



## ■ REVIEW ARTICLE

# Whiplash injury

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**This review discusses the causes, outcome and prevention of whiplash injury, which costs the economy of the United Kingdom approximately £3.64 billion per annum. Most cases occur as the result of rear-end vehicle collisions at speeds of less than 14 mph. Patients present with neck pain and stiffness, occipital headache, thoracolumbar back pain and upper-limb pain and paraesthesia. Over 66% make a full recovery and 2% are permanently disabled. The outcome can be predicted in 70% after three months.**

The orthopaedic surgeon will encounter whiplash injuries more often in medicolegal practice than in the fracture clinic. Patients who have sustained low-velocity injuries often describe more pain than those who have had a fracture<sup>1</sup> and show disproportionate psychological distress. While many patients give a consistent account of their injury, some appear to exaggerate their symptoms which leads to suspicion that they are doing so for gain. This has fuelled debate as to whether whiplash injury is a social or a medical condition.<sup>2,3</sup>

Whiplash injuries cost the economy of the United Kingdom approximately £3.64 billion per annum and have increased in number by 25% since 2002.<sup>4</sup> They constitute 76% of motor-insurance claims.<sup>4</sup> A similar experience in Canada stimulated the Quebec Task Force to undertake a systematic review of the literature in the early 1990s.<sup>5</sup> Only 346 of 10 000 publications were of sufficient scientific value to contribute to the analysis and the conclusions of the Task Force were accordingly limited. Since then, further research<sup>6-8</sup> has improved our understanding of the condition.

## Background

In 1928 Crowe<sup>9</sup> presented to the Western Orthopedic Association a series of eight patients who had sustained an indirect neck injury as a result of a rear-end collision in their cars. The mechanism of injury was described as a 'whiplash'. The term now encompasses any indirect injury to the cervical spine other than fracture. Although described in 1968 as a 'metropolitan plague' resulting from car accidents,<sup>10</sup> the condition was in fact recognised much earlier. It was recorded in *The Edwin Smith Papyrus*<sup>11</sup>

(case 30) in 17th century BC, described as spinal concussion<sup>12</sup> or "railway spine" in 1882, first appeared in a standard text-book in 1929<sup>13</sup> and was designated 'cervical sprain' by Watson-Jones<sup>14</sup> in 1940.

## Mechanism

Of all road-traffic accidents 90% occur at speeds of less than 14 mph<sup>4</sup> and it is in these that whiplash injuries occur. Since the mid-1950s, it has been recognised that the disability from whiplash is associated less with tyre skid marks or the degree of vehicle damage than the effect of differential velocity on the head and upper torso.<sup>15,16</sup> If this can be minimised, the risk of whiplash is reduced. The most common mechanism of a whiplash injury is a rear-end collision which generates approximately half of the cases.<sup>17-21</sup> This is also associated with more severe symptoms than collisions from other directions.<sup>22-24</sup> The trunk is forced backwards and ramps up the back of the seat, the neck hyperextends and then recoils forward. Factors which increase displacement of the neck are a rear-end collision with a heavier vehicle and the fact that in women the neck is thinner and less rigid. Accordingly, women have twice the risk of whiplash injury as men.<sup>17,25</sup> Some three-quarters of neck rests are incorrectly positioned.<sup>4</sup> A low neck rest acts as a fulcrum about which the head pivots with greater amplitude than if no neck rest was present at all. Strategies in car design are aimed at reducing the amplitude of displacement of the neck on the trunk. Accordingly, cars fitted with a more elastic seat back and a high head rest which is correctly positioned to reduce posterior excursion of the head will generate

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half of the number of claims than those without these features.<sup>26</sup>

Since the subject of Mathewson's<sup>16</sup> rear-end crash test reported "a cracking sound somewhere in the vicinity of the cervical spine and suffered pain for some time afterwards" at a collision speed of 5 mph, a number of studies on human volunteers<sup>27-30</sup> have all produced neck pain in a proportion of their subjects. A summary of the literature on crash tests on human subjects concluded that a change of velocity of 2.5 mph was sufficient to cause symptoms and that a speed of 8.7 mph was needed to cause damage to a vehicle.<sup>31</sup>

### Presentation

Of those involved in rear-end collisions, 15% experience pain.<sup>32</sup> Of those attending an Emergency Department, 37% described the onset of pain as immediate,<sup>18</sup> 62% to 65% as within 12 hours<sup>23,24</sup> and 90% within 24 hours.<sup>23,33</sup> These constitute the early presentations and account for the more symptomatic one-third of patients.<sup>23</sup> Two-thirds of women experience sufficient pain to take time off work for between two and 69 days after the accident.<sup>6</sup> Half of all cases of upper-limb pain and weakness occur more than a week after the injury.<sup>34</sup>

**Symptoms.** The most common symptoms are neck pain and stiffness, occipital headache, thoracolumbar back pain and paraesthesia of the upper limb.<sup>5,17,20,34,35</sup> Between 5%<sup>36</sup> and 9%<sup>37</sup> of patients develop subacromial impingement syndrome and 38% describe irritation of the brachial plexus.<sup>38</sup>

**Signs.** These are less prognostic than symptoms,<sup>17</sup> but include, in ascending order of severity, neck tenderness and stiffness<sup>7,39-41</sup> and neurological deficit.<sup>7,8,17,18,39,41</sup> The latter rarely conforms to myotomes or dermatomes and weakness and impaired reflexes may be the result of pain inhibition.

### Physical outcome

The literature on the outcome of whiplash injury ranges from questionnaires<sup>23</sup> and contemporary interviews with those involved in an accident<sup>34</sup> to reviews at six months or more after the injury.<sup>25</sup> The longer the symptoms last, the worse is the prognosis. A further difficulty in the interpretation of these studies is the lack of a uniform outcome measure. It is, however, possible to extract from most reports whether the patient made a complete recovery or was totally disabled. Thus, we find from the literature of the second half of the 20th century<sup>5,17-20,22,23,25,42-48</sup> that just under 50% of all patients made a full recovery and that 4.5% were permanently disabled. By inference, the remainder were less severely symptomatic. Using the scoring system of Gargan and Bannister,<sup>46</sup> reports of consecutive series of patients attending an Emergency Department have shown that 66% of patients make a complete recovery and 2% are disabled.<sup>34,48,49</sup> The figures from the only study which interviewed all the vehicle occupants regardless of whether or not they were symptomatic on acute presentation are probably the most accurate.<sup>34</sup>

It has been found that 88% of patients who are free from symptoms after two months<sup>18</sup> and 93% after three months<sup>34</sup> remain asymptomatic after two years. The rest may improve over 2.5 years<sup>6</sup> but the improvement is minimal after the first year.

### Outcome

Using the classification of Gargan and Bannister<sup>46</sup> the outcome after two years can be predicted in over 70% of cases after three months.<sup>34</sup> The symptoms associated with a worse outcome are rapid onset of pain,<sup>8,23</sup> severity of neck pain,<sup>50-52</sup> acute hospital admission,<sup>17</sup> radiation of pain to the upper limb<sup>7,8,17,25,33,53,54</sup> and headache.<sup>7</sup> The physical signs associated with a worse outcome include, in descending order of severity, neurological deficit,<sup>7,8,17,19,39</sup> neck stiffness<sup>39-41</sup> and neck tenderness.<sup>7,40-41</sup> These factors are incorporated in the whiplash-associated disorder grading system<sup>5</sup> which borrows heavily from the system of Norris and Watt.<sup>39</sup> The worse the initial whiplash-associated disorder grade is, the worse is the long-term outcome, particularly if there is associated neck stiffness.<sup>40</sup>

**Psychological outcome.** The whiplash syndrome has both physical and psychological components. The latter includes impaired concentration (cognitive disorder),<sup>50</sup> a somatoform disorder,<sup>55</sup> forgetfulness,<sup>56</sup> post-traumatic stress disorder<sup>57</sup> and driving anxiety.<sup>57</sup> Patients have normal behavioural profiles early after their injury, but as the pain persists they develop psychological sequelae.<sup>6,55</sup>

Depressive symptoms become apparent after six weeks.<sup>51</sup> With the exception of post-traumatic stress disorder, the psychological response after a whiplash injury is as marked as that after multiple fractures.<sup>57</sup> Only victims of motorcycle accidents have a worse outcome.<sup>57</sup> There is a negligible change between three and 12 months<sup>57</sup> and the greater the pain is, the worse is the psychological response.<sup>58</sup> Driving anxiety improves and only 4% of patients are unable to drive after three months, but all are able to do so after a year.<sup>57</sup> Mood disorder after one year is twice that expected in the general population.<sup>57</sup>

**Pre-accident psychological history.** The outcome of a whiplash injury will be worse if associated with pre-morbid psychiatric disease,<sup>8,57,59,60</sup> responsibility for dependents<sup>59</sup> and an above average rate of attendance to general practitioners for unrelated conditions.<sup>8</sup>

**Factors associated with outcome.** Older age,<sup>7,17</sup> lower educational achievement,<sup>41</sup> part-time employment,<sup>7</sup> pre-existing neck<sup>8,56,61,62</sup> and low back pain<sup>8,25</sup> and previous whiplash injury<sup>63</sup> are all associated with a significantly worse outcome. Gozzard et al<sup>64</sup> noted that clerical employees returned to work twice as quickly as manual workers and that the self-employed were half as likely to take time off, but took much longer to recover fully. These data are from univariate analyses. Of the variables addressed by two multivariate analyses,<sup>7,8</sup> pre-morbid psychological disease and radiation of symptoms were the most powerful independent variables associated with a worse outcome.

### Constitutional neck pain and whiplash injury

Given that a proportion of the population suffer from constitutional neck pain, the question arises as to whether patients with a whiplash injury erroneously attribute it to trauma.

Neck pain is common and has affected 43% of Swedish,<sup>56</sup> 34.5% of Norwegian<sup>65</sup> and 40% of British patients<sup>66</sup> at some time. Symptoms which have lasted for more than three to six months or are merely designated 'chronic' are present in 19% of Swedish,<sup>56</sup> 14% of Norwegian,<sup>65</sup> 14% of British<sup>67</sup> and 11% of Finnish patients.<sup>68</sup> One-third of Swedish patients with chronic neck pain have stated that it followed neck trauma.<sup>56</sup> There is some evidence that those who have had a neck injury and are engaged in litigation<sup>69,70</sup> describe pre-morbid levels of neck pain which are less than would be expected in a comparable population. Comparisons of the prevalence of chronic neck pain in various European populations with that of series of patients with whiplash injuries from the same region have indicated that the latter are five times more likely to be affected.<sup>23,34,45,56,65,70-73</sup>

### Effect of litigation

The view that a claimants' symptoms will improve once litigation has finished has long been suggested by psychiatrists<sup>74</sup> but is unsupported by the literature.<sup>18,39,72,75,76</sup> Their rate of employment is likewise unaffected.<sup>10,74,77</sup> Continuing litigation is associated with more severe pain.<sup>1,59,77</sup> After the Canadian province of Saskatchewan changed from tort (adversarial litigation) to no-fault compensation,<sup>70</sup> claims were settled quicker. The number of claims was reduced by 29% but 10% more had to be reopened later. Residual pain was slightly higher in the no-fault compensation era suggesting that, although claims were less frequent, the symptoms were more severe and the pattern of disease of whiplash injury was unaltered. Since patients with more severe symptoms attract greater compensation,<sup>46</sup> litigation in their cases is likely to be more keenly contested and therefore more protracted.

### Radiology and whiplash injury

Neck pain is weakly associated with cervical spondylosis<sup>66,78</sup> and less so with advancing age.<sup>66,67</sup> Radiological evidence of cervical spondylosis at C5-6 is present in twice as many symptomatic as in asymptomatic patients.<sup>79</sup> Multivariate analysis has indicated that a past history of neck injury is more significantly associated with the intensity of neck pain than is cervical spondylosis.<sup>78</sup> Patients whose necks are spondylotic at the time of their accident have an incidence of pain of 53% after two years,<sup>80</sup> but there is no association with angular deformity<sup>17,81</sup> or any other postural or soft-tissue signs.<sup>79</sup> Patients who sustain a whiplash injury in their third decade and undergo radiography ten years later show a level of cervical spondylosis which is typical of necks 15 years older.<sup>47,53</sup> However, only Watkinson et al<sup>53</sup> were able to associate late degenerative change with neck symptoms and this finding was not reproduced in other studies.<sup>17,81</sup>

Controlled studies of symptomatic and asymptomatic patients have shown no difference in the rate of disc degeneration on MRI<sup>81</sup> and abnormalities on MRI are not generally seen after a whiplash injury.<sup>81-83</sup> MRI should only be carried out after a whiplash injury if there is nerve-root pain in the arm which may potentially be relieved by discectomy.<sup>84</sup>

### Biosocial aspects of whiplash

A group of Norwegian neurologists compared neck pain in car occupants involved in a motor-vehicle accident and found little difference from a cohort group from the general population in Lithuania where whiplash injury is not recognised.<sup>2</sup> This and a study from Greece<sup>85</sup> are cited as evidence that the symptoms of whiplash are cultural rather than real.<sup>3</sup> The Norwegian study was too underpowered to draw any statistically significant conclusions<sup>86</sup> and neck pain was reported by 50% more patients in the collision group than in the control group.

In 1982, Balla<sup>87</sup> compared a series of 300 patients first reported in 1980 from South Australia with 20 from Singapore. In Singapore, the indigenous population virtually never described disability and the only complaints came from expatriate Europeans. This study was highly anecdotal. In another study the outcome after road-traffic accidents over one year in New Zealand was compared with those from the state of Victoria, Australia.<sup>88</sup> With a similar size of population and number of cars, there were 3.5 times as many rear-end collisions reported in Victoria, ten times as many patients claimed compensation and five times as many were off work for more than two months. New Zealand operated a no-fault compensation system and Victoria a tort scheme. In 1987<sup>89</sup> legislation was introduced in Victoria which required patients to report all whiplash injuries to the police and to pay the first 317 Australian dollars of their medical expenses. Claims fell by 68%. However, it was subsequently recorded that 10% of Australians who sustained whiplash injuries continued to have chronic neck pain after the legislation.<sup>90</sup>

It would appear that, despite these cultural differences, a significant minority of patients who sustain a whiplash injury continue to experience long-term symptoms.

### Treatment of whiplash injury

For an acute whiplash injury, a soft cervical collar is less effective than normal activity, physiotherapy<sup>45,48,71,91</sup> or Maitland's manipulations.<sup>43</sup> The relative risk of improvement with early physiotherapy is 1.2. The use of non-steroidal anti-inflammatory drugs is associated with a better range of movement two weeks after injury<sup>92</sup> and intravenous prednisolone gives reduction of short-term pain and long-term sick leave.<sup>93</sup>

For a late whiplash injury, the use of facet blocks<sup>94</sup> results in a median rate of recurrence of 50% within a week and radiofrequency neurotomy of the facet joints a median return of pain of 50% after nine months.<sup>95</sup> The use of botulinum toxin reduces pain by 7%. Cervical fusion after

**Table I.** Studies giving the relative risk of chronic symptoms vs none after whiplash injury

	Relative risk
<b>Pre-accident symptom/sign</b>	
Neck pain	10:1 <sup>62</sup> 3:1 <sup>41</sup> 1.2 <sup>8</sup>
Psychiatric history	10:1 <sup>62</sup> 1.5 <sup>8</sup> 3.6 <sup>60</sup> 2:1 <sup>51</sup>
Whiplash injury	3.7 <sup>63</sup> 1.1 <sup>8</sup>
<b>Post-accident symptoms</b>	
Early < 2 days	1.2 <sup>8</sup> 4:1 <sup>10</sup>
Visual analogue scale > 55%	3.2 <sup>37</sup>
Initial severe pain	1.5 <sup>50</sup>
Radiating pain	1.3 <sup>8</sup> 2.6 <sup>54</sup> 1.6 <sup>7</sup>
<b>Post-accident symptoms/signs</b>	
Neck tenderness	1.8 <sup>7</sup> 1.7 <sup>40</sup> 2:1 <sup>41</sup>
Neck stiffness	2:1 <sup>39</sup> 3:1 <sup>40</sup> 2:1 <sup>41</sup>
Headache	1.2 <sup>7</sup> 3.3 <sup>18</sup>
Neurological signs	2:1 <sup>39</sup> 3.3 <sup>18</sup>
Depression/psychiatric disease	2:1 <sup>60</sup> 2:1 <sup>51</sup> 3.2 <sup>54</sup>
<b>Later symptoms after three months</b>	
Symptom-free	0.08 <sup>34</sup>
Symptomatic	4:1 <sup>34</sup>

a whiplash injury may be indicated for brachialgia and is successful in 32% of patients.<sup>17,35,42,72,96-100</sup> Approximately 50% of patients who undergo a subacromial decompression for impingement after a whiplash injury describe benefit.<sup>37</sup> Overall, treatment for a late whiplash injury is relatively ineffective.

### The future of whiplash injury

The resources devoted to whiplash injury vary widely across Europe. While 76% of motor-vehicle accident costs in the United Kingdom are consumed by whiplash, in

France it is under 5% because neither compensation nor legal fees are paid.<sup>4</sup> By contrast, in the United Kingdom legal costs consume a mean of 40% of all claims and 80% of low-cost claims. In the United Kingdom, there appears to be a perverse incentive for all parties. Insurance companies sell claims to solicitors and car-hire agents. Solicitors are often paid more than the compensation received by the injured patient. Medical experts are remunerated for opining that patients with symptoms after three months are likely to recover within two years when this lacks any base in scientific evidence. All of this has to be funded by enhanced car-insurance premiums.

A better approach would be to prevent collisions, to treat the injured patient using the best evidence-based methods and to improve the evidence base with appropriately directed research.

Laser-initiated braking systems can prevent collisions and intelligent seat design can halve the rate of neck injury if an accident occurs.<sup>26</sup>

The use of the soft cervical collar gives worse results than that of no treatment at all, but is still widely prescribed. The routine prescription of physiotherapy does not help most patients,<sup>5</sup> who recover spontaneously. The patient who is at risk of a poor result (Table I) should be entered into a controlled trial with defined and uniform outcome measures starting at three months by which time the outcome is largely established.

Medical reports should be based on evidence (Table I). The best predictor of outcome is time. The relative risk of relapse in an asymptomatic patient after three months is 1:6 and of recovery of a symptomatic patient 4:1.<sup>34</sup> Previous neck pain, psychological disturbance and whiplash injury before the initial accident more than double the relative risk of chronic symptoms.

After a whiplash injury, neurological signs, the early onset of neck pain, severe neck pain, an adverse psychological response and neck stiffness are all significantly associated with an increase in the risk of long-term symptoms while there is a somewhat weaker association with radiating pain and neck tenderness.

Recovery after a whiplash injury can be predicted with a high level of probability at three months as can continuing symptoms. There is little evidence that rehabilitation programmes significantly improve the outcome of late whiplash injury. Most patients who are symptomatic after three months remain so indefinitely.

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