Research and Development of the Norton-Brown Spinal Brace

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An investigation of spinal bracing was begun about 1952, as a part of the work of a committee developed to study bracing in its entirety. This committee consisted of Dr. Joseph Barr, Dr. Thornton Brown, Karl W. Buschenfeldt, Dr. Paul Norton, and several others, with a consultant from the Veterans Bureau by the name of Dr. James Murphy, an engineer, who was the watchdog on us since the study was done under the auspices of the Veterans Administration. The investigation began in an effort to find out (1) What back braces did or were supposed to do; and, (2) What were the forces between the brace and the back:

In discussing this in committee we fluctuated between 5 to 50 lbs. of force, with nobody knowing what they were talking about. I remember well that at one of the early meetings the comment was made that the best brace would be a leather strap with a tack stuck in it. (I gave Karl Buschenfeldt credit for this, although he flatly denies this and says that Murphy was the father of it). The thought was that the tack would cause the patient to brace himself. After about four years of investigation we came to that conclusion.

The investigation started out in an easy, simple way (like falling into sin). We started by taking photographs of some well-proportioned models—these were males, without a backache—in various degrees of forward bend and side bend. It was obvious rather quickly that several things happened: (1) It showed that if we were using a long brace with secure fixation on the thorax, in forward bend the lower end of the brace was levered away from the lumbosacral area and had no control over that part: and (2) That braces which were slung low on the pelvis like the Goldthwait, adhered very well in that area but tended to pull away at the upper end.

The problem then became more complicated. We wished to know more about what was going on in the spine. The photographs were all right up to a point, but we wanted more accurate control so that we could define the motion with a degree of accuracy. So we began to use X-ray control, and here we used a special casette. The casette holder was designed by Karl Buschenfeldt. It was built so that we could control the amount of angulation in it by means of a protractor and a plumb line. We very quickly

ran into a roadblock here in that the X-ray Department pointed out to us that the amount of X-ray exposure was going to be prohibitive. To carry out this technique accurately would mean that each model would have to wear all of the braces that we were using through all the various degrees of bend. This would mean an exposure that they absolutely refused to countenance. So there we were, up a blind alley at that point.

To get around this problem, we finally fell back on the use of wires drilled into the lumbar spinous processes, and also one into the posterior iliac wing. You can well imagine that the volunteers for this type of testing weren't too numerous. We had only four. Three of them were medical and one was an engineering student. This was a very productive area of investigation. It taught us a great many things that we really didn't know, and I'll come back to that a little later.

Another area of study was pressure relationships. This started off originally with the idea that the pressures developed were going to be the important things in this study. Karl Buschenfeldt made some pneumatic gauges out of some old scraps from refrigerator valves. These worked very well, but were not accurate enough in the smaller ranges for our purposes.

It became necessary for us to go over to strain gauges. Here again, it being a pioneering effort, we didn't know just what we wanted, and we called upon the Mechanical Engineering Department of M.I.T. to bail us out. A Chinese electronics specialist came to our rescue. There was a certain amount of lack of communication in language, so that our ideas of what to use in the strain gauge were not accurately carried out, but we did construct gauges. They were clumsy, but far more accurate than pneumatic gauges and they, for the first time, gave us some accurate measures of the forces that were produced up and down the spine with the different types of braces in different degrees of bend.

The pressure studies showed that measurements made on the different types of braces—measured in pounds on the shoe of the strain gauge—varied in a range from 20 lbs. up to as high as 80 lbs. Yet it was obvious that pressures of this magnitude on the soft parts (the paraspinal muscles) had very little effect on restricting motion. However, when pressures were applied on bony prominences, it was a horse of quite another color. Now, as I said before, the first thing we noticed was that with the conventional types of braces, with paraspinal uprights, in any degree of bend there was an immediate departure of the back from the brace, either at the upper or lower end, depending on whether we were using a short brace or a long one.

This was confirmed by studies as we went on. The finding that set us off on the new trail was the demonstration of the effect of pain on spinal motion. This was done by means of a relatively simple experiment in which the victim was placed face down on a table with a frame over him. We had one of the strain gauges set up on a long screw mounted to the frame. The shoe was placed on an appropriate area, such as the posterior superior spine, a spinous process, or soft parts; and was screwed down in increments of a quarter of an inch to so many turns of the screw. It really was a modified electronic rack. By calibrating the amount of forward thrust of the shoe against the readings on the recorder, it was possible to plot the build-up of pressure at the various levels. It was evident that there was a very rapid build-up of pressure on the bony prominences.

Now, this type of thinking, that is to produce pain to stop motion, was completely foreign to the training of all bracemakers up until this time. Men had been trained with the thought of supporting the back; that braces should be comfortable; that you should stay away from bony prominences

at all costs. This new concept is rather heretical in its conception and it was with a great deal of difficulty, I must confess, that it was accepted at the start.

I think that this covers the basic principles. There is a tremendous amount of work that has gone into this. This research lasted about four years, probably four and a half. It reached the stage where my colleague's wife confided to her friends that I was public enemy No. 1 for keeping her husband out nights (we worked on this generally at night). But, over the period of time, our testing of the various types of braces showed that the long braces, securely fixed to the thorax, produced more lumbosacral motion than no brace at all in the same degree of forward bend. This was a little bit startling but it is perfectly reasonable that when you bend forward, you are bending through all your spinal joints as well as your hips. So the forward bend is a composite motion of trunk and thigh flexion, and the motion in the trunk is taking place over many segments. Now, if you eliminate some of them or compromise them by cutting down on the motion in the upper back, (the dorsolumbar area) you must bend somewhere and if you can't bend easily through the hips, you are going to bend through the lumbosacral area.

In spite of this finding, the long type of brace is still used by some surgeons to immobilize the lumbosacral junction following spinal fusion.

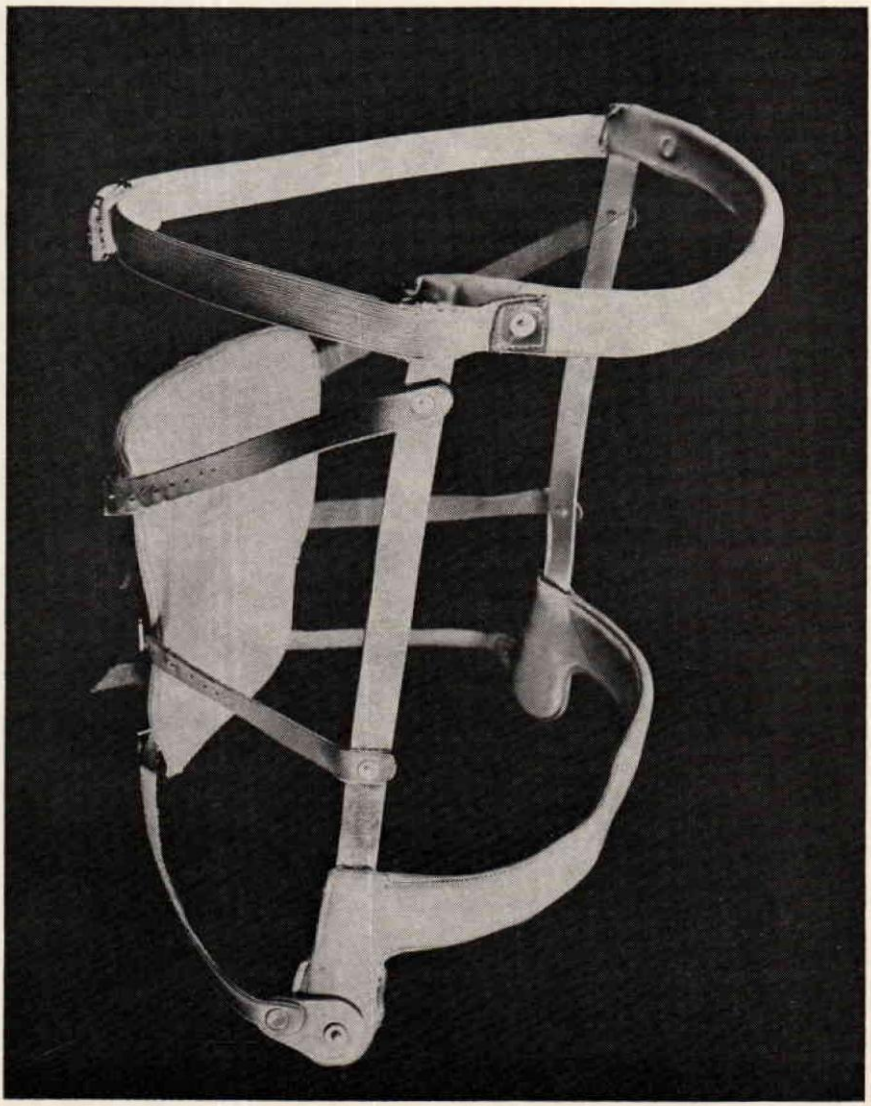
We had many other studies. We did force plate studies, testing the shift of gravity with various types of supports. We also went into an investigation as to the type of abdominal support: what effect it had; whether small pad or large pad; placed low, in the middle, or high. It seems so many people come in with braces in which the abdominal pad is riding up over the ribs and we thought it was important to find out just where the pad should be and where it would be most effective. The outcome of this study was that, for the pad to be effective, it had to be low. We found that the straps should be narrow, so that when the thigh was flexed the straps would lie in the crease of the groin. If you put a broad strap on some patients, the minute the patient sits down the thigh hits on the strap and the brace rides up and down on the back.

The design of the brace—this gradually grew on us and we finally ended with a brace that, (1) had no paraspinal uprights; (2) the uprights were in the mid-axillary line; (3) the axis of motion of the hip and the axis of motion of the bottom strap were positioned so as to be at the same point over the tip of the trochanter; and (4) the bottom cross-band was positioned so that it would impinge deliberatelly on a bony prominence. Ideally, one would like to have the band pressing on a spinous process of the vertebra which one wants to stop from moving. We were chagrined in one case, one of our victims had a very small spinous process of his 5th lumbar and when we put the wires in, we missed L-5. We figured that if this happened to us it would happen to the bracemaker too if he were to measure a patient with a small spinous process and there would be confusion.

The posterior superior spines are always subcutaneous, one can always palpate them, even in the well-padded females, one can spot them by the dimples on the skin. The cross-bar is placed low down towards the tail, below the posterior superior spine, so that in a bend the upper edge of the bar will ride into the spinous processes. We started out by placing the band on the top of the process but found that in the first minute the band was over the top and there was no discomfort associated with it at all so we deliberately dropped the bottom bar down and pitched it in a bit to be sure that the end sank into the posterior superior spine with a good bite.

The upper cross-bar is placed at a level from 3 to 4 inches below the inferior angle of the scapula, depending on the length of the torso. In the long individual, one would place it about 4 inches down, and on a shorter individual, 3 inches. This type of brace has the advantage of putting the bite where you want it and of not tying up any more of the spine than you need to immobilize.

The pad we finally designed was a fairly large one, actually 9 inches in most of the cases. This had two advantages: first, by being held snugly with the bottom strap, it gave effective support; and secondly, it was long enough so that it would dig into the region of the xyphoid if the individual slumped.



Norton-Brown Spinal Brace (Courtesy Orthopedic Services of Rhode Island)

Now, there are so many facets to this investigation that I find myself somewhat confused in trying to cover them all. There are several areas where rather important discoveries were made and probably one of the most interesting ones, beyond the fact that the long braces did produce more motion in the lumbosacral area than no brace at all, the next finding of interest was that in the wire studies we found that the patients (or the victims, let us say) sitting in the slumped position, in a relaxed posture, had more spinal flexion or bend than the same individuals bending over and touching the floor. This is rather important in the protection of a spinal fusion. When this paper was given in Los Angeles, Dr. Vernon Nickel said, "You know, that explains what we have been doing. We have, for several years, stopped all our patients from sitting, following spinal fusion. We either made them stand up or lie down, and this explains why."

Now, one other fact that I ought to mention that came out of this study, and this is basic, not only to the problem of bracing the low back but also, to my way of thinking, in the etiology of disc lesions in this area. It is that forward bend differed quite markedly in the individuals tested. Now, my colleague was able to bend forward and touch the palms of his hands on the floor, with his knees straight, one would say, "now there's a fellow who is quite limber. He can bend over and touch the floor." Whereas, when I bent over I was lucky if I could get just below my knees. So, one would say, "this poor devil is hamstrung and he has very little mobility." Actually, the wires showed that because I was hamstrung and muscle bound, I was getting my bend through the back. I was limited in getting down through the hips so I made it up in the back. Whereas, my co-worker had very loose hamstrings, he would go over into a forward bend without getting motion in his spine at all. Now, this brings up the point that the individual who is hamstrung, if he is working in heavy industry, lifting, is a perpetual candidate for trouble. For if he bends forward to his elastic limits, then he needs very little in increased load before something has to give. Dr. Thornton Brown later demonstrated that if too much stress is placed on the back, structures are susceptible to injury, particularly with fractures into the centrum and disruption of the mechanics of the disc.

The time spent on measuring the pressures was tremendous; this was due to the poor design of the brace. Actually, we didn't know what we wanted at the start. We just wanted to have them built and modified to overcome various difficulties as we went along. The design of the gauges was such that we had to take them apart every time we wanted to take off one brace and put on another. This would no longer be the situation today because these gauges, which weigh probably about ¼ pound a piece with the wiring, are now made up in the shape of a disc about the size of a tencent piece and, I hope, someday that we will be able to repeat some of this experimentation to get around certain technical objections to the study. In other words, we were measuring at specified points and not over a long consecutive strip on the skin.

One other device we used was a gadget that measured the degree of bend of the trunk. It might be interesting to know how these recordings were made. We used a four-channel Sanborn recorder, something like an overgrown cardiograph and we had a switch box which allowed us to measure 14 stations, by simply flicking the switches we could pick off 14 points, one of which was set up to give us the degree of bend of the trunk in relation to the thighs. We had three other areas to record at the same time.

Now, to come back to the point I made before about the difficulty we had with having the recordings comparable. We found, for example, that

we would set up an experiment and set the gauges in place. We would have the individual bend forward and when he came back up straight, instead of the baseline being back at zero, it would have shifted. It took time to realize what had happened was that in this area of the spine there was some give to it and that the pressure of the shoes was forcing the individual to move away. When we realized this, we began to think in terms of local pressure as a device for preventing the individual from bending. It is like the story of the fellow who got into trouble by killing somebody and finally ended up by playing cards. We went down the primrose path in this fashion and designed a rather crude looking brace which embodied some of these concepts, that is, the rapid application of pressure over a bony prominence so designed as to limit the degree of bend through the individual's own muscles.

Clinical experience has shown that the brace has been quite effective and, even making allowances for mis-application or mis-use, it has been well accepted. I might mention that as time has gone on there have been modifications added to this and within the broad concepts of what it is designed to do, individuals who study the problem may find variations that they will like particularly. The basic thing is that this is not designed to be a piece of apparatus that is worn in comfort. It is a hair shirt. It is designed to produce pain if the individual exceeds the allowable amount of bend that one decides upon.

The first thing that we did in some of the cases of a spine fusion was to use a latch-graft. This is the locking graft, which is shaped like the letter H and is wedged under the spinous process at L-4, 5 and hooked under the spinous of S-1. It can be modified by drilling a hole and pegging the spinous process of L-5 up through it. This type of graft is usually secure when the spine is in extension. It is put in when the spine is flexed and then the back extends and locks it into place. Now, so long as you hold the spine in extension, the graft is secure but the problem is that as the spine flexes, particularly in the sitting position, it opens and one begins to get motion and may run the danger of pseudarthrosis. The third cross-bar was put in to make the act of slumping painful. The way this is done is that the brace itself is made first, that is, with the upper and lower cross-bars, and as soon as the patient can get up it is fitted, and then the third cross-bar is placed with the patient in the erect sitting position. In that position, the cross-bar goes right across the incision and should just touch the skin so that if that person sits erect, he will not be uncomfortable. He may not even know the brace is on, but God help him if he slumps. It is just like getting stabbed, and it is a very effective way of stopping him. This type of brace will not be comfortable in a soft chair. In anything where there is a lot of give, the patient will be very unhappy about it. But he must be warned about this and must be conditioned to accept it. Once you have explained to him what you are out to do and get his cooperation, you find very little in the way of complaints. A lot of difficulty with the bracing I think, is the lack of communication between the patient and the bracemaker and the doctor as to just what you are trying to do and just how you propose to do it.

Another modification was to put on some cow-horns. I first did this in a rheumatoid arthritic who was completely unhappy with a Taylor brace and refused to wear it. Much to my surprise, it proved to be a very effective and comfortable rig, and I use it now almost exclusively.

I think at this point I might as well stop and have Karl Buschenfeldt take over and then we can come back if any questions are asked.