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● *Original Contribution*

DOSIMETRIC COMPARISON OF THE FLETCHER FAMILY OF GYNECOLOGIC COLPOSTATS 1950–1980

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The Fletcher gynecologic applicator was developed for irradiation of carcinoma of the uterine cervix in the early 1950's. Since that time, numerous modifications and changes have been made in the colpostat construction and in the location of the shields that provide a reduced dose to the bladder trigone anteriorly and to the rectal wall posteriorly. The original applicators include the preload radium double colpostat and the preload radium single colpostat. In the 1960's, afterloading colpostats were manufactured as the Fletcher-Suit and the Fletcher-Green devices. With the introduction of the Delclos mini-colpostat, a new generation of applicators followed in the 1970's. The Fletcher-Suit-Delclos colpostat recently manufactured by two companies can be used as a mini-colpostat. By adding a shield-containing cap, these applicators function as the original Fletcher colpostat. With the development of new applicators over the past 30 years, numerous changes in the position of the shields and, therefore, the dose transmitted to the surrounding tissues have been made. This paper describes dosimetric evaluation of all of these applicators and the various changes that have occurred through the generations of Fletcher colpostats in an attempt to provide information for radiation therapists and gynecologists who are using these instruments in their clinical practice.

Cesium-137, Fletcher colpostat, Dosimetry.

INTRODUCTION

The Fletcher applicator was developed for irradiation of carcinoma of the uterine cervix at M. D. Anderson Hospital and Tumor Institute in the 1950's. It was designed with a colpostat system that is easily applied and maintained in position in the lateral fornices of the vagina to produce an increase in para-cervical and parametrial irradiation, while shielding the bladder trigone and the anterior rectum.[2] The first system used preloaded radium sources; it was not until the 1960's that the original tandem and ovoids were adapted for use with afterloading radium tubes in the Fletcher-Suit system.[10] Since that time, the rectangular handle Fletcher-Suit colpostat has been modified into the round handle Fletcher-Green afterloading device.[3] In the 1970's, the Delclos mini-ovoid was developed for use in stenotic vaginal vaults. More recently, the Fletcher-Suit-Delclos gynecologic applicator, combining the features of the original Fletcher-Suit system plus the Delclos mini-ovoid, has been developed by two manufacturers.[4,5] Over the past 30 years, modification of the Fletcher colpostat has included changes in the basic construction material to include stainless steel and aluminum, alterations in the anterior and posterior shield location and in shield construction, development of afterloading source carriers, and changes in colpostat dimensions.

With such a variety of instruments available within the Fletcher group of applicators, radiation therapists and gynecologic oncologists need information that allows for selection of an applicator to best serve their clinical needs. As a way of describing the developments and changes in the Fletcher system over 3 decades, and to define the likenesses and differences in each generation, a comparison of these applicators was undertaken. All of the applicators were evaluated as to their physical parameters and their dosimetric characteristics. The colpostats were examined regarding (1) dimensions, (2)

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position of the shields, (3) position of the source in the colpostat, (4) transmission across the colpostat wall, (5) transmission ratios across the shielded surfaces of the colpostat, (6) the isodose curves around the colpostat, and (7) usefulness in the clinical situation.

METHODS AND MATERIALS

The experimental situation was devised so that all dosimetric information was obtained in the water phantom. The film, dosimeter, and experimental set-up were specially modified to meet this requirement. Details of the materials and methods are described in reference 4. Transmission ratios and isodose curves were determined for planes 1.2 cm from the colpostat top, and 1.0 cm from the colpostat bottom. These planes correspond anatomically with the bladder trigone and anterior rectal wall, respectively, and have been used in other studies.[6] Cesium-137 (3M) 30 mg-eq positioned with the eyelet toward the colpostat surface was used for each experimental run. Because the active length of cesium is not symmetrically positioned in the total source length, experimental error and clinical dose calculations can differ by as much as 9% for colpostats when compared with radium dose tables.[8,9]

RESULTS

Preload (1950's)

The preload Fletcher applicators include the original radium stainless steel colpostat with tungsten shields and the preload single colpostat. All the Fletcher general use colpostats studied are in the size range of 2 cm diameter by 3 cm high. They are supplied with 2.5 cm and 3.0 cm diameter spacer caps to push the vaginal wall further from the source and reduce the dose to the vaginal mucosa. The shields in the preload double colpostat occupy different positions at the top and bottom surfaces (Figure 1). The preload radium single ovoid was used for stenotic vaginal canals that could accommodate only one colpostat. The shield placement was rotated to shield a 180° sector at the top and bottom aspects of the ovoid.

The isodose distributions for the preload Fletcher double and preload Fletcher single colpostats are shown in Figure 1. The isodose curves are pinched-in over the area adjacent to the shield and show the region of tissues receiving a reduced radiation dose. By rotating the position of these shields, the isodose configurations are changed in the preload Fletcher single. Because only one colpostat is being used in this system, the shield has been rotated to produce a symmetrical dose reduction around the axis of source. The shield position is the same at the top and bottom of the single colpostat. For the double instrument, the right and left colpostat will give a combined isodose distribution that protects the bladder trigone anteriorly and anterior rectal wall posteriorly. There is a 5% reduction in dose across the applicator wall for both applicators due to absorption by the colpostat.

The transmission ratio describes the fraction of radiation dose that is transmitted through the shielded colpostat in the region of the tungsten screen. The ratio for the shielded portion of the colpostat is determined by dividing the radiation dose delivered to a point across the shielded source by the radiation dose delivered to the same point through the unshielded source. The Fletcher preload double and preload single provide a reduction in radiation dose to the shielded tissues of 15–20%. The configuration of the transmission ratios is directly related to the position of the shield in the colpostat and to the shape of the shield. Because the shield location in the preload double is different at the top and bottom surfaces of the colpostat, the reduced tissue dosage in this area, as reflected by the transmission ratios, also shows a different pattern. The transmission ratios for the preload single have a different configuration than for the double system, but are the same at the top and bottom surfaces, thereby providing symmetrical shielding to the bladder and rectum (Figure 1).

Afterload (1960's)

In 1963, the Fletcher system was modified to use afterloading radium tubes in the Fletcher-Suit colpostat.[10] The afterloading technique has the obvious advantage of greatly reducing exposure to the radiation oncologist and to operating room personnel during gynecologic implants as well as facilitating optimum treatment planning. In order to accommodate the afterloading feature, the shields in the colpostat were rotated. Both the top and the bottom aspects of the colpostat have the shields in identical positions (Figure 1). The applicator has been manufactured with shields of tungsten as well as of lead, although the tungsten screens are currently in use. The rectangular handles and stainless steel construction make the applicator bulky and heavy, weighing about 450 gm for the combined colpostats.

To reduce the applicator weight and return the shields to the position of the preload colpostat, the Fletcher-Green colpostat was introduced in 1969.[3] In this applicator, the shield position was returned to essentially that of the original preload radium colpostat (Figure 1).

The isodose lines for the Fletcher-Suit colpostat reflect the medial position of the shields and show a reduced dose area that is the same for the top and bottom aspects of colpostat (Figure 1). Isodose curves for the Fletcher-Green colpostat also demonstrate a dose reduction to the tissues shielded by the tungsten screens, although the configuration of this low dose region differs from the top to bottom surfaces of the colpostat because of the change in shield position.

The Fletcher-Suit colpostat transmission ratios demonstrate a 15–20% reduction in dose across the shielded colpostat and follow the configuration and position of the shield. Likewise, the transmission ratios for the Fletcher-Green colpostat demonstrates a lowering of

FLETCHER FAMILY OF GYNECOLOGIC APPLICATORS	Construction: Applicator	Construction: Shield	Spacer Caps	Dimensions & Colpostat — Handle ∡	Shield Position: Top	Shield Position: Bottom	Isotope	Isodose Curves: Top	Isodose Curves: Bottom	Absorption By Colpostat Wall	Transmission Ratios: Top	Transmission Ratios: Bottom
PRE-LOAD 1950's												
FLETCHER DOUBLE	Stainless Steel	Tungsten	2.5 & 3.0 cm	∡ 30°			Radium			5%		
FLETCHER SINGLE	Stainless Steel	Tungsten	2.5 & 3.0 cm	∡ 30°			Radium			5%		
AFTER LOAD 1960's												
FLETCHER — SUIT	Stainless Steel Rectangle Handle	Tungsten or Lead	2.5 & 3.0 cm	∡ 30°			Radium & Cesium 23.5x3.5mm Maximum Source Size			5%		
FLETCHER — GREEN	Stainless Steel Round Handle	Tungsten	2.5 & 3.0 cm	∡ 15°			Radium or Cesium 23.5x3.5mm Maximum Source Size			5%		
AFTER LOAD MINI 1970's												
DELCLOS — MINI	Stainless Steel	No Shields	No Caps	∡ 15°			Requires Sources With Eyelets			4%		
FLETCHER — SUIT — DELCLOS (RTR) MINI	Aluminum	No Shields	No Caps	∡ 15°			Radium or Cesium 23x3.5mm Maximum Source Size			3%		
F-S-D		Tungsten in Cap & Colpostat	2.5 & 3.0 cm									
FLETCHER — SUIT — DELCLOS (3M) MINI	Stainless Steel	Tungsten Caps	No Caps	∡ 15°			Cesium 20x3.1 mm Maximum Source Size			7%		
F-S-D		Tungsten in Cap & Colpostat	2.5 & 3.0 cm									

Fig. 1.

dose to the shielded tissues, although in a slightly different pattern because of the change in the shield location and to the difference in position from the top to the bottom surfaces of the applicator (Figure 1).

Afterload Mini-Colpostat (1970's)

A new generation of Fletcher gynecologic applicators was developed based on the Delclos mini-colpostat. The mini-colpostat is designed for use in patients with narrowed vaults. There is no shielding contained anywhere in the mini-colpostat. Because the system is designed for use in stenotic vaults, there are no nylon caps that fit over the colpostat to act as spacers for the vaginal wall (Figure 1).

The first afterloading Fletcher applicator based on the mini-colpostat was developed by Radiation Therapy Sources, Inc., previously Nuclear Associates.* Like the Delclos mini-colpostat, there is no shielding in the colpostat itself. A cap that contains medial shields slips over the mini-colpostat converting it to a Fletcher-Suit-Delclos. The shield arrangement is identical to the Fletcher-Suit instrument. This applicator is manufactured of aluminum and weighs 50% less than the Fletcher-Suit afterloading applicator. It is designed for use with radium or cesium sources.

The most recent addition to this generation of Fletcher gynecologic applicators is also constructed around a mini-colpostat,† with the shields arranged so that it is identical to the original preload Fletcher applicator (Figure 1).

Isodose curves around the Delclos mini-colpostat are essentially identical to the isodose curves obtained from the bare source. Because there is no internal shielding, the only perturbation in the isodose curves is due to absorption by the colpostat wall. The isodose curves obtained from the (RTR) Fletcher-Suit-Delclos mini-colpostats are the same as those of the original Delclos mini-colpostat, reflecting the absence of internal shielding (Figure 1). By adding the shield containing cap to the (RTR) colpostat, the medial isodose lines become pinched-in, demonstrating the area of reduced dose to the bladder and rectum. These isodose curves are similar to those produced by the Fletcher-Suit applicator, in that the lower dose region occurs at the medial aspect of each colpostat and is the same for the top and bottom surfaces of the colpostat. The isodose pattern of the (3M) Fletcher-Suit-Delclos mini shows an area of minor dose decrease secondary to internal shielding that is present in the mini-colpostat. When the tungsten shield-containing cap is placed on the mini-colpostat, a more dramatic change in the isodose configuration is noticed.

Because the Delclos-mini ovoid has no shielding, the transmission ratios show no dose reduction in any area surrounding the mini-colpostat, except for the dose reduction that is a result of self-absorption through the colpostat wall (Figure 1). Likewise, the (RTR) Fletcher-Suit-Delclos mini-colpostat has no reduced dose around the colpostat except that produced by self-absorption. The (RTR) Fletcher-Suit-Delclos applicator shows a 10–25% reduction in the dose of radiation delivered to the bladder and rectum screened by the shield. The transmission ratios are the same for the top and bottom aspects of the shield. The (3M) Fletcher-Suit-Delclos mini-colpostat produces an area of reduced radiation transmission just adjacent to the area of internal shielding in the mini-colpostat; however, this is a very small volume, and because there are no spacer caps to push the vaginal mucosa away from the source, the vaginal surface dose can be quite high.

The addition of the shielded cap provides a larger area of dose reduction. Up to 10–25% of the dose being received by the non-shielded area is attentuated by the shields.

DISCUSSION

Some of the basic tenets for use of intracavitary radioacive sources were elaborated by Gilbert Fletcher in the early 1950's. They include spatial distribution of the sources to allow for an increase in paracervical and parametrial irradiation, reduction in dose to the bladder and rectum through the use of selective shields, and use of paired colpostats in conjunction with a uterine tandem. Over the past 30 years, a number of new Fletcher-type applicators have been manufactured with various design modifications in an effort to improve upon the original Fletcher instrument. Along with the improvements in the Fletcher system have come applicators of poor design, poor construction with shielding lacking or in inappropriate position.[1] The general trend in modification of the original Fletcher system has been toward afterloading devices such as the Fletcher-Suit or Fletcher-Green applicators. More recently, the incorporation of the Delclos-mini colpostat as part of the Fletcher system has been developed. Throughout these years, the screening shields at the top and bottom surfaces of the colpostats have undergone numerous changes in shape and position as described in the results section. A change in the shield position obviously results in a different configuration and distribution of reduced dose to local tissues that are shielded by these screens. Articles reporting the dosimetry of Fletcher type applicators using afterloading with radium or cesium have stressed that doses delivered to the parametria, central disease bladder, and rectum may not correspond to the dosimetry outlined in Fletcher's original publication.[1,6,7,11] According to Delclos and Fletcher, tables that outline milligram hours and treatment times should be only used for the

* Radiation Therapy Resources, Inc., 25213 Avenue Stanford, Valencia, CA 91335.

† 3M, 3M Center, St. Paul, MN 55101.

original Fletcher preload applicator or for the Fletcher-Suit or Fletcher-Green afterloading models and only for radium tubes with the same filtration as those used to construct the tables.[1] If cesium sources are used, dose rate tables for cesium should be used for reference.[8]

The changes made in the Fletcher system over the past 10 years center around the Delclos mini-colpostat, which has the advantage of being able to use a Fletcher type geometry for treatment of cervical cancer, but has the disadvantage of increased vaginal surface doses, bladder and rectum doses because of the smaller colpostat and because no shielding is used with this system. The surface dose for the mini-colpostat with 10 mg-eq cesium is similar to that from the Fletcher-Suit ovoids loaded with 15 mg-eq cesium. The mini-colpostat should never be used in place of standard colpostats or vaginal cylinders if the anatomy will accommodate one of these applicators. The two Fletcher-Suit-Delclos applicators can also be used in the mini-colpostat configuration and the same constraints on source loading should be taken into consideration.[4] Although there is some internal shielding in the (3M) Fletcher-Suit-Delclos colpostat, the isodose curves and transmission ratios show that the effective reduction in dose to the bladder and rectum is quite small; therefore, the presence of this limited shielding should not give one false security in being able to use higher doses.[5]

While using the applicators in the laboratory for experimental work and for clinical patient care, a number of mechanical and technical problems were found. Some radiographs show that the source in the carrier buckets was not aligned between the two shields in the colpostat. In both of the Fletcher-Suit-Delclos applicators and in the Fletcher-Suit applicator, shields have fallen out of the applicator and had to be replaced. All the applicators have suffered from corrosion problems due to use of caustic solutions and autoclaving. Several of the applicators showed welding leaks on the dosimetry films where the source was not being shielded by either the tungsten screens or the colpostat wall.

SUMMARY

The Fletcher gynecologic applicator is a widely used instrument for intracavitary treatment of gynecologic cancers. Modifications and changes have been made in the manufacture of this applicator and its several subsequent generations since 1950.

- Afterloading instruments are now used to decrease exposure to personnel.
- Applicators made of aluminum are generally lighter, although this does change the amount of self-absorption through the colpostat wall.
- The general size and shape are similar through the years, but changes in shield position and shield shape have produced alterations in magnitude and configuration of isodose curves and transmission ratios.
- The introduction of the mini-colpostat gives flexibility to the armamentarium of instruments, but if not carefully used, may contribute to increased local tissue adverse effects.

Radiation oncologists and gynecologic oncologists need to be aware of the differences, similarities and peculiarities among the Fletcher applicators in order to select the instrument that suits their needs. A recently purchased applicator or newly manufactured modification of the Fletcher system should be evaluated with radiographs and dosimetry as to its physical makeup, shield position, dose reduction to shielded tissues, and self-absorption through the colpostat wall in order to produce the clinical effects that are desired and keep adverse side effects to a minimum. In addition, ongoing quality control of an applicator should be continued for an instrument that has been in service to detect misaligned shields, weld leaks, or other maladies resulting from clinical use.

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