

# The Role of the Faceguard in the Production of Flexion Injuries to the Cervical Spine in Football

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## ABSTRACT

The precise role of the single-bar face mask in producing major flexion violence to the cervical spine has been studied by review of game movies, analysis of the radiographs and detailed interviews with two players who sustained fractures of cervical spine. The single-bar face mask can become fixed in the ground, thereby forcing a runner's head down onto his chest as the trunk moves forward. Preventive measures embodying modifications in the face mask, strict coaching in football techniques and the institution of safety factors in the playing rules are proposed. Appreciation of the mechanism of injury is urged in order to encourage careful inspection of protective head gear as well as to direct the attention of team physicians to the possibility of serious flexion injury to the cervical spine occurring without dramatic evidence. This report is not a plea for abandonment of the face mask but rather a suggestion for careful selection of a safe and efficient mask.

THOSE of us concerned with the medical supervision of athletes at Queen's University had only an academic interest in cervical spine injuries until the season of 1962. While publications in both the medical and lay press<sup>2</sup> intrigued us, our own experience did not suggest that these injuries were increasing in frequency. In our opinion cervical spine injuries, although a potentially alarming complication of football, were extremely unusual; this opinion is shared by physicians attending all of the major intercollegiate and professional football teams in Canada. During the second game of the intercollegiate football season of 1962 one of the Queen's University halfbacks sustained a fracture of the cervical spine. During the final game of the 1961 season two of our players had sustained fractures of the cervical and cervico-dorsal spine, respectively. Thus, by the second game of the 1962 season, we were in the unenviable position of averaging one fractured spine per game. Not only did the number of injuries concern us but analysis of the radiographs and mechanics of injury suggested that, in at least two of these players, the

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## SOMMAIRE

Le rôle exact joué par le masque à barre unique protecteur de la face, dans la genèse de violents efforts de flexion exercés sur la colonne cervicale a été étudié. On a visionné des films des joutes, analysé des radiographies et scruté des entrevues avec deux joueurs qui avaient subi des fractures de la colonne cervicale. Le masque à barre unique peut devenir fixé, dans le sol forçant ainsi la tête du coureur à se pencher vers sa poitrine, alors que le tronc continue d'avancer. Les auteurs proposent des mesures préventives, comportant des modifications à apporter au masque facial, un strict entraînement des joueurs dans les techniques du football et l'introduction de facteurs de sécurité dans les règles du jeu. Ils conseillent d'étudier le mécanisme de la genèse des lésions en vue d'encourager l'inspection soigneuse du casque protecteur et attirent l'attention du médecin de l'équipe sur le risque d'une grave blessure par flexion de la colonne cervicale qui peut se produire sans entraîner de symptômes spectaculaires. Ce rapport n'est pas un plaidoyer en faveur de l'abandon du masque, mais plutôt une proposition en faveur de l'adoption judicieuse d'un masque efficace et sans danger.

injury was due to previously undescribed forces.

The classical mechanism of neck injury in football, recognized as long as football has been

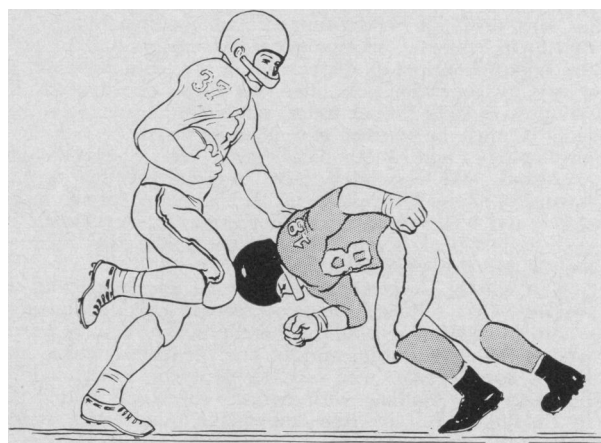


Fig. 1.—Direct impact.

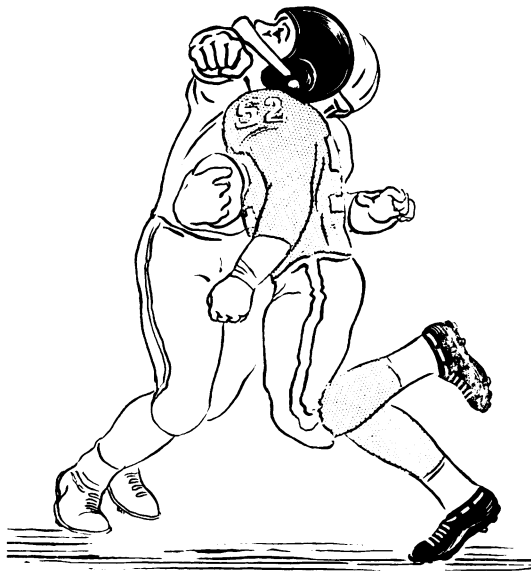


Fig. 2.—“Clotheslining” . . . hyperextension injury.

played, is the direct impact of the head against an opposing player (Fig. 1). Most typically these injuries occur during a misjudged tackle when the tackler, instead of putting his shoulder into the runner's legs, drives his head into the runner's knee. The first of our players was injured in this manner and dived head first into the oncoming knee of an opposing runner. This particular accident, while of great concern at the time and during the several months of the player's convalescence, was not of major continuing interest because the mechanism of injury was well known. The patient proceeded through an uneventful convalescence and returned to active football the following year.

Following the original description by Schneider *et al.*<sup>3, 4</sup> of hyperextension injuries among American football players, a second mechanism of cervical spine injury has gained wide acceptance (Fig. 2). Neither of our other two cervical spine fractures, mentioned above, could be fitted into the pattern described by Schneider. The helmets of these boys were not driven upwards, the circumstances under which they were injured precluded hyperextension injury, and the lesions in the cervical spines were typically those produced by major flexion violence.

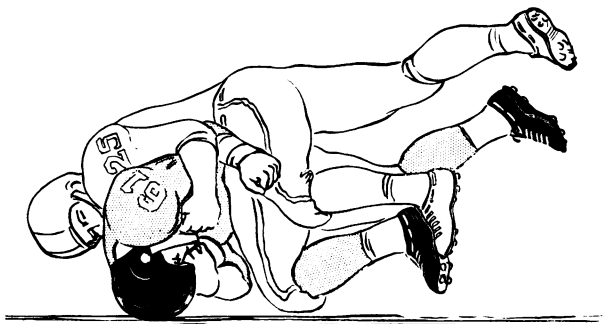


Fig. 3.—“Faceguard flexion”.

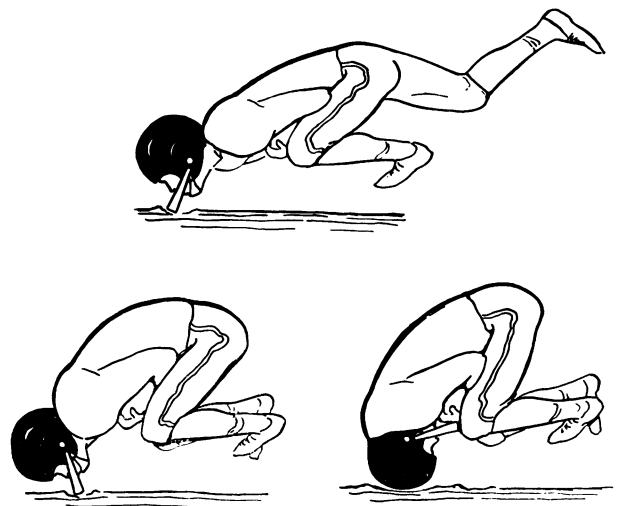


Fig. 4.—The mechanics of “faceguard flexion”.

It is our purpose in this communication to draw attention to a third, and we believe previously undescribed, mechanism of injury (Figs. 3-4). A single isolated fracture of this nature might have been accepted as a freak injury, not liable to be encountered again. However, the occurrence of two relatively identical injuries leads us to believe that a pattern of potential injury has developed which should be clarified so that it can be eliminated. In the two cases described below, identical forces were applied to the cervical spine and remarkably similar lesions were produced in the vertebral column. In both instances the player was tackled around the head while running at full speed and bent forward; this had the effect of driving the runner head first into the ground. Each player was wearing a protruding single-bar face mask attached to the helmet and the face bar made first contact with the ground. The face mask was driven into the ground and fixed thereby, flipping the player's head into acute flexion as the momentum carried his trunk forward over the locked helmet. This mechanism is the exact opposite of that which produces hyperextension injuries but, as with hyperextension injuries, the faceguard appears to be a major factor in misdirecting the forces applied to the helmet.

Certain features of the modern football helmet are essential to an understanding of its role in these flexion injuries. Historically, protective headgear in football has evolved from copying and modifying the natural protection of the intracranial contents. The brain is protected from external violence in two distinct ways: first, by a rigid bony cranium and, second, by an external padding consisting of the soft tissues of the scalp and hair. The scalp and the hair make a considerable contribution to the protection of the intracranial contents. It has been shown experimentally that the resistance to fracture of the cadaver skull is considerably increased by retention of the scalp and hair.<sup>1</sup> Historically the original head protection adopted by football

players was an exuberant head of hair. In their pictures the old-fashioned turn-of-the-century football players appear as a group of extremely shaggy-haired young men. In the early part of this century, padded head protection was evolved by increasing the external padding with the development of various types of helmet which were constructed of felt or resilient leather. Towards the end of the twenties and through the thirties, the tendency was to shift away from the natural soft-tissue protection by copying and mimicking the bony protection. There has gradually evolved what is, in essence, a second cranium, originally of hard leather but currently of plastic. This second cranium is retained by a firmly encircling webbing which dissipates the forces applied to the plastic shell and keeps the shell away from the scalp. The important feature of the modern helmet from the point of view of cervical spine injuries is that the helmet must fit extremely tightly. Only if the encircling webbing is tight is the helmet efficient. In addition to the webbing, a chin strap ensures that the grasp of the helmet upon the head is extremely firm. It is relatively unusual in modern football to see a helmet detached during scrimmage. While the accuracy of fit increases the protection of the skull and its contents from direct blows, all rotatory and angulatory strains applied to the helmet are unfortunately transmitted directly to the cervical spine. It is this firmness of grip which we believe is responsible for the translation of major forces to the cervical spine.

Some form of faceguard has recently been added because the basic helmet does not protect the face. Several forms of faceguard are currently available which vary considerably in their efficiency. Unfortunately the more efficient the faceguard the heavier it is, and the more it tends to interfere with vision. The single-bar face-mask which is slender to reduce weight, and which projects well out in front of the face to protect the nose and teeth, has been the decisive factor in the two flexion injuries described below.

**CASE 1.**—This young man, a halfback, sustained a flexion fracture of the cervical spine while running back a punt. We have been able to document the particular injury more thoroughly because the accident occurred directly beneath the movie cameras. In addition, because of the dullness of the weather, black and white film was being used, permitting enlargement of the movie frames (Figs. 5-8).

The rather slight halfback received a punt and started back down the field with the ball. After about four steps he cut to his right and attempted to burst through between two oncoming tacklers. The lead tackler cut in behind the runner and threw his arms across the helmet (Figs. 5a, b). At this juncture the tackler by virtue of superior weight was able to swing the runner off-balance and steer the ball carrier's head down into the ground (Figs. 6a, b). The maneuver

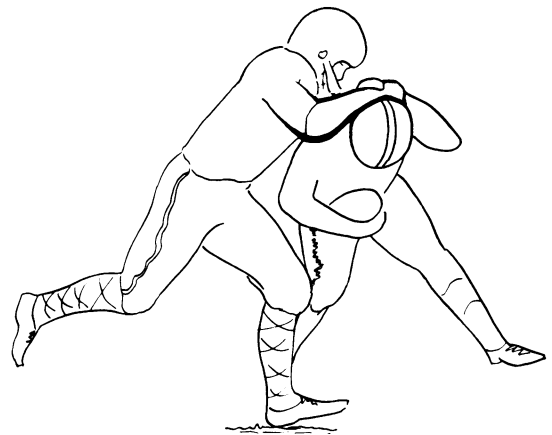


Fig. 5a.—Line diagram of Fig. 5b.

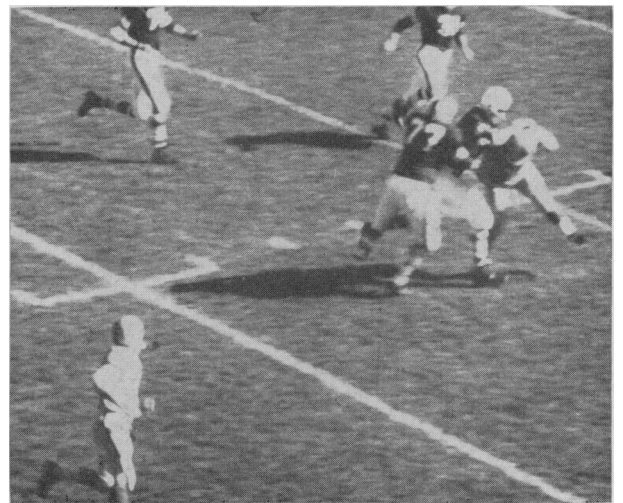


Fig. 5b.—The ball-carrier is in the light uniform. The lead tackler has his right forearm across the top of the ball-carrier's helmet and is starting to throw just like a cowboy wrestling a calf.

was very similar to that adopted by rodeo cowboys in throwing a calf. The relatively heavy tackler landed with his full weight on the player's helmet; the face mask made contact with the ground and dug in. The player's own momentum plus the added weight of secondary tacklers carried the trunk forward over the helmet which was locked in the ground by a combination of forces: the face mask was stuck and the considerable weight of the opponent was resting full on the helmet (Figs. 7a, b). The net result was that the head was flexed violently towards the chest, producing a major flexion strain with immediate damage to the cervical spine (Figs. 8a, b).

We were quite certain from our assessment of game movies that the mechanism of injury was "faceguard flexion". The boy himself when questioned about the matter confirmed the impression that the face mask had done the damage. His father who was a spectator at the game said that the boy had stated before radiographs were taken that his neck had been broken and that "the faceguard did it". The player described quite vividly his own reactions as he felt the faceguard digging in and his unavailing attempts to get his head up.

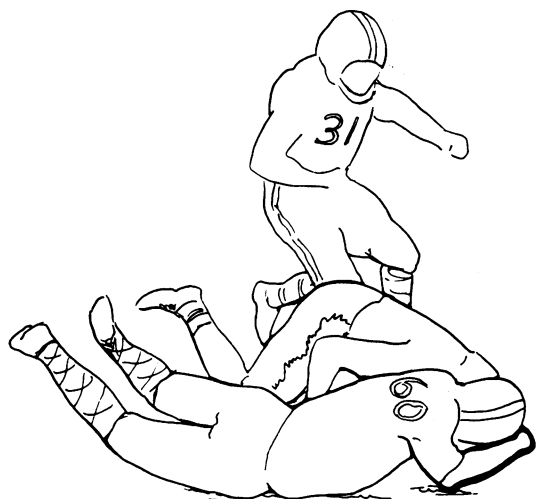


Fig. 6a.—Line diagram of Fig. 6b.



Fig. 6b.—The ball-carrier's helmet is now trapped in the ground—held there by the forearm and chest of the lead tackler.

Following the tackle it was obvious that the ball carrier had been injured. When the trainers reached him on the field he said that his neck hurt but that otherwise everything was all right. The player was able to leave the field between the trainers without any obvious appearance of injury. Indeed it was not until one of us (R.F.H.) was called from the stands to the dressing room that anyone except the team physician was aware that anything but a trivial injury had occurred. The player was assessed in the dressing room immediately following the injury by the neurosurgeon; no neurological deficit was evident and the sole complaint was of neck pain which was poorly localized within the cervical region without discomfort in the upper extremities. In addition to tenderness on palpation, guarding of the long cervical muscles with considerable limitation of neck movement was evident.

The player was undressed, a cervical bandage was applied and he was sent to hospital for radiographs. Standard cervical spine films were taken but unfortunately the significance of the minor abnormalities was not appreciated (Fig. 9). The player was sent on his way after being told to retain the cervical bandage

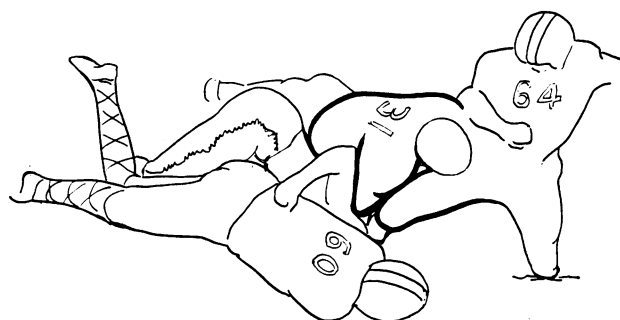


Fig. 7a.—Line diagram of Fig. 7b.

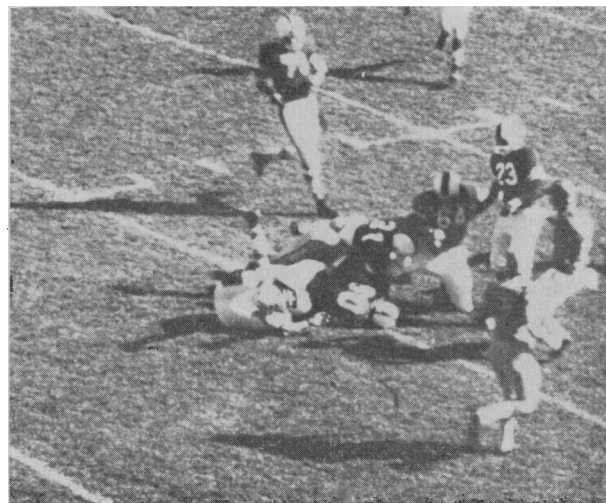


Fig. 7b.—Reinforcements arrive! No. 31 is now driving the ball-carrier's trunk forward over the locked helmet.

and report back to the training room for check-up examination after the week-end.

On Monday, October 15 (the injury occurred on Saturday) his radiographs were examined by more senior consultants and a subluxation of the 5th cervical vertebra on the 6th was recognized, with suspicion of minor collapse of the anterior portion of the body of the 6th cervical vertebra. The student was called from his classes and more radiographs were taken. It was quite striking that, following relief of the immediate post-traumatic spasm, the nature of the injury became more obvious (Fig. 10). The films of October 15 leave no doubt that a significant degree of instability had occurred. The patient's reaction was interesting and instructive. He was extremely annoyed at having been withdrawn from his classes. He announced that he was perfectly comfortable and had only a little neck discomfort and was mainly concerned with getting permission to remove the cervical bandage and getting back to scrimmage.

Because of the definite degree of instability (which was interpreted as evidence of posterior ligamentous injury) and the compression fracture of the 6th cervical vertebra, he was admitted to hospital for early surgical stabilization. The 5th and 6th cervical spinous processes were wired together and cortical cancellous strips raised from the right posterior iliac crest were laid over the denuded laminae.

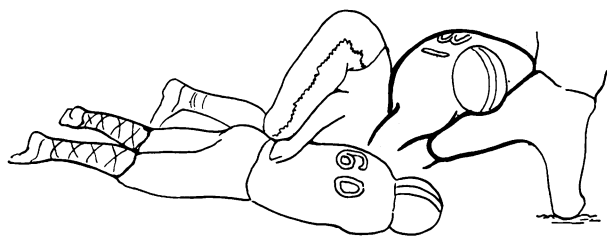


Fig. 8a.—Line diagram of Fig. 8b.



Fig. 8b.—Tackle completed—the ball-carrier's rump now emerges from the pack as all his opponents' weight is on the head and chest.

His postoperative course and convalescence were entirely uneventful. Solid bony fusion was achieved between the spinous processes and by the time of his final examinations in April 1963 he had no complaints of discomfort. He had approximately 15% limitation of rotation, and flexion and extension of his cervical spine, a limitation which he announced did not concern him. He was discharged from active treatment

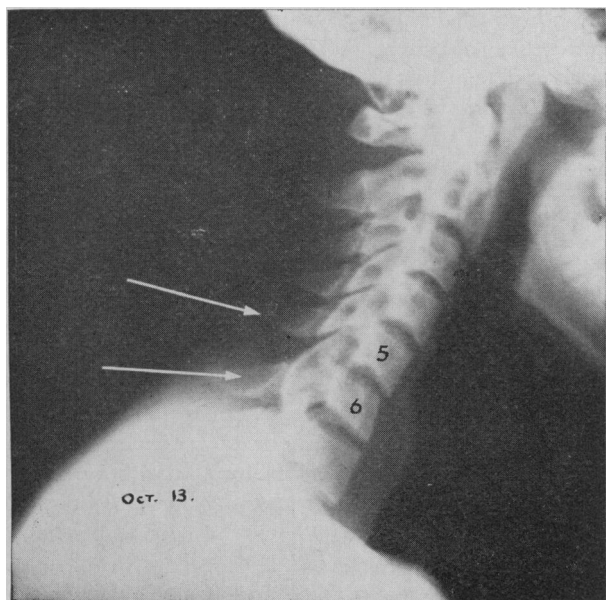


Fig. 9.—Flexion films taken two hours after injury are deceptively unrevealing.

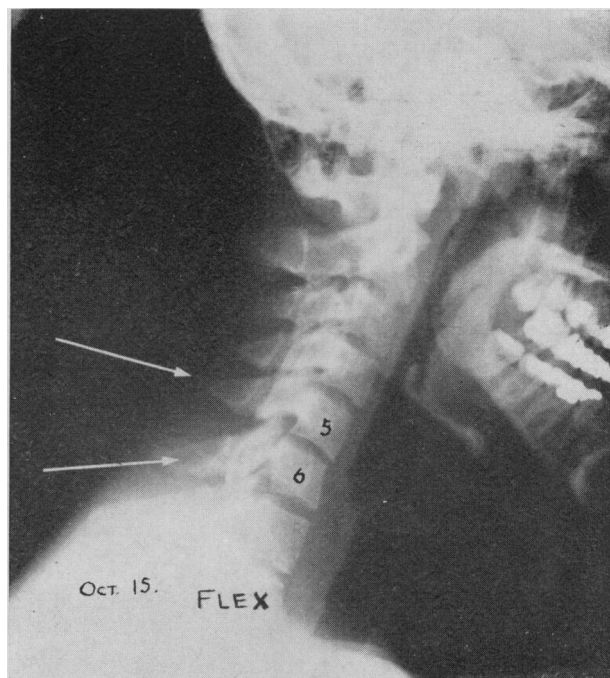


Fig. 10.—Flexion films taken two days after injury reveal, despite persistent protective spasm, a serious degree of subluxation of C5 on C6.

with the sole restriction of activities being the avoidance of collision sports. He has accepted this decision with some reluctance and at present he is continuing in individual sports but has given up football and hockey.

CASE 2.—This player, a halfback, received a short forward pass just over the line of scrimmage and, having caught the ball, folded it into his stomach with both hands, put his head down and drove forward bent over in attempting to gain every inch he could. The opposing centre linebacker was unable to make accurate contact but managed to get his arms around the player's helmet as he went past. This had the effect of dragging the runner downwards into the ground by his head, with the result that his helmet struck the ground and the projecting faceguard dug into the grass. The player's head was anchored to the ground by the faceguard digging in, as well as by the total weight of the tackler. The player's own momentum augmented by the weight of two other tacklers coming in from behind drove his body forward over his head. At this juncture the helmet rolled into acute flexion and major injury to the cervical spine resulted. The player has been interviewed in some detail, has read this description of the injury, and confirms that the mechanism of injury is as described here.

Immediately it became obvious that the ball carrier had been hurt. When the trainers arrived his initial comment was that his neck was "gone" and he absolutely refused to let anybody touch his head at all. He insisted that control of his head be left to himself; he directed that the trainers get him to his feet without handling him above the shoulders and, once on his feet, directed the trainers to take his elbows and steer him off the field. Usually the team physician is able to make some long-range diagnosis of an injured player as he is being brought off but in this instance no such



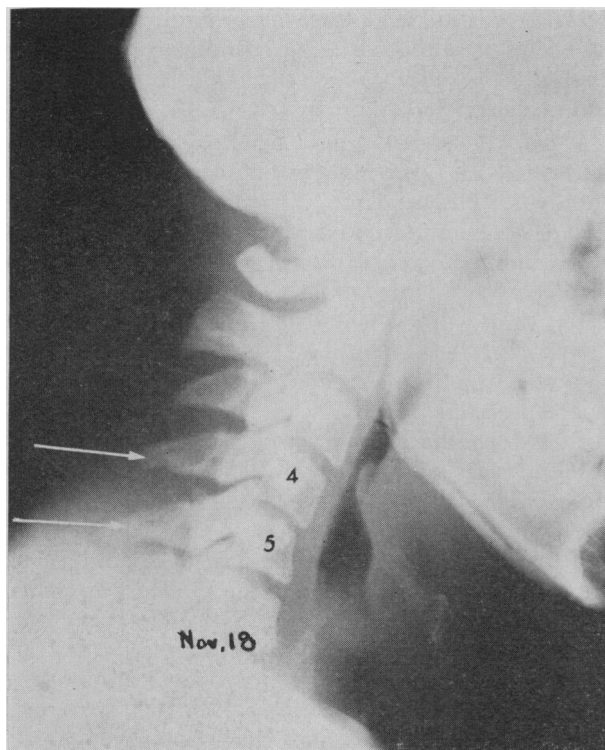


Fig. 11.—An apparently mild flexion injury of C4 on C5 in November . . .

calculation was possible. The player's gait and attitude resembled that of a "zombie". His gait from the waist down was extremely slow but normal, but it appeared that absolutely nothing was moving from the waist upwards. He stalked slowly across the field between the trainers with his body rigid and his face set.

He was met at the dressing room by the consultant neurosurgeon and an immediate careful assessment was made. At this time, some five minutes after the injury, no neurological deficits or abnormalities were identified; indeed at no time during the subsequent few months while he was under close supervision were any such abnormalities identified. He complained of "pain in the neck" without any precise localization within the cervical spine. Movements could not be assessed since he refused to move his head at all.

A cervical bandage was applied to support the head and he was transferred immediately to hospital where radiographs were taken.

This particular injury cannot be demonstrated in photographs because the accident occurred at the farthest point in the field from the movie cameras and the pictures obtained are not suitable for accurate enlargement. However, we are satisfied from our own studies of the game movies that the mechanism of injury was as described.

The original radiographs (Fig. 11) indicated that an apparently minor degree of subluxation of the 4th cervical vertebra on the 5th had occurred. A minor irregularity in the shape of a small protuberant portion of bone in the upper portion of the neural arch of C5 was identified.

The lesion was managed conservatively and he was kept in external cervical splintage, originally a soft quilted cervical bandage and subsequently a plastic collar. The original assessment was that a minor sub-

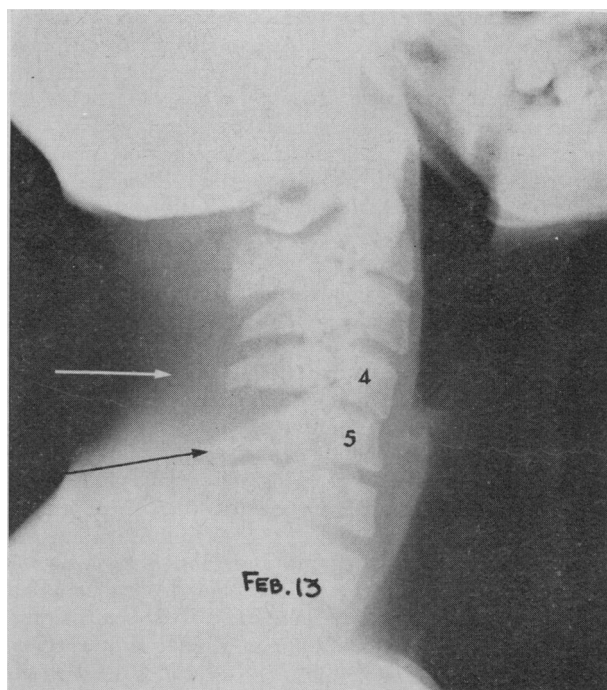


Fig. 12.—. . . can deteriorate until by February obvious deformity is present . . .

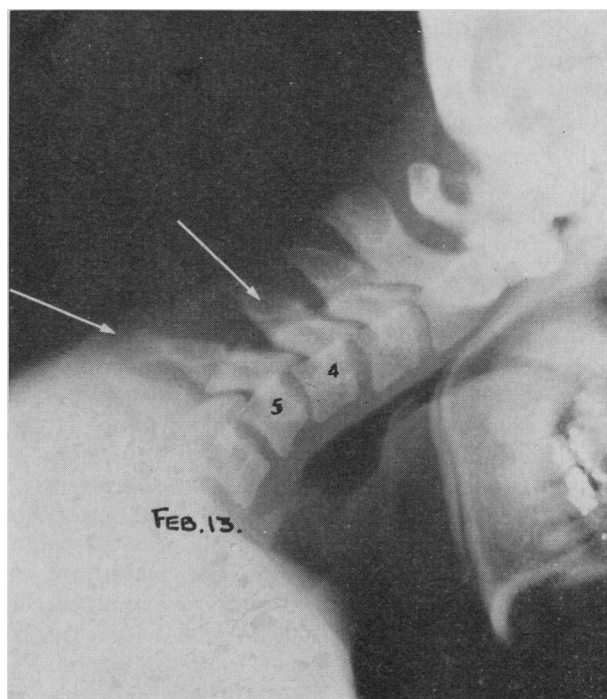


Fig. 13.—. . . as well as gross instability.

luxation had occurred without any major bony injury and without neurological damage.

During the course of the next two or three months the patient continued to complain of chronic discomfort in his neck of varying severity. His major concern during this period was the discomfort induced by working with his head bent—an essential posture for a university student. By February it had become obvious that increasing instability was developing, mechanically his neck was deteriorating and his discomfort was almost certain to persist (Figs. 12 and

13). In April (the date was chosen on social rather than medical grounds) at the conclusion of his final examinations, he was taken to the operating room and the 4th and 5th cervical vertebrae were reapproximated by wiring the spinous processes together, and onlay bone grafts were raised from the left posterior iliac crest and placed over the denuded laminae of the 4th and 5th cervical vertebrae. Postoperatively his convalescence was uneventful, his neck discomfort rapidly disappeared and he slowly regained an adequate range of cervical spine movement. By September 1962 the sole evidence of his rather alarming injury was a cleanly healed vertical scar on the back of his neck and approximately 10% limitation of cervical spine movement in all directions. He was advised not to play football again and apparently accepted this advice with good grace. It subsequently came to light that he had persisted to some extent in touch football under the mistaken impression that this form of activity was relatively safe. It was not until he fell over an opponent in a game and landed squarely on the top of his unprotected head that he realized that his days of active football were over. This last incident had the double effect of confirming the surgical stability of his cervical spine, and directing the player's activities into coaching.

#### DISCUSSION

Consideration of these two examples of an apparently previously undescribed mechanism of injury of the cervical spine in football players requires assessment of several features.

We are convinced, our coaches are convinced and the players are convinced that the single-bar face-mask played a major role in the production of the two fractures of the cervical spine, described above. All of us believe that the projecting bar, if it digs into the grass, may become locked and, if the player is moving rapidly or opponents are piling on to him, the helmet and the firmly entrapped head may be rolled violently into flexion with sufficient force to cause a major injury of the cervical spine. The escape of the cervical cord from injury appears to be due to the impingement of the face mask against the chest, which prevents further flexion displacement of the cervical spine. In other words, although the bar may transmit sufficient force to fracture the cervical spine, at the same time it seems to act in such a way as to protect against frank transection of the cord.

The role played by the athlete's physique in potentiating neck injuries in football players has always been a matter of considerable contention. Some medical authorities have suggested that a young man with a long thin neck should not be allowed to play football because of the danger of neck injury. The first patient reported in this communication was a relatively light player by senior football standards and had a long slim neck. However, the second player had an extremely stocky, short, broad neck which matched the rest of his solid chunky physique. Two cases cannot shed much light on the question of whether players

with long slim necks are more liable to cervical-spine injury although our experience demonstrates that players with heavy short necks are not immune to cervical-spine injury.

Team physicians and coaches are both concerned with playing techniques and training methods. The question of whether fault in the player's technique could be in part responsible for the injury requires consideration. One of us (W.J.S.M.), talking about the future of these boys after their spines are fused, pointed out to the coach that it was unlikely that the player would ever again put his head down and "drive". The coach pointed out that they had never put their heads down and driven forward, that it was an integral part of his teaching that the head must be carried sufficiently high so that the player could see where he was going. He said that both players, in discussing their injuries, had made a point of informing him that they had their heads up when the initial contact was made. Even if players keep their heads up and strive to see where they are going at all times, the situation inevitably passes from the player's control, particularly where a heavy opponent has a firm grasp on his helmet.

To physicians at least, tackling about the head is obviously a dangerous practice, is rarely essential to good football technique and might well be eliminated from the game by altering the rules. One of us (W.J.S.M.) recommended to the Rules Commission of the Ontario-Quebec Athletic Association that head tackling be penalized and this recommendation was adopted immediately. There are circumstances in which the only way a player can be tackled is around the head, for example in close scrimmages. On the other hand, when the player is in the open and the tackler has a clear option with respect to the form of the tackle, in at least one conference, the tackler will be penalized if he elects to go for the head. Similarly a recommendation that the referees pay more stringent attention to piling on was accepted immediately. These rules seem to be no more than an extension of the already widely accepted rule that tackling by grasping the face mask is illegal and subject to the same penalty as any other personal foul.

With respect to construction of the football helmet, and particularly the face mask, certain considerations present themselves immediately: First, does a faceguard provide as much face protection as has been assumed and, particularly is the protection offered to the face offset by the dangerous effects to the cervical spine? The criticisms we have offered with respect to the face mask apply specifically to the single projecting-bar type of face mask and not to the bird-cage mask worn by linemen. For backfielders the single bar offers the great advantages of lightness and a clear field of vision; unfortunately at the same time it provides a mechanically more efficient lever on the cervical spine. We do not recommend that the face

mask as such should be removed but rather that certain safety factors be incorporated. Thus, the narrowness of the single bar allows the cervical spine to undergo a major degree of flexion before impingement of the bar against the chest arrests the dangerous movement. A double bar, a broad bar, or the lineman's bird cage face mask all offer some degree of protection against overwhelming flexion violence. Another major consideration is the degree to which the mask projects forward from the face. It has been estimated<sup>1</sup> that one-inch clearance beyond the tip of the nose provides adequate facial protection and any further projection increases the liability to cervical spine injury without increasing protection of the face. Therefore face masks should be broad and should not project forward more than one inch beyond the tip of the nose in order to reduce their efficiency as cervical spine levers without interfering with their primary function of facial protection.

Cervical spine injuries in football players have always been a major concern to those physicians responsible for the medical supervision of players. The existence of a significant neck injury is not always indicated by the players' reactions. In Case 2, it was perfectly obvious to everybody in the stadium that something serious had happened to the player. In Case 1, on the other hand, the situation was much less dramatic, the patient's symptoms were minimal and if the radiological safeguard of "double-checking" radiographs had not been followed he might have been dismissed from treatment or indeed managed to get himself back into scrimmaging. Clinically the first player had twisted his neck, had a minor neck sprain and, judging by his physical abnormalities and symptomatology, had not sustained a major injury. Cervical spine injuries are often deceptive in their manifestations and only a high index of suspicion and unremitting supervision will prevent serious errors.

Apart from the precise mechanism of production there is nothing special about these injuries. They require the same management as similar injuries produced by other mechanisms. Like all cervical spine injuries, however, they are subject to deterioration, and progressive collapse of vertebral bodies and/or increasing laxity of ligaments often occurs. When such deterioration can be predicted

from the outset, as in Case 1, early surgical stabilization by wiring and/or fusion of the involved segments is indicated. Where potential deterioration is possible, serial follow-up radiographs are essential to ensure that adequate stability is attained through natural processes; failing this surgical intervention is required, as in Case 2.

#### CONCLUSION

Attention is drawn to a previously undescribed mechanism of injury producing major cervical spine lesions in football players. The authors believe that the modern football helmet has the potential of injuring as well as protecting the player. Schneider's work in identifying the helmet as a factor in *hyperextension* injuries is well accepted; we are equally certain that serious *flexion* injuries can be produced in the same way. We have re-emphasized the deceptive blandness in the early phase of neck injuries and the often unanticipated deterioration which may occur in the later phases.

#### SUMMARY

Two case reports are presented which demonstrate that certain features of the single-bar face-mask of the modern football helmet have played a role in producing previously undescribed major flexion injuries of the cervical spine. The various factors in coaching technique, helmet construction and game rules which have a bearing on such injuries are discussed. In addition, attention is again drawn to the fact that cervical spine injuries in football players are often insidious, liable to appear minor and insignificant at the outset, and are subject to considerable progressive deterioration in the later stages. Amendments to the basic rules of football which would improve the situation are suggested and recommendations are made with regard to construction of face masks for football helmets.

The line drawings are by Mr. Alex Wright, Medical Illustrator, Hospital for Sick Children, Toronto. The photographs are by Mr. Ron Irvine, Director, Audio-visual Department, Queen's University, Kingston, Ont.

#### REFERENCES

1. GURDJAN, E. S.: Proceedings, National Conference on Head Protection for Athletes, Wayne State University, Detroit, May 19, 1962, American Medical Association, 1962.
2. SHARNIK, M. AND CREAMER, R.: *Sports Illustrated*, 17: 14, November 26, 1962.
3. SCHNEIDER, R. C. *et al.*: *J. A. M. A.*, 177: 362, 1961.
4. SCHNEIDER, R. C.: Personal communication.
5. ALLEY, R. H., JR.: *J. A. M. A.*, 188: 418, 1964.

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### PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

#### CONSIDER THE ENVIRONMENT

In the modification of milk it may be possible for a trained nurse to follow elaborate directions for its preparation for infants, but few families can afford a trained nurse. The average mother has probably other children to look after, her numerous household duties have to be attended to and but little time can be given to the preparation of a food for one particular child; she therefore will

look for something easy and cannot be blamed for failure to follow out complicated methods of preparing an infant's food. The medical man should consider the environment of the case in question. Many of these women have come to me with these complicated formulæ and asked for something easier and in many cases I have had to go back to the proprietary foods.—D. H. Bernstein, *Canad. Med. Ass. J.*, 5: 847, 1915.