

History of the treatment of spinal injuries

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Injury of the spinal cord has been known since antiquity. There is no cure for the injury and until modern times patients died rapidly from a combination of pressure sores and urinary tract infection. Treatment consists of preventing complications until the spine has stabilised and the patient can be rehabilitated to an independent life. This article explores how this treatment developed in the ancient world, the middle ages, in Europe, Great Britain, and latterly in the United States. It describes how these principles of treatment were recognised particularly in Germany, the United States, and Great Britain and evaluates the relative contributions made by the different pioneers.

Traumatic injuries to the spinal cord do not occur in isolation. The spinal cord is protected by the vertebral column and cord injury is usually the result of an injury to the vertebral column such as a fracture or a dislocation. This bony injury impinges upon the spinal cord. The immediate consequences are damage to the nerve fibres with exudation of fluid. If the axons are completely transected no recovery will occur. If they are not completely severed then as the swelling recedes, over a period of weeks, months or even years, some recovery of the damaged axons may occur.

At present there is no cure and treatment consists of carrying out all measures, to prevent further damage to the cord by undue movement and then realignment of the vertebra either by surgery or postural reduction. It may be that in the future with the development of stem cell transplantation and pharmacological agents the damage to the cord can be reduced and the spinal cord repaired.

The results of a cord injury are loss of motor power, loss of sensation and paralysis of the bowel and bladder. All efforts are concentrated on preventing secondary complications from this loss of function—that is, pressure sores due to the loss of feeling, and ascending infection of the kidneys from the paralysed bladder.

This treatment was developed as a result of the pioneering work at the end of the 19th century by Theodor Kocher in Switzerland and Wilhelm Wagner in Germany, in 1936 by Donald Munro in the United States, and in 1944 by Ludwig Guttmann in the United Kingdom. This paper is a review the development of this treatment.

CLASSICAL TIMES

In Egypt, paraplegia due to injury of the spine was first described in the Edwin Smith surgical papyrus in Egypt about 3000 BC.¹ After the decline of the Egyptian Empire there are records from Hippocrates (circa 460–370 BC) who was the first to describe traction to reduce these injuries. This was followed by Paul of Aegina (AD 625–690), who used a windlass to reduce the dislocation and recommended laminectomy. Manual extension was recommended for the treatment of a fractured spine.

The fall of the Roman Empire led to an almost total abolition of the practice of medicine in Western Europe. Greek and Roman traditions were preserved in the Eastern Empire and in the Arabian Empire by Christian, Jewish, and Moslem physicians. Avicenna (980–1037) followed the teachings of Paul of Aegina and maintained that a fracture of the body of the vertebra was fatal when accompanied by paralysis (fig 1).

PRE-RENAISSANCE

In Europe before the Renaissance, medical schools associated with the universities were gradually re-established, the first at Salerno, where Roland of Parma (circa 1230) studied. He used manual extension for the treatment of fractured spines and was the first to emphasise one of the keystones of modern practice: the necessity for early treatment.

POST-RENAISSANCE

Ambroise Paré (1564–1598) recommended laminectomy for spinal injury.

19TH CENTURY

United Kingdom

In the United Kingdom with the development of the London teaching hospitals two prominent surgeons, Astley Cooper (1768–1841) and Charles Bell (1774–1842), were interested in the treatment of spinal injuries.

Cooper described in detail the clinical manifestations of spinal injury and recorded that his teacher, Henry Cline (1750–1827), had performed the first laminectomy for this condition.² Bell was an outstanding neurologist, artist, physician, and surgeon, was opposed to laminectomy, and indulged in a celebrated controversy with Cooper on the subject.³ Bell's approach was modern, pointing out that the damage to the spinal cord occurred at the moment of injury, and was not due to continued pressure (fig 2). He emphasised that all the efforts of the surgeons should be devoted to making an accurate diagnosis in the first instance, and that operation on the spinal column was both

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Figure 1 Reduction of a dislocation of the spine when the physician stands upon the gibbosity with his heels, Avicenna 980?–1037, (Bennett, 1964). Reproduced with kind permission from Kluwer Academic/Plenum Publishers.

dangerous and useless. He also pointed out that, in cases of paraplegia, death was attributable to the retention of urine and subsequent inflammation of the renal tract. This is the first mention of renal failure being a cause of death. Bell's views received wide acceptance in Britain.

There was little advance in treatment throughout the 19th century but there was a better understanding of the pathological sequelae. Renal failure remained the main cause of death. Thomas Curling (1811–1888)^{4,5} described the suppurative consequences of paralysis of the bladder on the kidneys, and pointed out that the survival time was proportional to the severity of the infection. Sir William Gull (1816–1890),^{6,7} William Thorburn (1861–1923),⁸ and Charles Fagge (1838–1883)⁹ also drew attention to the consequences of renal suppuration in this condition.

Germany

The first successful account of the management of spinal injuries was by Wilhelm Wagner (1848–1900) a general surgeon working alone in a small workers compensation hospital, Königshütte Hospital in Upper Silesia, where he spent his whole career (fig 3). He developed the practical treatment of spinal injuries and demonstrated how patients could and should be treated.

He wrote a book with his former pupil, Paul Stolper (1865–1906), on injuries of the spine and spinal cord.¹⁰ This dealt with every aspect of the subject. He started with anatomy of the spinal column, pathology of injury, the mechanism of injury, the symptomatology, and practical treatment including the indications for surgery. He understood the necessity of relieving pressure in preventing pressure sores and was concerned to prevent subsequent deformity. He identified six major problems: sepsis from pressure sores; treatment of cervical fractures; post-traumatic syringomyelia; infection of the chest; stones in the kidneys leading to sepsis of the renal tract; and the necessity of immobilising patients in bed until the fracture healed.

The textbook is remarkable in its breadth of vision and its emphasis upon such commonplace but vital aspects of treatment as how the patient should be transported and nursed. Particular attention was paid to the pressure points and positioning of the patient. Water beds were used. He emphasised the need to prevent soiling of the mattress in incontinent patients. For doubly incontinent patients special beds were designed, such as those used for cholera patients, with a bucket underneath that could be removed. Once the fracture had healed the patient was mobilised and put into a bath.

The object of treatment of the spine was to establish bony union. Wagner was opposed to operative treatment on the

spine and recommended that radiographs should be used to estimate the position of the fracture. He recommended palpation of the kyphus to reduce a dislocation. He described in detail how a dislocated cervical spine could be reduced. He devoted pages to the description of how the bladder should be managed.

Wagner treated patients with spinal injuries and was able to mobilise them. He gave opinions in court about their life expectancy so they were probably returning home. It is remarkable that he carried out all this work alone in a municipal hospital without an academic position.

At the same time, Theodor Kocher (1841–1917), professor of surgery at Bern was also interested in spinal injuries.¹¹ He carried out extensive research but his work was mainly on an anatomical and physiological basis. It is impossible to determine from his writings how many patients with spinal injuries he treated and whether they were successfully discharged home.

The textbooks by Kocher (1896) and Wagner and Stolper (1898) became the standard reference work and were referred to by subsequent writers.

FIRST WORLD WAR

Until the advent of the first world war spinal injury cases were few in number and it took surgeons many years to collect a series of cases. It was the first world war that served as the catalyst for the concept of the modern management of spinal injuries. Three of the belligerents, the United Kingdom, Germany, and France, faced with overwhelming numbers of casualties established spinal units that showed remarkable similarities.

They were all staffed by a multidisciplinary team. Surgeons, urologists, and neurologists worked together. One unit in Germany had a ward solely devoted to pressure sores. They all emphasised the vital necessity of teamwork, regular turning, and the need to give primacy to nursing care and physiotherapy but this did not take place as many patients developed pressure sores and severe sepsis. The importance of collaborative work and teaching was recognised and they all held meetings to discuss problems. Major sources of concern were whether a laminectomy should be performed and whether the bladder should be drained by continuous drainage or intermittent catheterisation. All the papers from that time reported high mortality.

BETWEEN THE WARS

At the end of the first world war the casualties ceased. The military hospitals closed down and along with them the acute

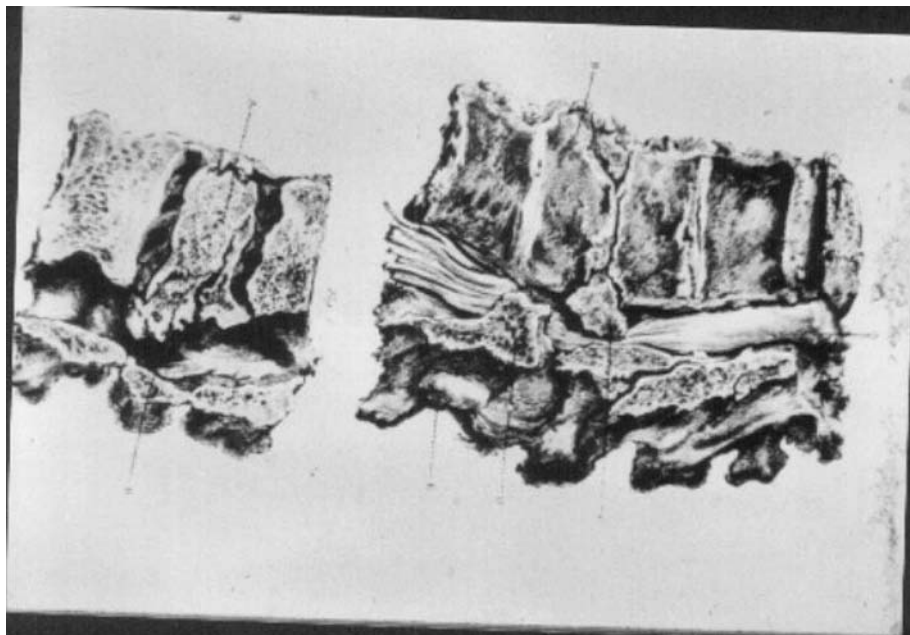


Figure 2 This beautifully drawn picture of the vertebral column by Sir Charles Bell shows the pathology of spinal cord injury. The damage is anterior and he emphasises the futility of trephining posteriorly (Bell, 1824). Reproduced with kind permission from Kluwer Academic/Plenum Publishers.

spinal units. The physicians and surgeons returned to their general practice of neurology and neurosurgery and in the United Kingdom those patients who survived were looked after on a custodial basis at the Royal Star and Garter Home, on a 20

bedded unit annexed to Queen Square, and at a home run by the Not-forgotten Association at Clapham Park.¹² There is no record of the units continuing in France or Germany.

THE MODERN ERA

At the beginning of the 20th century Germany was dominant intellectually, economically, and medically in the world. The logical place for the evolution of spinal injury management would have been in Germany. They already had fine spinal units for the treatment of servicemen injured in the first world war but this did not take place.

With the rise of the Nazis to power there was an attack upon hospital medicine and medical training. Marching and political indoctrination assumed a place in the syllabus at the expense of scientific training. Jewish doctors were expelled from their posts and eventually from Germany itself.¹³

The development of the treatment of spinal injuries shifted to the United States of America.

THE UNITED STATES

Charles Frazier (1870–1936) had looked after spinal injury patients in the first world war and wrote a book on the subject.¹⁴ This book is not just a historic document but a major textbook. It is not clear how many of these patients Frazier treated, whether they were in separate neurosurgical beds, in general wards, or on a spinal unit. His comprehensive survey quoted not only his own cases, but also a total of 717 cases of spinal injuries from the world literature. The work involved in translating German and French papers (he quotes Wilhelm Wagner in four different sections), and the detailed statistical analysis on results of surgery, prognosis, life expectancy, discharge home and work, make this a formidable source of information and very humbling. He was opposed to surgery but he only devoted a page and a half to physical management.

Donald Munro (1889–1973) was acknowledged by his contemporaries to be the father of the treatment of paraplegia. He set up the first effective treatment centre for spinal injuries at the City Hospital in Boston.

Munro had been Frazier's assistant in 1916 at the Augustana Hospital, Chicago. In 1919 he was appointed to the Boston City Hospital on the general surgical staff. He was



Figure 3 Wilhelm Wagner (1848–1900). This is the only illustration of Wagner from a commemorative plaque (Ljunggren and Buchenfelder, 1989). Reproduced with kind permission from Kluwer Academic/Plenum Publishers.



Figure 4 Guttmann at his happiest teaching in the Physiotherapy Department at Stoke Mandeville Hospital. Reproduced with kind permission from Kluwer Academic/Plenum Publishers.

primarily occupied in administering anaesthesia to other surgeons' private patients. In 1929 he took charge of the surgical part of the neurological unit in conjunction with Dr Abraham Myerson (1881–1948) and Dr Stanley Cobb (1887–1968). That service expanded.

Boston City Hospital was under the shadow of a superb neurosurgical service rendered by Harvey Cushing at the neighbouring Peter Bent Brigham Hospital.

Harvard Medical School serviced three hospitals: Massachusetts General, Peter Bent Brigham, and the City Hospital. At that stage the feeling at Harvard was that they should set up an academic unit. All this work was being done by the neurosurgeons and neurology did not have the same standing as neurosurgery.

The Harvard Neurological Unit at Boston City Hospital was founded to fill this gap funded by the Rockefeller Foundation. The unit was built as a research orientated department with a staff primarily of full time academics. Dr Stanley Cobb was chosen to be its first director.

Munro was appointed professor of neurosurgery. He pursued his studies and researches on traumatic injuries of the brain and spinal cord. He realised that more than half of neurosurgical admissions were the result of trauma. The City Hospital was paid for by public taxes and it was responsible for trauma cases. Treatment was consumer driven.

Munro realised that these patients could be successfully treated. His doctrine is the cornerstone of modern treatment of spinal injuries:

"...no matter how extensive the paralysis may be in such a patient and provided only that he has full use of his hands, arms and shoulders, ambulation, with infallible 24 hour control of bladder and bowel (without the need of a urinal or other artificial aid)—as well as that degree of overall rehabilitation that comes only with the ability to lead a normal social and work life within the limits imposed by the necessary use of braces and crutches—is well within the possibilities of present-day treatment".¹⁵

He emphasised that care of the bladder was paramount and would not countenance genitourinary sepsis in his service. He developed the Munro method of tidal drainage.

He recognised, in a forthright dogmatic way, that the patient's skin had to be protected from getting pressure sores. He said pressure sores always antedated bedsores. The former developed because of prolonged weight bearing on bony prominences and of maceration of the horny layers of the skin. The latter followed because of interference with the skin-vascular reflexes. According to Munro the best treatment of bedsores was prevention and this should be accomplished by keeping the patient constantly dry and never allowing him to lie in a wet bed and turning the patient every two hours night and day.

He believed that the treatment of the patient's spine was of only secondary importance, and that no effort should be made to reduce a fracture by operation, but that gentle traction should be used to replace the vertebrae.

Munro took a holistic approach to the overall management of the spinal injury patient. He recognised the virtues of physiotherapy in mobilising patients, was willing to carry out rhizotomies to eliminate spasm, and was a strenuous advocate of returning patients home to a wheelchair life.

He realised the financial implications of spinal injury. This problem was overcome by funding from the Liberty Mutual Insurance Company of Boston who arranged to concentrate those patients they were responsible for at the Neurosurgical Unit at Boston City Hospital. Patients were seen by nurse counsellors and were treated by genitourinary consultants, all paid for by the insurance company.

Rehabilitation led to healthy patients who could care for themselves, were able to lead active social and work lives, and had regained their self respect. For the insurance company rehabilitation of spinal patients led to financial benefits in the long term because of a reduced need for care.

Munro was a forceful, inspirational writer, teacher, and prophet who profoundly influenced civilian doctors throughout North America and, when America became involved in the second world war, doctors in the American armed forces. A successful series of veterans hospitals were set up in the United States where spinal patients were treated. The leading hospital was established at Long Beach, California headed by Ernest Bors (1900–1990). Munro also influenced Sir Ludwig Guttman.



Figure 5 Intermittent catheterisation was carried out on the patient's bed. The trailing curtain makes asepsis questionable. Despite these limitations, magnificent work was done that pioneered the modern treatment of spinal injuries. Reproduced with kind permission from Kluwer Academic/Plenum Publishers.

SECOND WORLD WAR

As Hitler's aggression spread across Europe, it was realised that a resumption of hostilities was inevitable. Unlike the first world war, when casualties had all been servicemen, many civilian casualties were anticipated because of the bombing.

Specialised orthopaedic units were established to deal with the many types of trauma. Provision was made to deal with peripheral nerve and spinal injuries cases.

In 1939 George Riddoch (1888–1947) was appointed consultant neurologist to the army with the rank of brigadier. More significantly, he was chairman of the Medical Research Council Committee on peripheral nerve injury with responsibility for setting up spinal injury units. He, like other doctors such as Geoffrey Jefferson (1886–1961), remembered his experience from the first world war. Riddoch had looked after patients with spinal injuries at the Empire Hospital during the first world war and had carried out fundamental work with Henry Head (1861–1940) on rehabilitation and the pathophysiology of spinal cord injuries. Just as second lieutenants in the infantry had returned to the second world war as generals, determined that there should be a different type of war with abolition of trench warfare and conservation of soldiers' lives, so Riddoch was determined that provision would be made for servicemen with spinal injuries.

Four units were designated to receive acute spinal casualties: Agnes Hunt and Robert Jones Hospital at Oswestry serving the Midlands, Royal National Orthopaedic Hospital, Stanmore serving London, EMS Hospital Winwick, Warrington serving the North West, and Bangour Hospital serving Scotland. These four units were set up in 1941. "Incurable" patients were to be transferred to long term units.

A unit was supposed to be established at the Nuffield Orthopaedic Hospital to serve the South of England but Professor Herbert Seddon (1903–1977) was unwilling to give up any beds so its opening was delayed until the opening of the second front when the National Spinal Injuries Centre was set up at Stoke Mandeville with Ludwig Guttmann as the first director.¹⁶

LUDWIG GUTTMANN

Ludwig Guttmann (1899–1980) is regarded by many as the founder of the modern treatment of spinal injuries.

He was born in Silesia in 1899. He finished his schooling in 1918 and as part of his military service he was recruited as a medical orderly, working at the Accident Hospital for Coalminers (Knappsschafts-Lazarett) in his hometown of Königshütte, where Wagner had treated spinal injury patients 20 years previously. He had his first contact with a spinal injury patient, a miner, who he was told would be dead within a few weeks from pressure sores.

When the first world war ended he trained as a doctor and worked for Otfried Foerster (1873–1941) in Breslau. Despite having worked successfully as first assistant to Foerster, Guttmann was expelled from his university appointment and his job in 1933 under the Nuremberg Laws and his title changed to "Krankenbehandler" (one who treats the sick). He was only allowed to treat Jewish patients at the Jewish Hospital in total isolation from the universities and academic medicine. The German Neurological Association was dissolved in 1934. Guttmann escaped to England with his family in 1939 and began work almost immediately as a research fellow at the Nuffield Department of Neurosurgery in Oxford. There too, he was not allowed to treat patients, as his neurosurgical operative skill (he was trained in the European and not the Cushing tradition) was not recognised.¹⁷

When Guttmann came to Stoke Mandeville in February 1944 to set up the spinal unit he was already armed with well established ideas on spinal cord physiology, neurosurgical techniques, and rehabilitation (fig 4). Despite being single handed, he insisted on having three research sessions to continue his work on sweating.¹⁸

He recognised, from his work in Germany on peripheral nerves, the need for:

- Specialised spinal units
- Continuous treatment
- After care
- Immediate treatment by the appropriate specialist
- Thorough documentation
- Supervision of patients immediately after injury
- Late supervision
- Availability of public health service

Table 1 Contemporary views of Guttman

Date	Name	Comment
1944	Prof G Gask ²¹	Impressed by spirit of self help and cheerfulness. "Guttman very good. Astonished to hear that patient can be returned to the workplace".
1944	Dr Ferguson	Chief Medical Officer—much impressed with what he saw
1945	Dr Dick	Commented on new methods being tried out, much better staffing but most important there was an attitude of hope
1945	Dr Riddoch ²²	"I am personally satisfied that the work he has been doing is good...in fact his is the best spinal injury centre we have got".
1945	Mr C Lee	Patient who spoke of wonderful work being done by G and his assistant
1945	Ministry of Health	Recommended that all medical superintendents and some sisters should be sent to Stoke Mandeville
1945	Doctor	"a wonderful show, he is of course madly enthusiastic and recommends that it be made THE centre for ALL paraplegics. Very generous staff and limitless physiotherapy trainees".
1945	Dr Sykes	Desirous to visit Stoke Mandeville to see G's work
1947	Dr Nicoll	Comments on how appalling death rates were at Wharncliffe compared with the USA and Stoke Mandeville Hospital
1948	Dr Seddon	"A very able German refugee, LG a pupil of Foerster has established a remarkable centre...No one in this country has ever made a comparable contribution to the treatment of these dreadful cases. He has a waiting list of 80 and needs more facilities".
1948	Dr Winner ²³	"only the Ministry of Pensions Hospital can be regarded as satisfactory. He runs his unit very autocratically, he is a good showman. There is no question however that he has completely changed the face of the world for the paraplegic pensioner, that his single minded enthusiasm has moved mountains and that his patients are almost passionately grateful to him, his results speak for themselves and the difference in atmosphere between Stoke and the other spinal centres is remarkable. Incredible as it sounds, a patient walks with his shoulder girdle and upper trunk muscles. Exercises including definite drills designed to render patients independent eg. Dressing putting on calipers and getting from bed to chair is 7 minutes!"
1949	Ministry of Health	"A very efficient institution; other two units, Sheffield (Wharncliffe) and Liverpool (Winwick) are not up to Stoke Mandeville's standard."
1950	Prof H Seddon	They are requesting that a doctor be sent over to Stoke for training before going to Stanmore together with two ward sisters and physiotherapists.
1950	Prof H Seddon	"Dr Guttman's experience must now be unique"
1948	Patient	"The hospital has come to be the principal spinal unit of the Ministry of Pensions and one of the largest spinal injury centres in Europe"

- Cooperation of health service with Ministry of Pensions and employer
- Rehabilitation/work
- Not to leave the patient alone in the reconditioning period

He adapted these peripheral nerve injury principles and expanded them to treat spinal patients.¹⁹ He was determined and refused to accept that patients who were the hopeless and helpless should be cast on the human scrap heap.²⁰ He was a very inspiring man and made both patients and staff feel wanted and worthwhile. He motivated other people and his enthusiasm was infectious. He made people believe that they were part of something bigger than themselves, so staff and patients cooperated fully (fig 5). I have experienced this personally. He had been made to feel worthless while in Germany and in Oxford, so he had great empathy, sympathy, and charisma to motivate people to do the work. He showed leadership. Because of his force of personality he saw that things were done. At the outset and much to the staff's annoyance, he gave the order that all patients should be turned supine and prone or from one side to another, every two hours, night and day, waking or sleeping. To ensure that his orders were being carried out, he began appearing on the ward unexpectedly, at all hours. He bullied patients and staff and established a series of checks and monitors. He taught patients and staff and instituted research at all levels. He recognised the value of physiotherapy and at any early stage incorporated sport into rehabilitation. His work was acknowledged by contemporaneous accounts (table 1).

CONCLUSIONS

Unquestionably Guttman put the ideas together. Few of them were original. They were all in existence before and being practised by Wagner and Munro. It was his drive, his energy, his enthusiasm, his intolerance of carelessness, refusal to accept inefficiency and low standards of treatment, which wedded them together in a comprehensive treatment programme.

The setting up of specialised units and the early transfer of patients under one consultant who could take all the decisions was backed up by full therapeutic treatment where all specialties were available. This was the cornerstone of spinal injury management.

It is apparent that Wagner and Kocher had initiated these ideas and shown how it could be carried out but their ideas, possibly because of the advent of the first world war, were not continued. Foerster, apart from his great physiological work, incorporated physical methods of treatment, which was revolutionary. Munro at the City Hospital, Boston, Guttman at Stoke Mandeville, and Bors at the Long Beach Veterans Hospital showed how the treatment could be successfully carried out. The credit for the development of the treatment lies with Munro who was the first to practise it. Munro set out a clear programme of treatment and arranged with the insurance companies to receive the spinal cases at his hospital. Unfortunately, he only had 10 beds but his publications were extremely influential, particularly with doctors treating American spinal injury casualties from the second world war and with Ludwig Guttman. While Munro showed the way, it is Guttman in the United Kingdom who instituted an integrated programme of treatment facilitated by the favourable structure of the health service.

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Further references can be found in my MD thesis *The development of the modern ideas of treatment of spinal injuries*, 2001, University of London and book *History of the treatment of spinal injuries*, 2003, Kluwer.

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