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A New Thermoplastic Resin Shell for Immobilization of Patients Receiving High-Dose-Rate Intracavitary Irradiation for Rectal Cancer

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直腸癌腔内照射中の固定の工夫

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照射中の患者の固定と，毎回の照射野の再現性は放射線治療を行う上で最も基本的な問題である．現在まで外照射，特に頭頸部領域の放射線治療に対してその固定と再現性の向上をはかるため固定具を用いた報告がなされていた．一方短時間に大線量を投与する高線量率腔内照射においてはより正確な線源位置の再現が必要とされ，そのため線源の固定が必然であり，固定が確立されてはじめて正確な線量分布が得られると言っても過言ではない．

今回報告のシェルは，直腸癌高線量率腔内照射時のチューブ固定を目的としたもので患者の殿部及び大腿の一部を覆う言わば簡易シェルで，材料として熱可塑性樹脂を用い線源位置決定時にシュミレータ台上で体位を保持したまま短時間に作成が可能で特に形成器などを必要としない．この簡易シェルを用いて直腸癌5例の臨床応用を試みた結果チューブ固定に極めて有効であった．それ以後の直腸癌術前照射には必ず本法による固定シェルを作り治療している．

今回，我々はこのチューブ固定シェルの作成ならびに有効性について報告する．

Introduction

Preoperative high-dose-rate intracavitary irradiation has been performed for patients with rectal cancer as a preliminary study at our department since October 1986. For the first five patients, tape was used to fix the outer tube to the buttocks, but with this method the position of the source was found to change during radiotherapy.

To stabilize the source during radiotherapy, we devised an adjustable immobilizing shell made of thermoplatic resin, and have used this since March 1987. It was found that the shell was highly effective for immobilizing the radiation source.

The present report describes the manufacturing procedure for the shell and its efficacy.

Materials and Methods

1. Materials

The shell is made of thermoplastic resin (Kurare Shell Fitter: KSF), which was originally developed for use in immobilizing the head and neck during external beam radiotherapy.

2. Fabrication of the shell

The shell was fabricated by the following procedure:

1) A piece of KSF was cut to about 15 × 30 cm in size. Initialy KSF was heated to 70~80°C using a heater so that it became soft and then was left at room temperature until it cooled to 40°C. Thus, it could be molded at a temperature which was not hot to the skin.

2) A colonoscope was used to determine the source position in patients who were placed in the left lateral position on the table of the simulator. The piece of KSF (at about 40°C) was then molded around the patient, who remained in the same position, so that it fitted over the gluteofemoral region in conformity with the body curvature (Fig. 1a).

3) The position of the anus was confirmed and marked on the KSF. A towel wetted with cold water was applied to the shell to harden it rapidly while the patient maintained the same posture.

4) When the KSF became transparent and hard, it was detached from the patient. A hole was made at the marked for the anus to allow insertion of the outer tube of the radiation source. Then a cylinder for immobilization of the outer tube, also made of KSF was attached at this point (Fig. 1b).

3. Use of the immobilizing shell

The outer tube of the radiation source is inserted into the patient lying in the left lateral position on the radiotherapy couch.

Fig. 1 Process of making the shell: (a) The shell is forming and hardening on a patient, who is lying on the table of the simulator.

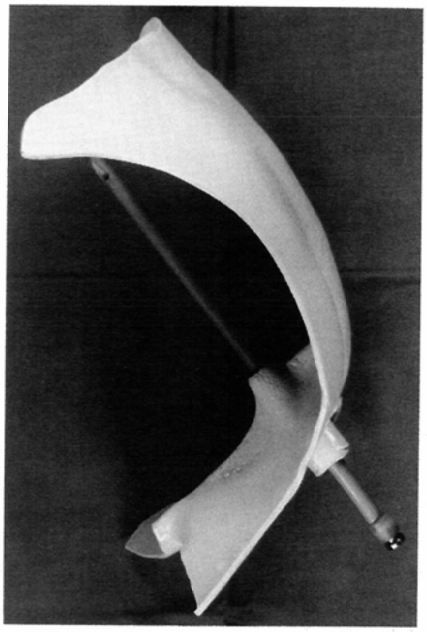

Fig. 1 Process of making the shell: (b) Completion of the shell.

The shell is then placed over the outer tube and hold in position on the patient using elastic tape. The inner tube with its dummy source is then introduced into the outer tube, and the source position is fluoroscopically determined. The shell and the inner tube are then immobilized with tape and irradiation is commenced (Fig. 2).

4. Evaluation of the efficacy of the shell

Five patients for whom we used the shell (shell (+) group) were compared with five other patients for whom we did not use the shell (shell (−) group) with respect to the movement of the source during radiotherapy.

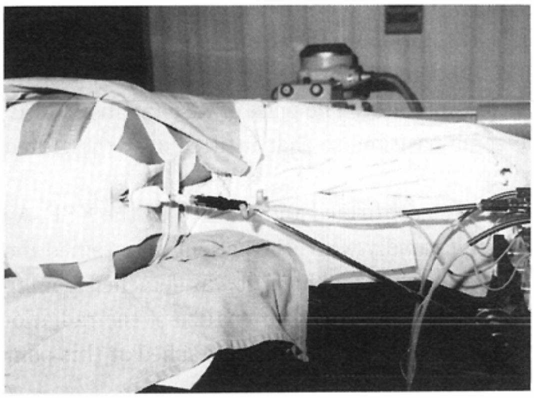

Fig. 2 Application of the shell at irradiation: The shell and outer tube are immobilized with elastic tape.

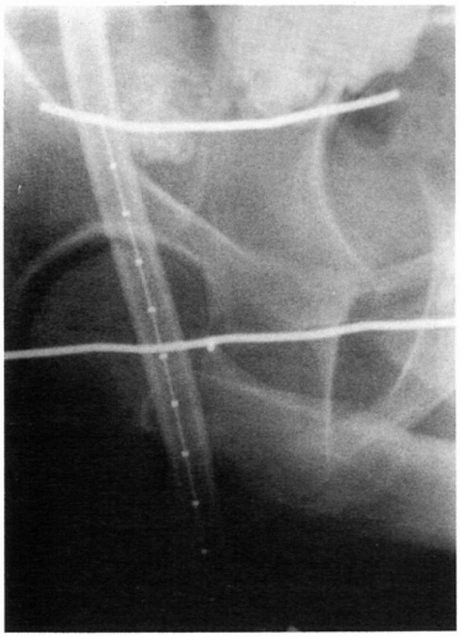

Fig. 3 Verification of the position of the source: (a) Before irradiation.

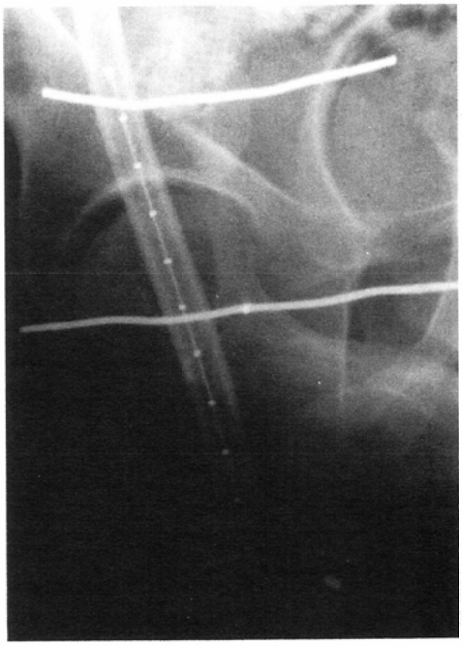

Fig. 3 Verification of the position of the source: (b) After irradiation.

On the treatment verification films taken before and after irradiation, the distance between the skin mark indicating the superior margin of the source position and that for the superior margin of the dummy source was measured (Fig. 3).

The mean absolute values for the shell (+) group and the shell (−) group were then calculated.

Since the duration of radiotherapy differed among the patients, the movement of the source per unit time was obtained by dividing the total movement by the treatment time.

Results

1. Patient characteristics and treatment regimens

The shell (−) group were aged from 48 to 65 y. with a mean of 59.2 y., and the tumor length ranged from 4 to 7 cm with a mean of 5.4 cm. The tumor site was Rb in all patients. The duration of irradiation ranged from 8.2 min to 45.0 min, with a mean of 23.4 min (Table 1).

In the shell (+) group, the ages ranged from 51 to 86 y. with a mean of 69.0 y., and the tumor length from 4 to 8 cm with a mean of 5.4 cm. The tumor site was Ra in 2 patients and Rb or lower in 3. The treatment time in the shell (+) group ranged from 22.7 to 38.3 min with a mean of 31.0 min (Table 2).

While the two groups showed no significant difference in irradiation time, which was the parameter thought to be most related to movement of the source, the duration of irradiation in the shell (+) group was actually longer by a mean of 7.6 min.

2. Movement of the source

The movement of the source ranged from 3 to 16 mm with a mean of 8 mm in the shell (−) group, and from 0 to 5 mm with a mean of 1.5 mm in the shell (+) group. There was a significant difference between the two groups ($p<0.01$).

The movement of the source per unit time (L/T) varied between 0.09 and 0.60 with a mean of 0.48 in the shell (−) group, and between 0 and 0.13 with a mean of 0.05 in the shell (+) group. Again, a significant difference was recognized between the two groups ($p<0.01$) (Table 3).

Table 1 Patient characteristics of the shell (−) group

Case/Sex/Age (yrs.)	Tumor Length (cm)	Tumor Site	Total Dose/Fraction (Gy/fr)	Treatment Time (min.)
1/M/61	7	Rb	16/2	8.2 8.2
2/M/62	4	Rb	20/1	22.5
3/M/65	4	Rb	40/1	26.8
4/M/60	5	Rb	50/1	45.0
5/M/48	7	Rb	80/2	26.8 26.8

Table 2 Patient characteristics of the shell (+) group

Case/Sex/Age (yrs.)	Tumor Length (cm)	Tumor Site	Total Dose/Fraction (Gy/fr)	Treatment Time (min.)
6/M/61	5	Rb	80/2	28.5 28.5
7/F/51	4	Rb	80/2	22.7 22.7
8/F/86	4	Rb-P	80/1	33.9
9/M/78	6	Ra-Rb	60/1	35.4
10/M/68	8	Ra	80/2	38.3 38.3

Table 3 Comparison of the movement of the source during intracavitary irradiation between the two groups.

Shell(−)group			Shell(+)group		
Case	L (mm)*	L/T (mm/min)**	Case	L (mm)*	L/T (mm/min)**
1.	12 3	1.47 0.37	6.	1 2	0.04 0.07
2.	5	0.22	7.	0 2	0.00 0.09
3.	11	0.41	8.	1	0.03
4.	4	0.09	9.	0	0.00
5.	16 5	0.60 0.19	10.	1 5	0.03 0.13
mean	8.0	0.48	mean	1.5	0.05

*($p<0.01$) **($p<0.01$)

Discussion

Immobilization of the patient during irradiation is one of the most basic requirements in radiotherapy. Karzmark et al.[2] and Marks et al.[3] found a bite block to be useful for immobilization of the head and neck. Inoue et al.[4] successfully reduced motion of the irradition field during laryngeal treatment by using a combination of a bite block and casting tape.

There are also a few reports about immobilization shells, which were variously made of acryl, vinyl chloride, urethane foam[5], water-hardening resin[6] and thermoplastic resin[7,8].

In Japan, Irie et al.[9] have used a shell in short-term small fraction radiotherapy to improve the precision of the treatment.

In intracavitary irradiation, immobilization of the source is essential to obtain an accurate dose distribution. Henschke et al.[10] reported that in the treatment of carcinoma of the cervix by means of afterloading, source immobilization and dose distribution were ensured by the use of an applicator.

Tazaki et al.[11] and Suit et al.[12] were able to immobilize the source by using a modified applicator and gauze packing in treating carcinoma of the cervix.

Our adjustable immobilizing shell was made of thermoplastic resin and has been in use since March 1987.

In that time, we have found that the shell was highly effective for immobilizing the source.

Since KSF has already been used for the treatment of the head and neck with no reported skin reaction, its safety should pose no problems.

A shell for immobilizing the source in high-dose-rate intracavitary irradiation for rectal cancer can be convenietly produced in a short time by following the procedure reported in this paper. Use of such a shell facilitates the accurate delivery of irradiation even over a long period with minimal discomfort to the patient.

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