Development of Membrane Type Liquid Variable Compensator

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ABSTRACT

Heavy ion and proton therapy necessitate range weeks, which are time consuming. Three types of variable compensator, membrane type liquid variable compensator, are proposed by some of the authors to overcome the difficulties, by those arbitrarily thickness distribution of compensator obtained from treatment planning is created at the site of treatment. None of the ideas, however, is yet realized. In this research, we are trying to construct prototype membrane-type liquid variable compensator. This variable compensator partitions air and liquid with elasticity membrane and changes the surface of the elasticity membrane with the thread. The air and oil move through holes to and from the out of beam side of two boxes in which they are contained. The boxes are made of Plexiglas(PMMA), the thread which is made of nylon, the elasticity film which is made from latex for the moment.

Keywords: Variable compensator, bolus, proton therapy, inverse treatment

1. INTRODUCTION

In proton therapy, a bolus or a compensator is used to change proton beam energy on position depending on the shape of a tumor to be treated. Figure 1 shows schematically the application of compensator. Compensators are created by machining from wax or resin. As the shape of the compensator is dependent on the shape of the tumor, it should be created for each patient and for each irradiation directions. To minimize damage to normal tissue, tumor had better be irradiated from many directions. For that purpose, many compensators have to be created and have to be changed depending on the direction of the irradiation. And compensators should be stored approximately for one month during which each patient is irradiated. At least three types of variable compensators are proposed up to now. None of them has been put to practical clinical use. Membrane type liquid compensator is under development as is reported in the following.

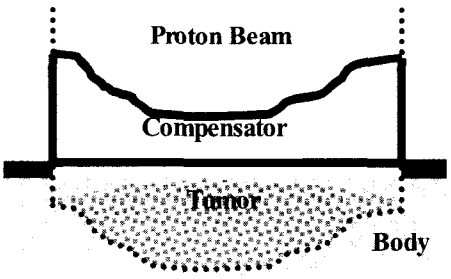

Fig . 1. Application of compensator

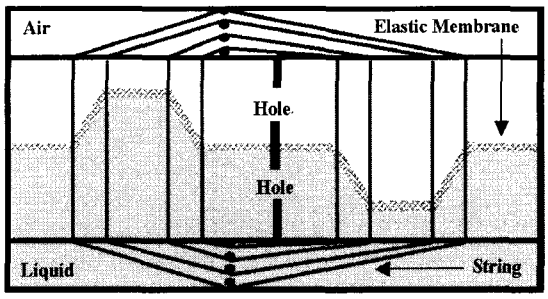

Fig.2 Membrane Type Liquid Variable

2.MEMBERANE TYPE LIQUID VARIABLE COMPENSATOR

Membrane type liquid variable compensator consists of air, membrane, liquid, and strong string to move the membrane as is shown in Fig. 2 in crosssectional view (Patent pending).

3. CONNECTION OF STRING TO ELASTIC MEMBRANE

Most fragile part of the Variable Compensator seems to be the connection of string. to elastic membrane. Nylon string is passed through latex membrane hole and connected. The strength of connection is measured by a spring balance. The limit of extension of membrane, limit force are measured. Fig.3-1 shows the picture of extension of membrane.
In this experiment, 4cmx4cm square opening was created in 7cmx7xm plastic plates fixed the membrane placed in between. And Nylon string of 0.7mm in diameter Was fixed in the middle of the membrane by letting it pass through

a hole. Fig. 3-2 shows schematically the way by which membrane is fixed.

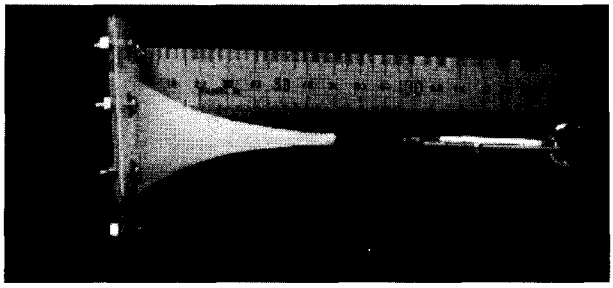

Fig.3-1 Picture when Nylon String is pulled.

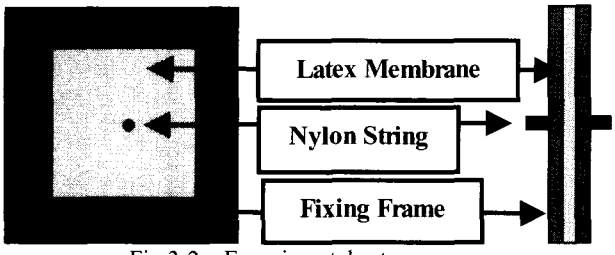

Fig.3-2 Experimental set-up

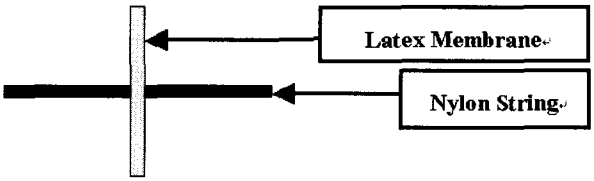

Fig.3-3 Adhesion by Resin Glue

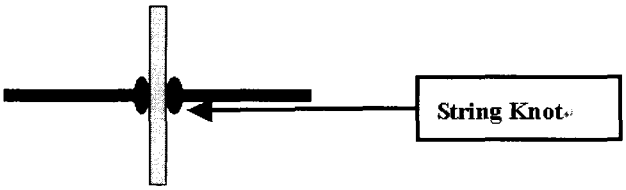

Fig.3-4 Adhesion with String Knot

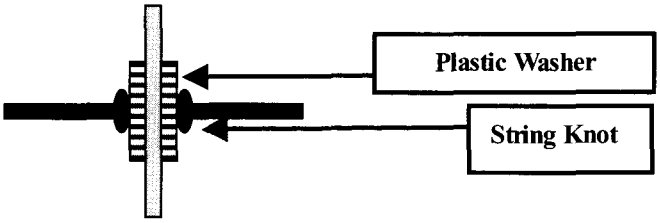

Fig.3-5 Adhesion with Washer and Knot

3.1 Connection method ①.

Nylon string was pierced through latex embrane. Next string and membrane was glued by dhesive resin. Fig.3-3 shows adhesion only by resin glue.

3.2 Connection method ②.

Nylon string was pierced through latex membrane. And knot was made to the string. The diameter of knot was approximately 1.7mm.Next knot of string and membrane was glued by adhesive resin. Fig.3-4 shows schematically the adhesion.

3.3 Connection method ③.

Nylon string was pierced through latex membrane and thorough plastic washer of the outer diameter of 3mm.. And knot was made to the string. The knots were glued to plastic washer of the outer diameter of 3mm.
Figure 3-5 shows schematically the adhesion.

3.4 Experimental Results on Connection Strength

Fig.3-6, and Fig.3-7 show the results of experiments measuring the forth and extension of latex just prior to break down. Although, adhesion of Nylon string directly to latex is not strong, a small modification making knot to Nylon string made adhesion much stronger.

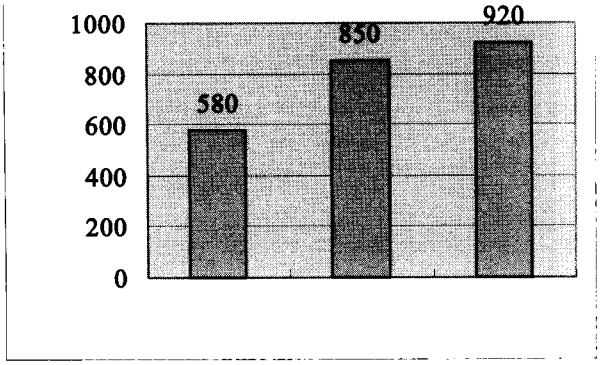

Fig.3-6 Forth Measured by Balance

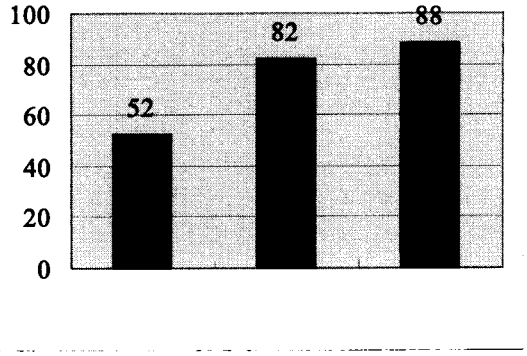

Fig.3-7 Extension of Membrane

4. STRETCHING OF LATEX MEMBRANE BY TWO NYLON STRING

Fig.4-1 shows the experiment of stretching latex membrane by two Nylon string 5mm or 10mm apart. Fig. 4-2 and Fig.4-3 show the forth and extension of the latex membrane just prior to break down.

4.1 Experiment result by two nylon strings

Although the value of big growth was able to be somewhat acquired when enlarging the interval of connection of thread, the small value came out compared with the experiment. however, since it is thought that most neoplasm which have the difference in a distribution with a thickness of no less than 40mm at the interval of only 10mm cannot be considered, it is thought that the value of this experiment is a value within tolerance level.

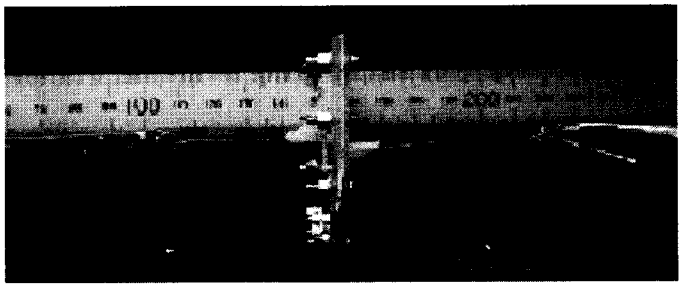

Fig.4-1 Stretching of Latex

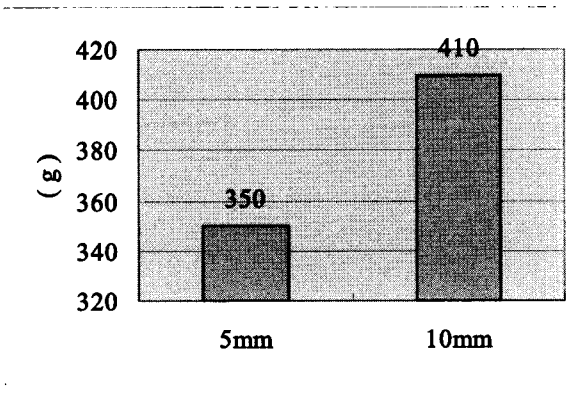

Fig.4-2 Forth Measured by Balance

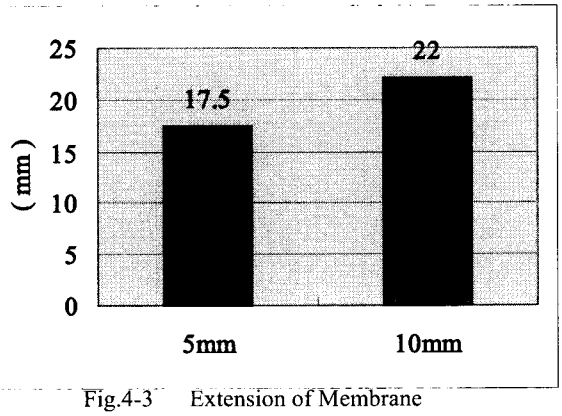

Fig.4-3 Extension of Membrane

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