methods of Baumrind.[20] A template was placed over each of the 40 films to allow piercing of four standardized corner holes in the area surrounding the anatomic region of interest, used later for registering different tracings of the same films.

The films which were taken with conventional screens were given the number 01 and the films taken with rare earth were given the number 02, and then divided in five subgroups, each composed of eight films. Every subgroup had four consecutive films from the 01 group and four consecutive films from the 02 group. The division of film in subgroups was done so that none of the tracers would have received two films from one patient at the same time to avoid bias. Landmark location was accomplished by five graduate orthodontic students, with identical cephalometric training.

Each student was asked to record the five digit number identifying the film and his/her own two-digit identification number. Then he/she located, marked and identified with a sharp pencil on an overlaid .003 matte acetate sheet the film perforations and the requested landmarks in a standard numerical sequence.

Eleven bony and seven soft tissue landmarks were used in this study, selected as being commonly found in conventional hard and soft tissue analyses. Their difficulty in identification had been shown in the literature.[21] The 18 landmarks used in this study are shown in Figure 1 and listed in Table 1.

For each of the 18 landmarks, 100 independently located estimates were available for each rare earth screen/film system and 100 for the conventional film-screen system, five for each of 40 headfilms. The analysis was carried out by computer programs developed by Baumrind et al, and have been reported in detail.[20]

The peripheral reference points and landmarks on each tracing were digitized with a SAC GP3 Graf/Pen acoustical digitizer. The systems established a coordinate system common to all films with the Sella-Nasion line as X axis, while the Y axis was perpendicular to the S-N line, with its origin at Sella. All other land-

* *Dupont, Wilmington, Delaware*
** *Kodak, Rochester, New York*
****Summa Graphics, Seymour, CN*

Table 1

Standard deviation X (horizontal)

Pt. Name	Conventional	Rare	Significance
1. Sella	0.424	0.440	
2. Nasion	0.368	0.514	
3. Orbitale	2.012	2.421	
4. ANS	1.355	2.218	Conv<rare p<.02
5. Ul Apex	0.977	0.861	
6. Point A	0.728	0.783	
7. L1 Apex	1.432	1.223	
8. Point B	0.734	0.641	
9. Pogonion	0.395	0.370	
10. Menton	0.752	0.795	
11. Condyle	1.523	1.321	

Standard deviation Y (vertical)

Pt. Name	Conventional	Rare	Significance
1. Sella	0.418	0.512	
2. Nasion	1.154	1.682	Conv<rare p<.001
3. Orbitale	1.712	1.584	
4. ANS	0.637	0.989	
5. Ul Apex	1.282	1.306	
6. Point A	0.978	1.444	Conv<rare p<.015
7. L1 Apex	1.197	1.136	Rare<conv p<.033
8. Point B	1.388	1.443	
9. Pogonion	0.814	0.670	Rare<conv p<.008
10. Menton	0.466	0.416	
11. Condyle	1.966	1.927	

Standard deviation X (horizontal)

Pt. Name	Conventional	Rare	Significance
12. S Nasion	0.577	0.776	
13. Nose Tip	0.294	0.358	
14. U Lip ANT	0.338	0.358	
15. L Lip ANT	0.340	0.290	
16. L Sulcus	0.786	0.767	
17. S Pogonion	3.168	0.959	Rare<conv p<.001
18. S Menton	1.034	1.138	

Standard deviation Y (vertical)

Pt. Name	Conventional	Rare	Significance
12. S Nasion	1.262	1.404	
13. Nose Tip	0.463	0.755	
14. U Lip ANT	0.656	0.788	
15. L Lip ANT	0.735	0.581	
16. L Sulcus	2.299	1.195	
17. S Pogonion	2.166	1.500	Rare<conv p<.02
18. S Menton	0.482	0.507	

marks on each tracing were then mathematically expressed in terms of this "sella-nasion coordinate system."

The program checked the reliability of estimates of the various landmarks for several tracings of each film. If the dispersion of individual estimates was within the program's built-in acceptable deviations, the computer determined the best estimate to be the mean value among the five tracings.

The final output of the program was a set of values containing the best estimate of the X and Y coordinates of each landmark and fiducial points. It also evaluated how good those best estimations were for that particular point are in the form of the sums of squares in X and Y and the sum of squares of the cross products XY. Since its file was the averaging of the tracings of one cephalometric film by the five tracers, there was a total of twenty tables for each film-screen combination.

The values from all the films were combined for each screen-film combination to give X and Y values for each landmark. The sum of squares, mentioned above, gives a mean value of deviation from the mean estimate. The reliability of the landmarks could be expressed in terms of magnitude of standard deviations (SD) from the mean value. All standard deviations have been computed using the formula:

$$SD = \sqrt{\frac{\Sigma X^2}{K(N-1)}}$$

where X= the deviation of an individual tracing value from the mean value for that landmark from a film, K= the number of headfilms and N= the number of tracings per headfilm.

Findings

The findings of the study are summarized in Table 1, which shows the standard deviations of each of the 18 landmarks as located by the five judges, in the horizontal and vertical directions. Out of these 36 pairs of standard deviations, only six were shown to have statistically significant differences as evaluated by the Siegel-Tukey test. Of these six, three showed greater deviations or uncertainty of location for the conventional screen and three showed greater deviations for the rare earth screen.

Larger deviations were shown by conventional screens for:

#9 Y Pogonion ($p<.0008$);
#17 X Soft Pogonion ($p<.001$);
#17 Y Soft Pogonion ($p<.02$).

Greater deviations were shown by rare earth screens for:

#4 X ANS ($p<.02$);
#2 Y Nasion ($p<.001$);
#6 Y Point A ($p<.015$).

The most reproducible bony points in the X axis were Nasion (0.368) in the conventional and Pogonion (0.370) in the rare screens. The least reproducible landmark in the X axis for both screens systems, was Orbitale (2.012, 2.421).

In the Y axis the most reproducible landmarks were Sella (0.418) for the conventional screens and Menton (0.416) for the rare earth screens. The least reproducible for both screen systems was Condylion Y axis (1.966, 1.927).

Among the soft tissue landmarks the least reproducible landmarks were soft tissue Pogonion (3.168) in the conventional screens and soft tissue Menton (1.034) in the rare earth system for the X axis. In the Y axis they were lower sulcus (2.299) and soft tissue Pogonion (1.500) respectively. The most reproducible in the X axis was Nose tip (0.294, 0.358) for both systems and in the Y axis for the conventional screens Nose tip (0.463) and for the rare screens soft tissue Menton (0.507).

Thus it was found that while there were some significant differences between screens in the accuracy of location of various points, there were about as many advantages as disadvantages to each in this regard. In most of the measures (83 percent) there was no significant difference.

Discussion

Observer performance in the detection of radiographic detail depends on some factors related and others unrelated to the quality of the radiographic image.[22] In studies similar to the present one, there is comparison of the observer's relative ability to detect detail when viewing patient's radiographs made under different exposure and/or recording conditions. The evaluation of observer performance indirectly leads to an evaluation of the radiographic image quality.

An effort was made to filter out the observer effect by statistical procedures, so that differences in the results would be attributed to the quality of the screen/film systems. Mechanical variation in landmark location includes a number of factors, such as individual resolving ability, memory bias in identification of the same points, film/screen characteristics, film processing, illumination conditions of the working area, observer experience, interpretation of landmark definition by the observer and lack of clarity of anatomic sites.

The individual's resolving ability plays a significant role in landmark location. However, people with normal visual ability can perform adequately in such a task.[23]

Another factor that may influence the subjective evaluation of the films is the memory bias. The first location of a point will prejudice the observer as to the location of landmarks on the subsequent films. This error is inherent in the testing system and cannot be completely eliminated. In each group of films given to the observer, only one was from each patient and within groups there was a difference of a few days. A conscious effort was made to ignore foregoing assessments[17] or allow a minimum of 14 days between two assessments on the same patient.[24]

Some variation in film quality was observed due to the processing procedures. Since this was a retrospective study, it was not possible to control that factor. The films from conventional screens were developed manually and the films from rare screens were processed automatically with settings for optimum quality. Films designed to be processed manually did not differ significantly in their resolving ability when processed automatically.[23]

Viewing conditions were standardized for all observers, so that their performance in the interpretation of radiographs would not be affected. All five judges were encouraged to use same facilities located in the orthodontic department.

Observer experience was found to be significant in the x-ray interpretation procedure. In another study where two orthodontists and one technician were asked to evaluate the same sample, the results indicated that there was less variability among the experienced orthodontists as compared to the technicians.[24] In this study all judges had gone through the same course of cephalometrics and had at least eight months of experience with a maximum of 20 months. A set of definitions was also distributed to all judges prior to the film evaluation.

The selection of the 18 landmarks was based on the fact that they are used in common cephalometric analyses. The degree of difficulty in identification is determined by the specific anatomic site and the superimposition of other structures. The replication of tracings of the same film allows significant reduction in the expected error in locating a landmark. The five independent estimates ensure that the average estimate will tend to approach the true value, calculated by dividing the usual error in a landmark by the square root of the number of judges.[21,24]

In spite of the fact that a direct comparison may be difficult, we disagree with the Halse and Hedin[17] evaluation of the rare earth systems. In their phantom head cephalometric evaluation of rare earth systems, they rated the definition of all the rare earth systems examined inferior to the conventional high-definition calcium tungstate system. This may be a reflection of the fact that some of the judges become accustomed to a certain contrast level and tend to think that a film that has either higher or lower contrast characteristics is "good" or "bad." This evaluation may be unrelated to the real diagnostic value of the radiograph itself.

The results are comparable with the findings of Hurlburt[18] and Hurlburt et al.[16] where they compared the two screen/film systems for panoramic and cephalometric radiography. In both studies they concluded that the faster rare earth screen/film combinations may be substituted for the calcium tungstate screen/film combinations without any apparent loss in image visibility. They also add that a single rare earth screen combined with a detail single emulsion film can definitely improve image visibility.

Our study is in agreement with the subjective assessment of Kaugers and Fatouros[19] regarding the rare earth screens; that they are comparable to conventional screens, if not slightly superior.

Burgess and Hicken[12] performed subjective and objective comparisons of imaging performance for a number of intensifying screen film combinations on a cadaver. Their results indicate that, "dose considerations aside, the calcium tungstate screens were superior to the rare earth screens." As it was suggested, better matching of each screen with comparable film as well as using patients instead of motionless cadavers or phantoms improves the rare earth system performance.

Differences between the two systems are in the order of a fraction of millimeter. From that perspective, it is questionable if that level of difference could be of significance to the clinician. When a very high degree of precision is required, one method of improving the reliability of landmarks is replication of the evaluation procedures.[21,24]

The most important advantage of the rare earth systems is a reduction in the radiation exposure required. In this study the setting for the rare earth system was 25mA for 1/6 second, resulting in 14 mrem patient exposure, when the conventional settings were 100mA for one second resulting in 330 mrem exposure respectively. This significant reduction of patient radiation without loss of diagnostic information makes the use of rare earth screens imperative for cephalometric radiology.

Conclusions

The accuracy of cephalometric landmark location was determined in 20 pairs of headfilms, measuring the differences of 18 points in two planes of space using five independent observers. Each pair had one film taken with a conventional (calcium tungstate) intensifying screen system and one taken with a rare earth system.

1. There were statistically significant differences in accuracy in only six of the 36 measurements.
2. Three of the differences favored the accuracy of the rare earth system (Pogonion Y, S Pogonion X and Y), while the other three favored the conventional system (ANS-X, Nasion-Y, PT. A-Y).
3. The least reproducible point in both systems in the horizontal axis was condylion.
4. Since these findings showed no landmark accuracy preference of one screen system over the other, the 96 percent reduction in patient radiation with the rare earth system would mandate this be used in cephalometric radiography.

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