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The Effect of Head Rotation on Pain Location in Delayed Recovery Subjects

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ABSTRACT

The rear end collision occupant accounts for a large percentage of the delayed recovery head and neck pain group, relative to other impact mechanisms. This mechanism has classically been titled "whiplash". Head rotation has been implicated in delayed pain recovery in rear impact collisions. The purpose of this study was to evaluate if there is a significant relationship between head rotation and the location of pain in delayed recovery patients. A total of 121 subjects were evaluated in the course of the study. There were 24 males and 93 females. The population was selected from those subjects whose pain was related to a rear end collision in which they were the occupant or driver of a vehicle hit from behind. Head rotation was defined using the following possibilities: looking to the left, looking to the right, straight ahead or unknown. The subjects were selected from both genders and the age group of 18 and older. Patients with multiple traumas, pre-existing symptoms, significant co-morbidity/disease or multiple impacts were excluded. The results of the study reveal that the location of pain in delayed recovery rear end collision patients is more common on the ipsilateral side of rotation. The data also revealed that those subjects that were looking straight ahead did not have a significant pain dominance side. This implies that head rotation is a factor in delayed pain recovery subjects.

INTRODUCTION

Neck and head pain are two of the most common ailments in our society today (Hallgren, 1994). The rate of Social Security disability claims for soft tissue injuries has grown ten times that of the population in the last ten years. The cost for neck pain alone has been estimated at 33 billion dollars in the United States annually (Cassidy, 1995, Nordhof, 1997). Neck pain has been estimated to affect the lives of 9-12% of the general population (Wilison, 1991). Ylinen and Ruuska have reported that neck pain is more commonly encountered in clinical practice than is low back pain and that neck trauma becomes chronic in up to 40% of patients. Of the patients with

chronic neck pain, 8-10% experience severe pain (Deans et al, 1987, Miles et al, 1988, Norris et al, 1983, Pennie et al, 1991.

Motor vehicle injuries account for a large percentage of the known causes of head and neck pain (Cassidy, 1995). The rear end collision occupant accounts for a large percentage of the delayed recovery head and neck pain group, relative to other impact mechanisms. This mechanism has classically been titled "whiplash". Bogduk reported, in a prospective experimental design study with double blind blocks, that the cervical facet joints account for greater than 50% of the pain in post motor vehicle accident delayed recovery patients with head and neck pain (Bogduk, 1996).

Head rotation has been implicated in delayed pain recovery in rear impact collisions. Ryan documented a 15 fold increased incidence of persistent symptoms after a rear end collision if the occupant has head rotation at impact (Ryan, 1994). Matsushita indicated that extension and rotation of the cervical spine, as exists in the mechanism of a rear end collision with head rotation, increases ligament tension and injury potential (Matsushita, 1994). Randanov documented head rotation as one of four poor prognostic factors associated with long term pain for rear end collision occupants (Randanov et al, 1995). Other researchers have reported similar findings, involving small samples, in both staged and actual collisions (McConnell et al, 1995, Smith, 1999).

When the head is rotated and then extended, as occurs in a rear end collision injury, there is compression on the same side as the rotation and tension on the opposite side of rotation. The most common symptoms reported by rear end collision target occupants are: neck, head and upper back pain. The rear end collision target occupants utilize the majority of the motor vehicle collision injury health care resources and account for the majority of the delayed recovery group. The delayed recovery group, which is the group of patients that have had symptoms longer than 90-180 days, account for between 8-12.5% of the total post traumatic patients, yet they utilize up to 80% of the dollars spent.

Several theories currently exist about the mechanisms and the pain producers involved in the rear end collision. The documentation supports the fact that a disproportionate percentage of the occupants in rear end collisions that have persistent symptoms. The research also supports that head rotation at impact is a poor prognostic sign. Review of the literature did not reveal research that evaluates the location of pain relative to head rotation. One possible explanation for the increased delayed pain recovery is pre-loading. During the first 250 msec of a rear impact, anterior cervical structures are placed in tension while posterior structures are in compression. This sequence is then reversed during the next 250 msec. If the structures are preloaded by rotation, the tension and compression will be magnified. When the head is rotated and then extended, as occurs in a rear end collision injury, there is compression on the same side as rotation and tension on the opposite side of rotation.

The current state of knowledge in this area is limited. There are several theories on post traumatic pain mechanism. Therefore, the purpose of this study was to evaluate if there is a significant relationship between head rotation and the location of pain in delayed recovery patients.

METHODS

Subjects

A total of 121 subjects were evaluated in the course of the study. There were 24 males and 93 females. With the exception of one woman, all of the subjects were drivers of the vehicle. The average age of the subjects was 38.3 years old with a standard deviation of 12.8 years. The subjects for this study were selected from one of three groups: looking left, looking right and looking straight ahead. The subjects were selected from patients entering several clinics that had

delayed recovery as defined by persistent neck or head pain that existed more than three months post trauma and was significant enough for the patient to still seek care. The population was selected from those subjects whose pain was related to a rear end collision in which they were the occupant or driver of a vehicle hit from behind. Head rotation was defined using the following possibilities: looking to the left, looking to the right, straight ahead or unknown. The subjects were selected from both genders and the age group of 18 and older. Patients with multiple traumas, pre-existing symptoms, significant co-morbidity/disease or multiple impacts were excluded.

Instruments

A survey was provided to all delayed recovery rear impact patients. For the purpose of this study, the location of pain was defined as follows; left and right were divided by the spinous processes of the cervical spine; the upper two quadrants were from the spinous process of the C3 vertebrae and above; the lower two quadrants were from the spinous process of the C3 vertebrae to center of the T1 vertebrae. The survey extracted data regarding the impact conditions and pain profile. The survey was designed specifically for this study and has face validity. The survey provided data regarding head rotation at impact and location of the pain by percentage of total pain in the upper quarter. The choices provided were lower left, lower right, upper left and upper right. The data was scored by assigning a one to the area of maximum pain and a zero to all other quadrants.

Procedure

The selected subjects were given the survey documents. They were instructed to fill out the forms completely. The clinic staff instructed the subjects that the two forms included information about their rear end collision. They were instructed to ask questions of the clinic staff if there were any parts of the survey that they did not understand completely. They were instructed that this survey was not mandatory and would not be a part of their medical file. They were instructed that their name would not be listed anywhere in the study. They were instructed that the goal of the survey was to publish the data in a medical journal. Each subject understood that his or her participation was optional. They were given the choice of unknown on the survey so as to ensure that they would not guess or force themselves into another category.

Subjects, entering selected clinics, that qualified were given the survey. This survey asked the patient to select certain factors about their trauma that were evaluated. The two key factors, gathered from the selected subjects, were head rotation and the location of the largest portion of their pain.

The subjects were asked to identify how much of their pain is located in each of four optional quadrants in the upper quarter of the body. A pain drawing was provided with the areas clearly marked. The patients were asked to divide their total pain into what percentage was in each area. The dividing line was the C3 vertebrae. Anything above this area was defined as neck to head and anything below this area was defined as neck to upper / back shoulders. The spinous process was the centerline that divided left and right. See the enclosed pain drawing utilized to supplement the forms and case history. A standard transparency template that outlined the anatomical mid-line and the third cervical spinous process overlaid the pain drawing and determined the pain distribution.

The determination of head rotation at impact was based on patient perception. Any subject listing rotation as unknown was removed from the sample. A score was assigned to each side. Information was collected on the percentage of pain in each quadrant, however only the side dominance was used in the statistical analysis. The percentages on the left quadrants were added to obtain a value and the percentages on the right quadrants were added to obtain a percentage. These values were used to determine the side dominance of pain. The location of maximum pain was assigned a value of 1 and the other area was assigned a zero. The data was correlated using the

scores versus head position. The data was also tabulated using three directional choices; left, right and straight.

RESULTS

The data collected was evaluated using Chi Squared analysis. The results of this study show that head location was significant for ipsilateral pain when the subject's head was turned. The results showing pain location versus head orientation are shown in Table 1.

Table 1. PAIN LOCATION VERSUS HEAD ROTATION.

	LOOKING RIGHT	LOOKING LEFT	TOTALS
Pain on Right	24	4	28
Pain on Left	11	15	25
Totals	35	19	$Chi^2 = 9.32$*

* $p < .005$

The data was also evaluated independently for each possible head orientation. The data remained significant for occupants who were turned left and right. The results were not significant for those occupants facing forward. The results of this are shown in Table 2.

Table 2. DISTRIBUTION OF PAIN BY IMPACT DIRECTION.

	LOOKING RIGHT	LOOKING LEFT	LOOKING STRAIGHT
Pain on Right	24	4	12
Pain on Left	11	15	12
Pain Evenly Distributed	15	5	13
Chi^2	5.32*	9.25**	0.054

* $p < 0.025$
** $p < 0.005$

The data was also evaluated for the gender distribution among delayed pain patients. The data was determined to be highly significant for gender. The results of this are shown in Table 3. Data was collected on five subjects under the age of eighteen who were excluded from the study. However, all five subjects were female. Inclusion of the data would have increased the significance.

Table 3. DELAYED PAIN BY GENDER.

GENDER	NUMBER
Male	24
Female	**92**
Chi^2	**53.3****

** p<.005

CONCLUSIONS

The results of this study reveal that the location of pain in delayed recovery rear end collision patients is more common on the ipsilateral side of rotation. The data also revealed that those subjects that were looking straight ahead did not have a significant pain dominance side.

Women were greatly over represented in the subject population. There are several possible explanation for this. Research has shown that women are injured more easily than men. Other studies have shown that women are more likely to seek treatment than men.

This data compares with the research of Sturzenegger, Bogduk, Meyers, and others in that head rotation is a complicating factor in rear end collision patients. This data also supports the theory of Meyers, that head rotation increases the potential for cervical facet capsule damage as a significant factor in delayed recovery pain. Additionally, it supports the work of Bogduk that head rotation increases the potential for cervical facet compression as a cause of delayed recovery pain. This study revealed that the side of initial compression is more likely to be significant in delayed recovery rear end collision subjects.

The data suggests that treating physicians may be able to predict the prognosis in this patient population if they collect adequate data on the biomechanics of the trauma. By identifying those patients predisposed to delayed pain recovery syndrome, the provider may be able to implement other procedures, at an earlier stage, to reduce the likelihood of wasted health care resources and to promote recovery with more appropriate therapies based on the suspected pain producers.

The data also reveals another problem with the attempt to extrapolate controlled experiment tests to the general population. The individual characteristics of each trauma and patient must be considered when analyzing the potential for injury in these collisions.

The data suggests that the rear end collision mechanism provides the treating provider with several complicating factors. The potential pain producers in the upper quarter are very diffuse and complicated. The isolation of the exact pain producer requires not only an intimate understanding of the neurological potential of each anatomical structure but also an in depth understanding of accident biomechanics, and pain management techniques.

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DISCUSSION

PAPER: **The Effect of Head Rotation on Pain Location in Delayed Recovery Subjects**

PRESENTER: ***John Smith, Scott Rosenquist, RPSA Inc.***

QUESTION: *Guy Nusholtz, Daimler Chrysler*

There's potentially some very interesting data. It looks like the data may be censored so you may not be able to answer this. Is it possible to determine when you're more likely to be injured whether you're looking straight ahead or whether you're looking right or whether you're look left? Is there a greater potential in one of those initial configurations than in the other?

ANSWER: I think there's a greater predominance of people that would enter the clinic that would know that they are looking right or looking left and I say that simply from personal experience. Because when you interview a patient in a history if they are looking in their outside left rearview mirror and they see the impact and they know that the impact is coming and they're braced they're more cognizant of that. The same thing with looking up and to the right or out to the right talking to the passenger as they are waiting at a stop light. So, I think that data would be skewed primarily by the demographics of the people's knowledge of their head position as opposed to being able to determine if there's a predominance of injury in those populations compared to the other head positions. I think that would be a difficult thing to analyze. We thought about that, but I think it would be difficult considering the subjectivity of the patients and the cognitive factors of their head position at impact.

Q: Okay. So you don't either have a large enough sample size to figure it out or there is too much bias by their perceptions and everything else?

A: Yes. I believe it is too biased to actually make a statistical conclusion.

Q: *Bob Levine, Wayne State University*

Obviously, you're using pain drawings from pain clinics. Did you filter out patients who had psychological overlay in the pain drawing or psychological overlay in any other factors since that's going to effect the outcome of any kind of injury?

A: Yes, we did. We do standard psychological screening analysis in our clinic because our clinic is primarily a multi-disciplinary approach. And then also if they had F-16's pointing at their head or anything of that nature we excluded those patients as well. That does occur and if they had any really strange factors we considered those unreliable.

Q: *Frank Pintar, Medical College of Wisconsin*

It is interesting this head rotation right or left. As you know the C1-C2 joint has about 30 degrees of rotation by itself.

A: Yes, sir.

Q: So, you're not really rotating any other part of the spine until you get a very large rotation. Is there any indication from these people how much rotation they had?

A: No, we didn't quantify the amount of rotation, but rotation was explained to them. And then they were asked if they understood what head rotation meant. Really what we ended up with was people that were fully rotated looking out of their side window or fully rotated talking to a passenger. The people that said, well, I might have been looking up into the rearview mirror or I

might have been looking slightly to the side were excluded. So, in our opinion, they were truly rotated patients. And you're right in that the contribution initially occurs from the upper cervical spine. But another factor that we're looking at right now for a potential follow up paper is the actual distribution of the C3 and above as opposed to the C3 and below population because of the contribution on this study was strictly on side dominance. Now we may look at the contribution head to neck pain as opposed to the kind of coat hanger distribution neck to shoulder pain. And I think that will help us with the predominance of if there was a large contribution of people rotating right or rotating left in the lower cervical spine because of the pain mapping that we know of C4-5 and 6 contributing to the coat hanger distribution or the neck to head distribution which is typical of the work that has been done with C1-2, C3 with greater occipital, lesser occipital or ocular contributions. I think that will be interesting data if we find it statistically significant because that will tell us maybe indirectly. I don't think we can make conclusive evidence, but it can tell us indirectly if the side of head rotation has a higher predominance in neck to head or neck to shoulder. And that may tell you bio-mechanically what level.

Q: *Erik Takhounts, NHTSA*
Did you consider all the cases like direct impact or were there oblique impacts also?

A: They were all direct impacts. There were no offsets.

Q: Okay. Thank you.