

INTERNAL DERANGEMENT OF THE KNEE JOINT IN MINERS

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Internal derangements of the knee joint appear to be prevalent among British coal-miners. In recent years such injuries have accounted for between 15 and 30% of all cases admitted to the rehabilitation units provided in each coal-field, and at which a large proportion of miners suffering from acute orthopaedic disabilities are treated, as well as some of those suffering from the more chronic orthopaedic conditions. Occupational and non-occupational conditions are treated alike at these centres.

Precise figures are not available for the incidence of these internal derangements among miners, for notification of them is not made to the Inspectorate of Mines, nor is it likely that all are reported at collieries. An indication of their frequency is given by the fact that about 150 such cases (including cases of injury to a collateral ligament, but not of bursitis) are treated annually at the residential rehabilitation unit which serves the South Wales coal-field. If to these is added the number of cases treated solely at hospitals and at the small rehabilitation units attached to some of their orthopaedic departments, we may assume that certainly not less than 200 fresh cases occur annually in a working population of under 110,000 men. Figures of a similar order are obtained from the English and Scottish coal-fields. Such an incidence is probably higher than that in heavy industry outside the mines in Britain. Figures for a South Wales steelworks employing over 8,000 men (Jones, J. G., 1956, personal communication) suggest that steelworkers suffer an annual incidence of comparable knee-joint injuries which is little more than half that experienced by miners.

It is known that in other countries also this problem is a large one. In Germany, about 600 fresh cases of meniscus lesions are said to occur annually in the Ruhr coal-field, where damage to a meniscus in mineworkers is accepted for compensation; it is suggested that the nature of their work,

often performed in a crouching posture, results in degeneration of the meniscus (Husten, 1953).

In studies undertaken among miners in Lancashire, Kellgren and Lawrence (1952) and Lawrence (1955) demonstrated a high prevalence of symptoms referable to the knee joint. These workers seem not to have investigated the connexion between various types of injury to the joint and the osteo-arthritis in which they were mainly interested. But they demonstrated osteo-arthritic changes radiologically in the knee joints of 17 to 35% of sample populations of underground workers aged 40-50 years, and after investigation of various possible aetiological factors stated that "apart from injury to the knee we have found no factor in mining which appears causally related to osteo-arthritis." Bonar (1950), analysing 200 cases of meniscectomy among Scottish miners, noted that injury to the menisci was commonest among coal-face workers, and from his figures it appears that they suffered an incidence 72% above that for miners as a whole. Smillie (1951), whose profound studies of injuries of the knee joint are largely based on his experience among Scottish miners, stresses the aetiological importance of work in narrow seams.

It seemed worthwhile to undertake some further examination of the extent of this problem, and particularly to investigate the nature of the accidents and other types of trauma which may be responsible for these injuries.

The material for study consisted of patients undergoing rehabilitation at a residential unit in South Wales during 1953. One hundred consecutive cases of presumed damage to a knee cartilage were studied, including 22 cases where a final decision to perform meniscectomy had not been reached, but in which there seemed a likelihood that a meniscus lesion would ultimately declare itself. In 78 cases meniscectomy had been performed, and lesions of a cartilage sufficient to account for

symptoms had been found in all but one of these. This series was not fully representative of cases admitted to this rehabilitation centre, for of the cases of soft-tissue knee-joint injuries rehabilitated there, only about half are cases recovering from meniscectomy.

Meniscus Injuries as a Cause of Disability

As is well known, damage to the meniscus is commonly recurrent and causes recurrent symptoms. Thus in a series of 186 meniscectomy cases Duthie and Macleod (1943) found that half the subjects had previously been in hospital with symptoms before admission for operation. Care was therefore taken in this enquiry to elicit a complete history relative to the affected knee and not simply one concerning the latest incident leading to operation or rehabilitation at the unit. It was explained to the men concerned that all information to be volunteered would be treated in the strictest confidence, and could thus not prejudice any claim for injury benefit or compensation; it can therefore be claimed that, within the limits of the patients' memories, the histories obtained were reasonably accurate.

However, detailed memory for events which sometimes covered many years must inevitably afford only an approximate answer to the question of what is the average loss of working time before hospital treatment begins. The period from onset of symptoms until return to work after rehabilitation averaged 21 weeks in this series. It is likely that this is an underestimate of the true average period of disability, for some at least of the 22 patients not operated upon are likely to have further symptoms, probably more troublesome than those who have had meniscectomy performed. Bonar (1950) recorded an average total disability in his series of about seven weeks, the period tending to be longer with increasing age. It is not clear, however, that his calculations took account of disability arising from earlier symptoms before the final breakdown. Smillie (1951) quotes series of 16 and 25 weeks' average total disability, also among Scottish miners.

It is thus evident that these injuries represent a serious problem in terms of economic loss both to the miner and the nation. For comparison, 50 consecutive cases of fracture of the tibia and fibula, a severe injury not uncommon in miners, who were treated at the South Wales Rehabilitation Unit in 1953, lost an average of 36 weeks' work. Figures from this Unit and from notifications made to the Mines Inspectorate indicate that about 65 cases of this injury occur annually in South Wales mines compared with some 200 cartilage injuries. In aggregate, therefore, soft-tissue injuries of the knee

joint represent a much greater drain on manpower than do these more spectacular fractures.

Much of this disability time is caused by delay in obtaining specialist advice. Thus in this series of 100 men there were 140 well defined and separate periods of disablement, each of three or more days' duration, arising from definite traumatic incidents. These men suffered in addition numerous lesser episodes provoking symptoms, severe enough in some cases to cause loss of work for a day or two; many suffered prolonged periods of impaired efficiency. In this series, no less than 10 weeks of the total 21 weeks' disability, on average, had occurred before specialist advice had been secured for symptoms which, in the majority of cases, must inevitably have suggested injury to a cartilage. Duthie and Macleod (1943), noting an average duration of symptoms before operation of two years nine months in their series, entered an eloquent plea for earlier recognition of these injuries. It seems possible that the degenerative lesions described by Husten may, in some cases at least, have been due to such recurrent injuries.

Some of the possible explanations for these delays are examined by Smillie, who points to the key position occupied by the general practitioner in these cases. The industrial medical officer is also often in a position to influence these delays.

Finally, there is the difficult question of long-term disability. Whatever may be the truth about the development of osteo-arthritis following meniscectomy, there appears to be no dispute that neglect of a torn meniscus speeds this untoward development (Smillie, 1951). The following case seems to illustrate this point, and also Smillie's teaching on the traumatic origin of cysts of the meniscus.

A 31-year-old collier was struggling to right an overturned tram of coal while in a squatting position, when he slipped. Twisting a knee, which became locked, he lost some four months' work. Symptoms recurred on his return to work, and a lump appeared on the outer side of the joint-line. This (undoubtedly a cyst of a damaged lateral meniscus) was removed without exploration of the joint. Eleven years later, as the knee was unstable and had caused periodic absences from work, the joint was explored and the remnants of this meniscus removed. Despite full rehabilitation, the joint continued to give trouble and acute symptoms followed a slight stumble at work. Further exploration of the joint revealed advanced osteo-arthritis at the age of 44 (not present in the other knee), for which removal of the patella and anterior arthroplasty was performed.

That meniscus lesions are frequently accompanied by osteo-arthritic changes was noted by Adamson (1946), while in Bonar's series osteo-arthritis was demonstrated radiologically in "fully 50%" of knees operated upon. Unfortunately the incidence

of osteo-arthritic changes in the sound knees of these cases was not recorded. Such a study would have afforded valuable evidence on the inter-relationship of these conditions.

There have been few attempts to follow cases of meniscus lesions beyond the first months after meniscectomy. Fairbank (1948) examined radiologically a series of cases at varying intervals up to 14 years after meniscectomy; he found narrowing of the joint space in 32% of knees which had been submitted to medial meniscectomy and in 40% of those from which a lateral meniscus had been removed. He suggested that this narrowing would predispose to degenerative changes, but was unable to decide whether there was a connexion between the various radiological changes he observed and the later appearance of osteo-arthritis.

Factors in the Causation of Meniscus Lesions

Age.—Table 1 shows the ages at which the first definite symptoms of meniscus damage (accompanied by incapacity of three or more days' duration) occurred. This age distribution accords with those in other published series (Bonar, 1950; Adamson, 1946) in showing a maximal incidence of first symptoms between the ages of 20 and 40.

TABLE 1

AGE AT FIRST ONSET OF SYMPTOMS IN 100 CONSECUTIVE CASES OF MENISCUS INJURY CAUSING THREE OR MORE DAYS' INCAPACITY, AND RATE PER 1,000 EMPLOYED BY AGE GROUPS

Age in Years	No. of Cases	No. on Colliery Books	Rate per 1,000 Employed
16-20	9	9,624	0.94
21-30	27	18,861	1.43
31-40	32	24,053	1.33
41-50	25	24,361	1.03
51+	7	27,147	0.26

Sport.—Cartilage lesions are notoriously common among athletes, particularly footballers. The onset of symptoms in middle age may be held, therefore, to be presumptive evidence against sport being a major factor in the production of these injuries among miners; it is rare, in my experience, to find miners taking part in any sport after the age of 25, and few indulge in strenuous sport other than football.

Table 2 shows that symptoms originated during some sporting activity in 13% of cases. As a rough check on the accuracy of the histories given regarding the circumstances of the injuries in this series, the dates were noted when symptoms occurred, wherever this could be recalled with any certainty. The distribution of these episodes was: March 1-August 31, 50 incidents, September 1-February 28, 67 incidents. Such seasonal variation could well

TABLE 2

NATURE OF ACTIVITY RESPONSIBLE FOR INITIAL AND SUBSEQUENT INJURIES CAUSING THREE OR MORE DAYS' INCAPACITY IN 100 CONSECUTIVE CASES

Nature of Activity	(i) No. of Initial Injuries		(ii) No. of Subsequent Injuries		(iii) Total Injuries Caused		(iv) Percentage of Total Injuries
Non-mining		16		7		23	
Sport			5				12.9
Football	11		5		16	18	
Other	2		0		2		
Other non-mining		3		2		5	3.6
Mining		82		33		115	
Surface		8		7		15	10.7
Underground		74		26		100	
On roads	29		16		45*		32.1
At coal-face	45		10		55		39.3
Undefined		2		—		2	1.4
		100		40		140	100

* One of these injuries occurred in the pit-shaft.

be explained by a combination of football injuries and extra liability in winter to slipping accidents above ground. It seems likely, therefore, that sport does not account directly for more than about 15% of meniscus injuries in miners, though what its influence may be on the occurrence of symptoms in later years remains undetermined.

Mining Occupation.—In this series 54% of cases studied were face-workers, 35% were employed elsewhere underground, and 11% were surface workers. The actual distribution of man-power in South Wales mines was: Face-workers 46%, others underground 35%, surface workers 19%. It did not appear, therefore, that precise occupation within the industry was a major factor in the production of these injuries.

Table 2 shows that of the 140 major incidents (those causing three or more days' incapacity) suffered by the men in this series, 100 occurred below ground. Of these latter, 55 occurred at the coal-face, 44 on roadways, and one in the pit-shaft. Here again, there is fairly close correlation with the distribution of mining populations at risk, though there is some support for the view that coal-face work is attended by greater risk of meniscus damage than is other mining work. These figures, however, certainly do not suggest that work at the coal-face, at least in South Wales, is the main cause of the high incidence of these injuries among miners, as Smillie appears to suggest is the case in Scotland (Smillie, 1951). Smillie there draws attention to the type of case in which a coal-face worker tears a meniscus in getting up from a crouched position within a confined space, pointing out that the strain of such a working position gradually stretches the posterior peripheral attachment of the meniscus, allowing it to become caught between the condyles

on some occasion when the joint is extended from the flexed position.

Of the 55 coal-face incidents in this series, nine occurred to men while crawling, kneeling, or squatting in a thin seam, the direct cause, however, being a blow from falling coal, roof, or support, or violent evasive action to avoid such a blow. In a further 10 incidents there was no such external factor, the injury occurring either while the body pivoted upon the knees, as in throwing or shovelling on to a conveyor (three incidents), or slipping while kneeling on an uneven surface (two incidents); in only five incidents did the injury occur on rising from the crouched or kneeling position, the mechanism described by Smillie. It is noteworthy, however, that in two of the latter incidents the patients were unaccustomed to work on their knees and had done so only for a few hours; the same was true of the two similar incidents which occurred in men working on the surface. Thus it would appear that, at least in South Wales, the mechanism described by Smillie is something of a rarity, and other factors must account for the majority of the cases there.

As will be seen from Table 3, the largest number of coal-face incidents was due to falls of roof or coal which directly caused 20 incidents and indirectly, by inducing violent evasive action, a further two. Next in importance, and ranking nearly equal with the combined direct and indirect consequences of kneeling, were slipping and tripping incidents at the coal-face (15 incidents), which do not include slipping accidents while crawling. Crawling or kneeling was the main factor in the injury in 10 out of 55 coal-face incidents.

TABLE 3
PRINCIPAL MINING FACTORS RESPONSIBLE FOR INITIAL AND SUBSEQUENT INJURIES TO MENISCI

	No. of Injuries Caused by Given Factor Underground			
	Surface	Roadways	Coal-face	Totals
Kneeling and crawling	2	—	10 (9)	12 (9)
Fall of stone or coal	—	3	20 (2)	23 (2)
Haulage accident	—	9 (2)**	—	9 (2)
Tripping or slipping	7	30	15	52
Miscellaneous	6	3*	10	19
	15	45 (2)	55 (11)	115

* Includes one incident occurring in pit-shaft.

** The number of occasions on which a given factor was partially responsible for injury is shown in brackets.

It might have been expected, had kneeling at work been the major factor in these injuries, that lesions of the right knee would be more frequent than those of the left, for weight is probably thrown more on the right knee in the right-handed majority when work is performed in a low place. Of the 45 men in the South Wales series whose first symptoms

arose at the coal-face, 22 had suffered injury of a meniscus of the left knee and 23 of the right knee. As might have been expected, however, the left knee was the site of injury in the three cases where symptoms originated in the act of shovelling or throwing on to the conveyor from the kneeling position.

Slipping and Tripping Accidents.—Table 3 shows the important role of tripping and slipping accidents in the production of meniscus lesions in miners. Fifteen such incidents occurred at the coal-face, amounting to one-third of the coal-face incidents. The majority (30 out of 44) of the roadway incidents were caused by slipping or tripping, and this figure would be increased if some of the haulage incidents were included under this head, where men slipped in handling trams of coal and the like. Of the 15 incidents occurring on the surface of the mine, seven were due to slipping or tripping.

Analysis of the coal-face incidents showed that the difficulties of negotiating a conveyor caused most of these slipping and tripping accidents (10 out of 15 incidents). It is possible that in some of these cases the conveyor was in motion at the time (the point was not investigated) but even when stationary a conveyor represents a considerable obstacle, especially in a confined space, while the risk of slipping is great when traversing a conveyor on an inclined coal-face. It is probably significant that no case occurred in this series of slipping or tripping while negotiating a conveyor in the less confined conditions of a roadway.

The majority of the 30 slipping and tripping incidents which occurred on underground roadways were due to slipping on steel rails or the sleepers of the haulage track (18 incidents). Others were falls on a "greasy" patch of roadway (three incidents), tripping on uneven ground (five incidents) or over some obstruction (three incidents), and slipping on a smooth steel cover plate on the roadway in one case. It was a feature of many of these incidents that the mishap occurred while the miner was burdened with some heavy object or was struggling to manoeuvre coal trams.

Slipping on smooth steel plates was also the cause of two meniscus lesions in surface workers. The danger of these surfaces, especially to men wearing hob-nailed boots, was illustrated recently when a miner controlling trams at a surface tippler slipped in his nail-studded boots on the smooth sheet surround and fell into the tippler, where he received immediately fatal injuries.

In connexion with these roadway incidents it is of interest that Lawrence (1955) found a greater prevalence of osteo-arthritis, as judged both by

symptoms and radiographs, in the knees of roadway workers than in the knees of other mining groups he studied. Such findings and those presented here relating to non-faceworkers need to be qualified by his warning that faceworkers with injured knees may tend to leave the coal-face for work outbye.

Other Derangements of the Knee Joint.—As mentioned above, meniscus injuries which are sufficiently definite to warrant meniscectomy make up about half the cases of internal derangement of the knee joint treated at the miners' rehabilitation unit where cases have been studied. The other half consists of cases of traumatic effusion (sometimes of uncertain origin), osteo-arthritis, and injuries to the collateral ligaments. Of these latter, the medial ligament is much the more commonly affected, and the mechanism of its injury is similar to that of meniscus lesions (Smillie, 1951). Injuries of the medial ligament make up a not insignificant group among the knee-joint injuries seen in miners, as might be expected in an occupation where work with the knees semi-flexed is not uncommon (Wilson, M., 1954, personal communication). They frequently occur in conjunction with meniscus injuries, as noted by Smillie.

An interesting case of chronic strain of the medial ligaments was seen at a colliery recently. A conveyor shifter nearly 6 ft. in height had worked in a seam averaging 3 ft. 6 in. in thickness for about two years when he began to experience aching pain in the knees. When seen, he had been compelled to take several periods of absence from work, and exhibited unmistakable signs of injury to both medial ligaments. These injuries were clearly due to his task of straddling the conveyor while pans were being detached or assembled in the new position; because of his height in this narrow seam, this had to be done with his knees semi-flexed and abducted. It proved necessary for this man to find other employment.

Conclusions

In view of the recent interest in miners' osteo-arthritis which has been stimulated by the studies of Kellgren and Lawrence, it is desirable that attempts should be made to elucidate further the relationship between the osteo-arthritis of the knees which they have shown to be so prevalent and meniscus injuries also prevalent in miners. One method of studying this relationship, which should not present great difficulties, would be to radiograph both knees of a series of cases being submitted to meniscectomy, and such a study is now contemplated.

The challenge presented by these injuries is con-

siderable. If any features of the mining environment are found to contribute materially to this loss, it would obviously be desirable to attempt their elimination. The present study indicates that such factors include work in confined places, injury by falling roof, coal, or supports, and haulage accidents.

In so far as work in low seams is a factor in the production of these injuries, reduction in the number of cases can probably only be brought about by mechanization, which will reduce the number of men at risk. This process is taking place fairly rapidly. The present study has not confirmed the theories that the postures adopted for work in narrow seams lead to degenerative changes in the menisci (Hunsten, 1953) or to increasing mobility of the menisci, leading to their injury in normal joint movement (Smillie, 1951). On the contrary, although coal-face workers in South Wales appear to suffer a somewhat increased risk of meniscus injury compared with other groups of mineworkers, the affected faceworkers had almost invariably experienced specific trauma of a type and severity which might have been expected to produce injury to a normal meniscus. Again, the fact that the incidence of these injuries does not appear to rise in successive age groups, but is greatest in the decade 21-30, does not suggest a degenerative process of any slowly developing type. It seems rather that repeated specific trauma, together with personal variations in susceptibility to this, account best for the incidence observed in these mineworkers.

Falls of ground and haulage accidents have for long received attention from those concerned with mine safety and their efforts have had considerable success. Only recently, however, has much attention begun to be paid to slipping and tripping accidents, which are so frequent a cause of knee-joint injuries in the mines. It is probable that slipping and tripping, besides directly causing these and other injuries, are also not inconsiderable factors in many of the more serious haulage accidents. A determined attack upon this problem should prove rewarding.

It is possible that the present types of miner's boot could be improved by the use of soles less liable to slip than the present rubber or steel-studded leather soles, and the "commando" type of boot now available has some advantages. The improvement in mine roadways which has been a feature of the National Coal Board's development programme may be expected to reduce the number of slipping and tripping accidents, as also may the general improvement in "housekeeping" both below and above ground at coal-mines. There is clearly need for managements to have always in mind the provision and maintenance, wherever men have to travel on foot, of walkways in good repair

unencumbered by obstacles or haulage tracks. Avoidance of smooth steel surfaces on footplates, manholes, steps, or machinery housings upon which men may tread is another obvious need.

Further improvement of general lighting may also be expected to reduce these accidents. Light from a cap-lamp fixed to the helmet affords no protection from tripping or slipping upon objects or surfaces underfoot unless the gaze is directed sharply downward; the result of this movement may easily be failure to see an obstruction at head height.

The grosser dangers associated with conveyors are well known. What is not generally realized is the danger of knee-joint injury inherent in traversing them, especially in confined places, even when they are stationary.

Another matter upon which the miner might with advantage be better informed, and which the doctors who see his injuries in their earliest stages might profitably bear in mind, is the importance of ensuring that these injuries receive without delay the benefit of the specialist attention and excellent rehabilitation facilities which are available. There are good grounds for assuming that such treatment is beneficial both on a short- and long-term view, even though fully satisfactory proof of this may at present be lacking and indeed may never be possible.

Summary

The problem of damage to the menisci of miners has been studied in a series of 100 men, drawn without selection from those undergoing treatment at a rehabilitation unit in South Wales in 1953.

It is shown that these injuries are common and of considerable importance in the mining industry. They are predominantly of occupational origin.

The consequences of injury to menisci in terms of disability are described and their possible relationship with osteo-arthritis is discussed. The factors in mining which appear to contribute to the occurrence of these lesions have been studied. Kneeling in narrow seams is of itself by no means the only, or even the main, cause of them. Attention is drawn to the importance, as causal factors, of slipping and tripping both at the coal-face, on underground roadways and on the surface of mines.

Finally, some suggestions are made as to means of reducing the numbers of these common injuries.

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