The Relationship of the Double Crush to Carpal Tunnel Syndrome
(An analysis of 1,000 cases of carpal tunnel syndrome)
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In this series of 1,000 cases of carpal tunnel syndrome (888 patients) there is a statistically significant incidence of bilaterality in patients with cervical arthritis. There is also a statistically significant increase in the incidence of diabetes mellitus over the general population. These findings lend further support to Upton’s Double Crush hypothesis. Further, the double crush syndrome predisposes to bilateral carpal tunnel syndrome and may be an important prognostic factor. It may also be an explanation for some of the failures following carpal tunnel surgery and lead surgeons to look for other associated systemic diseases or mechanical blocks, when attempting to alleviate recalcitrant symptoms.

The theory of the double crush syndrome was originally described by Upton (1973) in a study of 115 patients. The theory states that serial impingements upon a peripheral nerve can act in a cumulative manner to cause a symptomatic distal entrapment neuropathy. The existence of the double crush syndrome was further substantiated by Massey’s (1981) study of nineteen cases of carpal tunnel syndrome co-existing with a cervical radiculopathy. The present retrospective study of 1,000 cases (888 patients) was undertaken in order to confirm the association of cervical arthritis and diabetes mellitus with carpal tunnel syndrome and to test the hypothesis that the double crush syndrome predisposes to bilateral carpal tunnel syndrome.

It is well known that carpal tunnel syndrome is frequently a bilateral condition, but the reasons for this are not well known. Small cross sectional carpal tunnel areas may anatomically predispose certain patients to bilateral carpal tunnel syndrome (Tanzer, 1959). However, the double crush syndrome may be an additional reason for the high incidence of bilateral carpal tunnel syndromes. This hypothesis is reasonable because the primary components of the double crush syndrome are cervical arthritis and diabetes mellitus. Cervical arthritis is almost universally present above the age of fifty (Bland, 1981) and is frequently a bilateral problem (Rothman, 1975). Furthermore, diabetes mellitus frequently causes a diffuse neuropathy (Omer, 1980). Despite these observations, the hypothesis that the double crush syndrome is related to bilateral carpal tunnel syndrome has never been tested in a statistical manner in a large series of patients.

Materials and Methods
The records of one thousand carpal tunnel releases performed in 888 patients between the years 1950 and 1979 were retrospectively analyzed. 77% were female and 23% were male. Ages range from eight to ninety-three years with most being between thirty-five and seventy years old. The duration from onset of symptoms to treatment ranged from less than three months to five years. Two hundred and seventy-one patients (32%) had bilateral carpal tunnel syndrome (P<0.001).

All statistical analysis of the data from these 888 patients with carpal tunnel syndrome was performed using the Chi square test (Syndecor, 1980).

Results
Among the associated disorders, accompanying the 888 patients with carpal tunnel syndrome, cervical arthritis was found to have the highest correlation with bilateral carpal tunnel disease. The diagnosis of cervical arthritis was based on clinical signs and symptoms and cervical x-rays. Patients with cervical arthritis represented ninety-five of the 888 patients (11%). In this cervical arthritis subgroup, thirty-nine patients (41%) had bilateral carpal tunnel syndrome. This represented 15% of the total number of patients with bilateral carpal tunnel syndrome. The correlation of bilateral carpal tunnel syndrome with cervical arthritis was thus statistically significant (P<0.05).

The diabetic patients represented sixty-five of the 888 patients (7%). Of this population twenty-two (34%) also had bilateral carpal tunnel syndrome. Overall the diabetic subgroup represented 8% of the total number of patients with bilateral carpal tunnel syndrome.

In the overall population, the incidence of diabetes is 1.7% of the general population (Traisman, 1965). Although these numbers clearly show a highly significant incidence of diabetic patients in this carpal tunnel syndrome study group of 888 patients, it does not show a statistically significant incidence of bilaterality. In contrast to the subgroup of patients with cervical arthritis or diabetes mellitus, those patients in the carpal tunnel syndrome study group who had a history of an
THE RELATIONSHIP OF THE DOUBLE CRUSH TO CARPAL TUNNEL SYNDROME

"DOUBLE-CRUSH" SYNDROME

Fig. 1a: This is a diagrammatic representation of a normal cervical spine, median nerve and carpal tunnel. The large black arrow represents the antegrade axoplasmic flow. Note the normal appearance of the exit of the roots from the cervical spine and the normal configuration of the transverse carpal ligament and median nerve.

Fig. 1b: Here the symptomatic threshold, i.e. denervation, has not been reached despite the fact that there is mild median nerve compression at the level of the carpal tunnel (small black arrow).

Fig. 1c: This figure shows impingement of the cervical root (upper black arrow) with abnormal axoplasmic flow as exemplified by the parallel lines in the nerve with distal mild carpal tunnel noted by the lower black arrow. A combination of the proximal and distal impingements with the associated impairment of axoplasmic flow by the proximal lesion results in denervation and symptomatology because the symptomatic threshold has been surpassed.

Fig. 1d: In this situation the cervical roots are normal. Axoplasmic flow is normal but there is a severe distal carpal tunnel syndrome (at the double black arrow). The result is symptomatic carpal tunnel syndrome secondary to denervation.

Fig. 1e: Abnormal axoplasmic flow is diagrammatically represented by the parallel lines in the nerve. This combined with mild carpal tunnel impingement at the black arrow results in denervation and once again symptoms because the safety margin has been surpassed by the combination of the peripheral neuropathy such as diabetes plus the mild carpal tunnel syndrome.

Antecedent distal radius fractures represented seventy-one of the 888 patients (9%). Thus, distal radius fractures do predispose to unilateral carpal tunnel syndrome; however, only four patients (5%) had bilateral carpal tunnel syndrome. Therefore, the patients with distal radius fractures and bilateral carpal tunnel syndrome represented only 1.5% of the total number of patients with bilateral carpal tunnel syndrome. Statistical evaluation of these numbers showed an extremely highly negative correlation between distal radius fractures and bilateral carpal tunnel syndrome (P<0.001).

Discussion

The nucleus and perikaryon of the nerve cell synthesize many different materials which are prerequisites to the survival and efficient function of the axon. Some of these materials are enzymes, polypeptides, polysaccharides, free amino acids, neurosecretory granules, mitochondria and tubulin subunits. These materials are transferred to the axon where a combination of fast and slow axoplasmic transport mechanisms move them distally. These materials are essential to the normal structure and function of the nerve fibres. They are required for normal growth, for regeneration after injury, for normal conduction, and for normal transmission at the neuromuscular junctions and at the sensory receptors (Guth, 1968; Sunderland, 1978; Pleasure, 1980) (Figure 1a). Any dysfunction of the perikaryon which results in a disruption of the synthesis of these materials or blockage to the transport of these materials will lead to axons which are more susceptible to disruption.

The mechanism of the double crush syndrome, as described by Upton, states that serial impairments to neural axons act in a cumulative manner to disrupt neural transmission. A safety margin exists for the
prevention of denervation (Figure 1b) which when surpassed leads to clinical symptoms. This symptomatic threshold is sometimes demonstrated by electromyographic studies on patients who clinically have unilateral carpal tunnel syndrome. The symptomatic wrist frequently shows abnormal electromyographic results. The asymptomatic wrist usually shows normal electromyographic values but may show values in the upper limits of normal or even mildly abnormal despite the fact that the patient is totally asymptomatic. Obviously, in these patients the symptomatic threshold for the contralateral wrist has not been reached. This safety margin is also demonstrated by Wick Catheter measurements of intracarpal canal pressures. The mean pressure in patients with carpal tunnel syndrome is 32 mm Hg while the mean pressure in controls is only 2.5 mm Hg (Gelberman, 1981).

Complete dysfunction and symptoms can be caused by serial mechanical blocks. For example cervical arthritis causing mild proximal impingement in combination with mild carpal tunnel syndrome may cause symptoms which would not be present if either one of these mild impingements were acting alone (Figure 1c). Symptoms could also be caused by one severe blockage, for example, a small carpal tunnel canal with associated tenosynovitis (Figure 1d). Alternatively, a normal subclinical mechanical blockage could combine with a nerve which is already impaired by a systemic disease, for example, diabetes mellitus, leading to a clinical dysfunction (Figure 1e).

The data from this large series supports this concept. Our statistics show a markedly increased incidence of carpal tunnel syndrome in patients who have diabetes. Although it is not statistically significant, this study also shows a trend towards the occurrence of increased bilateral carpal tunnel syndrome in the subgroup with diabetes mellitus. In addition, there is a highly statistically significant increase in the incidence of bilateral carpal tunnel syndrome with patients who have cervical arthritis. In contrast, the study shows that the incidence of bilateral carpal tunnel syndrome in patients who have had a previous distal radius fracture is highly negatively correlated. This finding could be anticipated because patients who insidiously develop bilateral carpal tunnel syndrome, are often predisposed by anatomically small carpal tunnel canals, cervical arthritis, or diabetes mellitus (Green, 1982). In contrast, in the post-traumatic group an abnormally high incidence of factors which predispose to bilateral disease is not likely to exist. Thus, unilateral carpal tunnel syndrome is the predominant finding after distal radius fractures.

That the double crush syndrome is operational in some cases, is further substantiated by the fact that in some electromyographic proven cases of carpal tunnel syndrome there is a slowing of the nerve conduction proximal to the point of entrapment (Cseuz, 1966). In addition, some investigators have reported failure rates after carpal tunnel release as high as 9%. Perhaps this is due to the fact that a more proximal lesion is causing the symptomatology (Thomas, 1960). With this in mind estimations of the potential post-operative result should take into account the pre-operative existence of a double crush caused by either cervical arthritis or diabetes mellitus. Patients with a double crush must be informed that their chance for complete relief of the symptoms is decreased slightly because of the presence of co-existing cervical arthritis or diabetes mellitus.

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References