TECHNICAL NOTES

Principles in positioning cross-projecting lasers

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With the increased sophistication of lasers used for patient positioning in radiotherapy comes increased possibilities for mistakes in installing the lasers, which can result in serious patient positioning errors. Two principles must be followed when mounting cross-projecting lasers: (1) the horizontal line must be on the same level as the treatment unit isocenter, and the vertical line must be coplanar with the gantry rotation, and (2) If one of the lines of the cross rotates, it must be the line which is perpendicular to the line joining the two holes from which the laser beams exit the laser casing.

Key words: patient positioning, lasers, treatment errors

I. INTRODUCTION

Technical advances in laser construction, such as lasers which project lines and crosses, allow more flexibility than simple point projecting systems. The stability of modern commercial systems also has increased the possible precision with which patients can be positioned. However, improper installation can nullify all the advantages of a sophisticated laser system, and result in errors in patient position of several centimeters. Some of the errors take on the appearance of drift in the laser projection, while the more subtle, though substantial, show no overt symptoms. Following the principles for installation of cross-projection lasers given below will avoid the potential pitfalls.

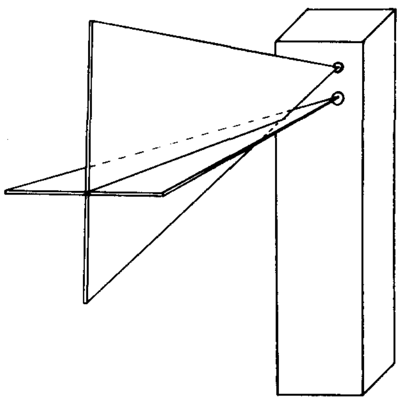


FIG. 1. Example of how the two planes are projected from the laser system.

II. DESCRIPTION OF LASER SYSTEM

The laser system[1] splits the laser beam with a glass and directs each of the two resultant beams through a cylindrical lens as described by Hughes, Karzmark, and Rust,[2] which spreads the beam into a fan-shaped plane, projecting a line on a surface normal to the plane. Orientating the two lenses at right angles makes the planes perpendicular to each other and projects a cross (Fig. 1). The line of intersection of the two planes is used as the spot projected by the more traditional lasers used in radiotherapy or the cross hairs of non-laser optical systems, to define a patient's orientation, or to establish a distance from the source. Whereas the intersection line is usually set and checked at the point of the treatment unit isocenter, in clinical use the intersection of the two lines is frequently viewed on the lateral surface of the patient's body.

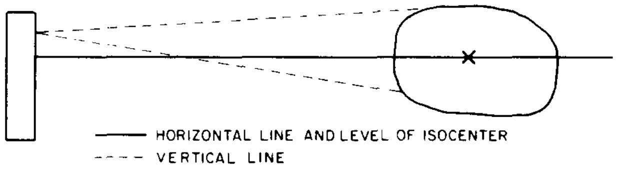
On some lasers,[3] the angle on one of the planes can be varied such that the projected line will follow some anatomical feature. Thus, the feature can be realigned with the line after the latter has been set to a specified angle in order to duplicate the patient's position in each subsequent treatment.

III. GEOMETRIC PRINCIPLES FOR INSTALLING LASERS WHICH PROJECT A CROSS

A. Alignment of planes

The projection of the horizontal line of the cross must be on the same level with the isocenter of the treatment unit [Fig. 2(a)], and the projection of the vertical line must be in the plane of gantry rotation. If the hole from which the vertical line emerges from the laser is not located on the level with isocenter, the horizontal line must travel upward or downward to intercept the vertical line at isocenter [as in Fig. 2(b)]. This means that the point of intersection of the two lines on a patient's surface would be a function of the lateral distance from the isocenter. If the patient's orientation were defined by marks placed on the patient using a properly installed laser system (such as spot lasers on a simulator), improper orientation could result, or the treatment delivered with the isocenter at the wrong position in the patient.

The amount of error, of course, depends on the size of the room. With the laser 2.5 m from the isocenter and a separation of 3.2 cm between where the vertical and horizontal lines



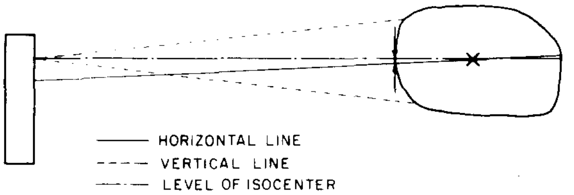


FIG. 2. (a) Properly installed cross-projecting laser, with the horizontal line on the same level as the isocenter of the treatment unit. (b) Improperly installed cross-projecting laser, with the hole for the vertical line on the same level as the isocenter of the treatment unit. The error in the indicated level of isocenter is shown between the arrows.

exit the laser box, an error of 0.13 mm per cm lateral distance from the isocenter results. That is, for a patient with a lateral thickness of 36 cm, the error in the position of the intersection of the two lines of the cross is 2.3 mm. The analogous error results from a displacement of the vertical line.

B. Criteria for a Variable Line

If the angle of one of the lines of the cross can be varied, it must be the one which is perpendicular to the line joining the two holes from which the laser planes exit the casing. Most mountings place the two holes vertically stacked. In this case, the normally horizontal line should be the one which can be set to various angles. Having the vertical line variable in this situation makes the intersection of the two arms a function of the angle set. The effect of violating this principle can be seen in Fig. 3. Figure 3(a) shows the normal method of installation, with the horizontal line properly set on the level with isocenter, but with the vertical line rotatable. For the room, patient, and laser described in the example above, this configuration with the vertical line rotated through 45° results in a 4.5 cm error in the indicated position of isocenter. Such a large error, it is hoped, would be noticed; however, if large angles are not used, the smaller errors, though still significant, may not be obvious. In Fig. 3(b) both principles have been violated, but the situation has improved due to the reduction of the variable line error. For the example situation, the error in this case would be 3.2 mm. Using either arrangement, daily errors in setting the angle would cause an uncertainty in positioning akin in magnitude and effect to patient movement. If the horizontal line rotates instead of the vertical line [Figs. 3(c) and 3(d)], the position of the intersection of the two lines remains constant. (In Fig. 3(c) there still exists the 2.3 mm error from violating the first principle). If the holes for the laser beams are oriented side by side, the roles of the vertical and horizontal lines in the foregoing discussion must be reversed. Mindful of the first principle, it is readily seen that the axis of rotation of the variable line arm must be on level with isocenter.

For lasers mounted on a ceiling, the principles would dictate that the transverse laser plane coincides with the plane of source rotation, and the longitudinal laser plane contains the source with the gantry vertically up and down.

Mounting errors are easily committed, even by persons with well developed senses of geometry. In addition, the design of commercially available variable angle lasers is such that, if mounted as produced and supplied, one or the other of the principles must be violated. Minor, but important modifications correct the problems. Just as with any other

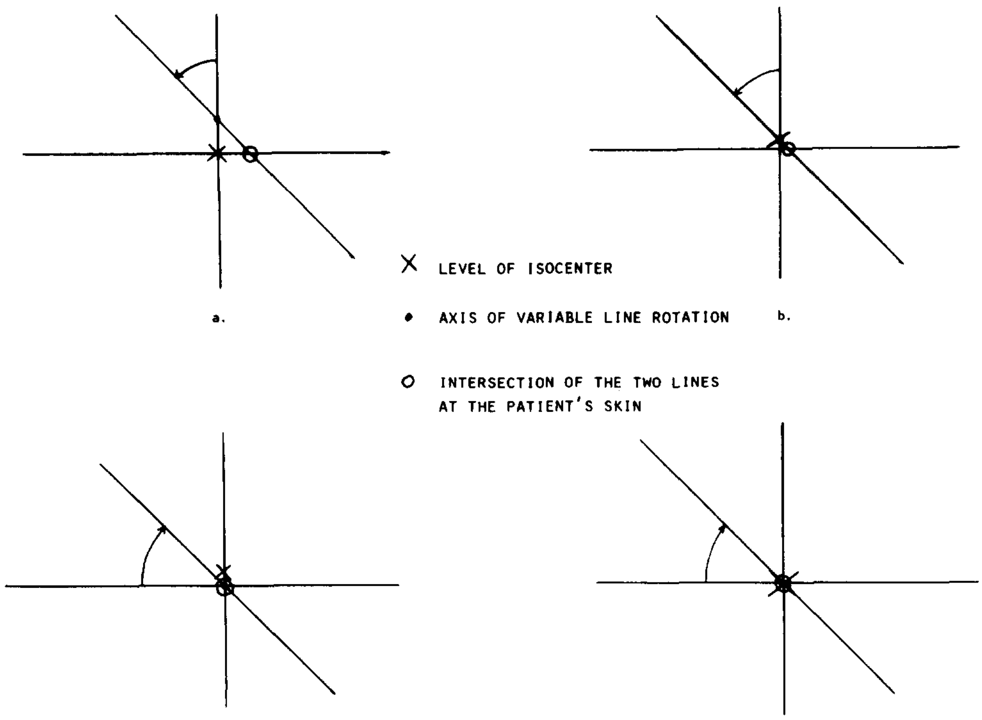


FIG. 3. The effect of various possible installations of a cross-projecting laser with one variable-angle line.

piece of radiotherapy equipment, the positioning of lasers must be carefully planned, and undergo strict acceptance testing.

ACKNOWLEDGMENTS

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[1]Gammex® Isocross.

[2]D. B. Hughes, C. J. Karzmark, and D. C. Rust, Phys. Med. Biol. **18**, 881 (1973).

[3]Gammex® Varicross.

ANNOUNCEMENT

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