Method for Continuous, Controlled Application of Separating Force to Rat Molar Teeth

HUSSEIN M. HADJ-SALEM, D.D.S., M.S.

While planning a study of the cortisone effect on tissue response to tooth movement,[3] it became necessary to devise a reliable means of delivering force to the molar teeth of rats. Review of the literature showed that several different methods have been developed.

Seipel[5] designed a lingual arch of light stainless steel wire (.008 to .004 inch diameter) to exert expansion forces on the upper first molars of rats. It was capable of delivering a force of two grams or less per mm of arch compression in short-term experiments not exceeding three days' duration. In addition to the limitation of short-term action, the close adaptation of the wire to the lingual surfaces of all the molars invited food accumulation and gingival irritation.

Waldo and associates[9,10] inserted pieces of rubber elastic between rat upper molars which were said to remain in place for five to seven days. This method has the disadvantage that the magnitude of force is unknown but probably is quite large initially followed by a sharp reduction as tooth separation occurs. Those who have used this technique report privately that good position of the elastic is difficult to obtain and that the rubber segment most often remains in place for only a few days at best. An undesirable factor is also introduced by the displacement of the soft tissues with resulting inflammatory response and necrosis.

The extensive investigations of Storey[6,7,8] on tissue reactions in rodents utilized a helical torsion spring with two arms which were inserted into holes drilled into the incisor teeth. Its fundamental deficiency lies in its inability to deliver force to molar teeth.

Meyers and Wyatt[4] described an appliance used in hamsters which consisted of a closed coil ligated to the first molar, either upper or lower, and a band cemented on the corresponding incisor teeth. The device is bulky, delivers an excessive loading of over 100 gm and, because of the reciprocal forces upon the incisors, may introduce factors which complicate the experimental findings.

Acosta et al.[1,2] have developed a palatal expanding helical spring which attaches to horizontal lingual tubes on upper first molar bands in rats. The spring is made of .012 inch stainless steel round wire designed to produce a constant force of up to 70 gm for three days. Possible disadvantages include the high degree of skill required for band placement and the irritating influence of the bands on the gingiva. The appliance, in common with Seipel's device, exerts force primarily in a lateral direction.

It was felt that none of the existing devices used to produce orthodontic movement of the molar teeth of small animals satisfied the ideal requirements which include: simplicity of design, economy of size, stability in position, minimal interference with occlusion and oral structures, and delivery of light, measurable forces over long periods of

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From the Department of Orthodontics, Eastman Dental Center, Rochester, N.Y. Adapted from a thesis submitted in partial fulfillment of requirements for the Master of Science Degree, University of Rochester, Rochester, New York. Author's present address: Dental School, University of Damascus, Syria.

time. Consequently, steps were taken to design and make a spring which would incorporate as many as possible of these features.

Design of Spring

The upper right first molar of a rat was separated from the other teeth and mounted on the tip of a bar of wax which was carved to the size and shape of the circumference of the tooth. This wax bar was duplicated in Melottes metal. A loop of .016 inch stainless steel wire was formed around an .045 inch arbor. While this was still in place, the free ends of wire were adapted with orthodontic pliers around the cast metal bar in the same horizontal plane as the first loop. This, in effect, created a figure eight conformation with the larger loop open at its free end. At the point at which they came in contact, the two free ends of wire were bent up at right angles to the plane of the spring. These vertical extensions were reduced to a length of 0.5 mm, which trial had shown would fit snugly in the interproximal embrasure between the first and second molars without interfering with occlusion. In the open-spring position the extensions delivered force between the molars and prevented rotation of the spring about the molar in either a vertical or horizontal direction (Fig. 1). Test sample springs on the molars of healthy rats showed that they remained satisfactorily in position in the animals' mouths for several weeks.

To determine the force which would be exerted when in position, the bucco-lingual width of the flat interproximal contact surface between upper first and second molars was measured. The average dimension of 1.3 mm was used as the standard spring opening for measuring applied forces on a specially designed calibrating device. This device (Fig. 2) is made up of three components: a stress loading screw, a spring holder, and a force measuring gauge with capacity of 0 to 100 gms. The separation of the spring arms was measured on the calibrated scale of a dissecting microscope and the spring load-

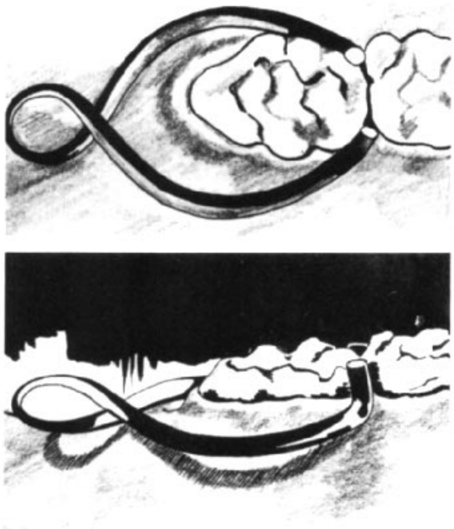

Fig. 1 Photographs of the spring in place, occlusal view above and buccal view below. The upturned free ends of the clamp are engaged between the upper right first and second molars; the small loop lies anteriorly while the body of the spring is roughly parallel to the plane of occlusion.

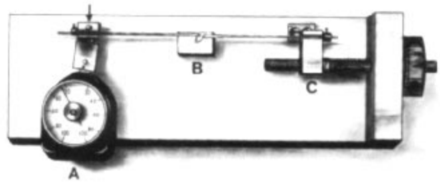

Fig. 2 The calibrating apparatus showing the free ends of the clamp inserted in small holes at the ends of two horizontal rods (B). These rods lie loosely in slots in nylon blocks at either end. The loading is accomplished by means of the screw on the right (C) and recorded on the force gauge (A). The axis of rotation indicated by the arrow keeps the length of the arm at C constant and prevents binding.

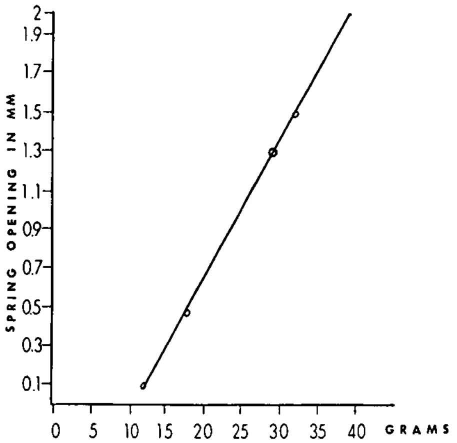

Fig. 3 Typical stress-distance calibration curve.

ing was recorded directly on the gauge.

Arrangements were made with a commercial manufacturer to make a number of springs of .016 inch stainless steel wire in the shape and size desired. These springs were found to deliver a force of about 85 gm at 1 mm opening. The force was brought to desirable limits by reducing the diameter of the wire of the small loop in an orthodontic anodizer to approximately .010 inch. Each spring was treated and measured individually. When the ends were opened 1.0 mm and 1.3 mm, forces of 25 gm and 29 gm, respectively, were recorded. A typical curve showing the distance—force relation is given in Figure 3.

Use of Spring

The animals were anesthetized with ether and placed in a tubular restrainer. The head protruded through a pillory-like device at one end of the tube and was held in place on an operating board in open-mouth position by means of rubber elastics. The closed loop of the spring was held in a mosquito hemostat while the free arms were separated and flared around the upper first molar with a plastic filling instrument.

Springs exerting 29 gms of force at a standard 1.3 mm opening have been used to produce tooth movement of the upper first molars in fifty rats over periods of from one to twenty-one days. After the first day of application about one third of the springs had to be reset, and after one or two weeks a few had to be repositioned or replaced. In general, the spring produced tooth movement throughout the maximum experimental period of twenty-one days. Interference with occlusion and oral structures was negligible and in normal animals such local irritation and inflammation as occurred diminished after three days and disappeared after two weeks.

It is reasonable to believe that springs of the design described here could be modified in size or by choice of wires for use in other animals or for comparisons of the effects of different forces on the same animal. This possibility is reinforced by noting that a somewhat similar separation clamp, the "sep-clip," has been employed to create separation between human posterior teeth prior to band fitting.

Summary

A small stainless steel spring has been devised to deliver light, measurable separating forces on rat molar teeth with minimal interference to occlusion and oral structures. This spring produced orthodontic tooth movement of rat molars in a manner not achieved by previously reported methods.

800 Main Street East
Rochester, New York 14603

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