CINERADIOGRAPHY IN ORTHOPAEDIC SURGERY

BY

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In 1897 Dr. John MacIntyre produced a pseudo-cineradiographic record by taking a series of ordinary skiagrams of the frog's leg in different positions and arranging them in order to show the movements. These were afterwards transferred to a cinematographic film. Since then three distinct methods have been adopted: (1) The original synthetic method of MacIntyre. (2) The direct method, in which a band of film is exposed direct to x rays in a rapid series of exposures, as in ordinary radiography. (This method has been successfully developed in recent years by Van de Maele, of Brussels, and Barclay, of Oxford.) (3) The indirect method, where a motion picture record is made of the fluorescent screen image.

Russell Reynolds has worked on the indirect method since 1921; later he coined the word "cineradiography." To this pioneer must be given most of the credit for the development of this particular method into a true cinematographic recording. The indirect method is the only practical method available for study to-day.

Cineradiographic films can be studied indefinitely, and repeated examinations within reason are not detrimental to the health of the patient or examiner. The strips of film recording these examinations can be kept with the case notes and may accompany the case anywhere. Their value lies in a permanent record of movements which can be used for: (1) diagnosis; (2) comparison with former records to watch the effect of treatment or the progress of a pathological condition; (3) research (as in cases where it is impossible to visualize a whole physiological process or, for instance, the behaviour of a stump within an artificial-limb socket); and (4) teaching purposes. The immediate advantages of a record of what can be seen on the fluorescent screen are that the film will permit a leisurely and repeatable study of movement and that the action can be stopped at any stage for a closer scrutiny of any particular image which may excite interest.

Normal and Abnormal Joint Movements

In 1905 Levy-Dorn showed a synthetic film of the movement of the knee and elbow obtained by placing in order a number

of exposures, taken in series, of various positions of the bones. In 1907 Köhler followed with another synthetic film. To-day we can study joints in the body and record their movements accurately, and so obtain a knowledge of the disposition of the elements of the joints in any particular phase of the cycle of their movement.

The physiologist and the anatomist benefit by this knowledge, and the orthopaedic surgeon who is in doubt as to what is actually happening in a joint can see, without the introduction of any contrast medium, any alteration in its mechanics—for example, abnormal movement consequent on a torn cartilage or ligament in a knee-joint.

It is possible to see whether a joint has been successfully arthrodesed. Recently an arthrodesis of a wrist was attempted by two well-known surgeons, but the wrist remained painful in spite of prolonged immobilization. A skiagram showed that there was apparently complete bony fixation. Clinically no movement could be detected, yet the patient complained of pain. A cineradiographic film revealed that movement was taking place. An exploratory operation showed that bony union had not in fact occurred.

Often it is difficult to tell radiographically and clinically whether a fracture is soundly united. In cases of doubt cineradiography may show that movement is still present. A large series of abnormal joint movements have been filmed, examined, and compared with the normal. It is revealing to see the deviations from normal joint movement caused by abnormal posture, ligamentous injuries, subluxations, and fractures.

Artificial Limbs

Even with the employment of the best artificial limbs there remain some cases in which the wearer of an appliance complains of pain in his stump. It is in such cases that cineradiography opens up a completely new field of investigation. The cause of the pain may be obvious. It may be due to ulceration, to a bursitis, or to a septic sebaceous adenitis. On the other hand, there may be nothing to see, or even to feel, and the diagnosis may not be apparent. The painful stump may be relieved by leaving off the limb, in which case the limb is probably to blame. In order to be able to understand why the pain is either initiated or aggravated while the limb is being worn it is necessary to know the behaviour of an ideal stump in a well-fitting limb. Hitherto we have relied on experience and clinical judgment in the diagnosis and treatment of the causes of a painful stump.

Cineradiography opens up a new field in the diagnosis and treatment of this condition and provides us with a new and

Table showing Cineradiographic Observations on Stumps with Artificial Limbs

Case No.	Amp. Level	View	Markers	Shape of Stump	Spur Form	Movements of Stump in Prosthesis				Result on Soft Tissues at Apex of Stump	Correspondence of Axis of Stump with Axis of Limb	Remarks
						Ant.-post.	Side to Side	Rotation	Piston Action			
Above-knee Amputations												
1160	Upper 1/3	A.-P.	+	Conical	—	Slight	Slight	—	—	—	+	No movement at all between limb and prosthesis
1162	Upper 1/4	A.-P.	+	Square	++	0	++	—	—	+	+	Very marked lateral movement. Ischial bearing
1178	Lower 1/3	A.-P.	+	„	++ in socket	+	+	—	++	—	+	A curious lateral-medial-lateral movement of stump in socket on weight-bearing. Very large medial spur. Only slight A.-P. movement
Below-knee Amputations												
1164a	Upper 1/3	A.-P.	—	Conical	—	0	—	—	Marked ++	—	0	Bone-end very close to skin
1164b	Upper 1/3	Lat.	—	„	On fibula	+	0	—	++	—	0	Bone-end of tibia very close to skin. Stump became more pointed with weight-bearing; there is slight latero-medial movement of stump on weight-bearing and also antero-posterior movement
1164c	Upper 1/3	A.-P.	—	„	„	0	Slight	—	++	—	0	
1194	Upper 1/3	A.-P.	—	Tends to square	—	0	—	0	++	—	0	Bone-end well padded. Stump tends to square. Fibula about 2 in. (5 cm.) shorter than tibia, which is amputated above upper third level. A.-P. movement present on weight-bearing. Stump more conical in lateral than in A.-P. view. Film shows that when weight is applied correspondence of axis of prosthesis and joint is good all through flexion
1195	Above upper 1/3	Lat.	—	„	—	+	0	—	++	—	0	
1195a	Above upper 1/3	Lat. flexing knee	—	„	—	0	0	—	0	0	Good	A little longitudinal movement on weight-bearing. Movement of bone very great and of soft tissue much less. Skin attached on the medial side. This is the most marked feature
1150	Upper 1/3	A.-P.	+	0	—	0	—	0	+++	0	0	
1151	Upper 1/3	A.-P.	+	Square	—	+	Slight	0	+++	+++	0	

0 = Not observed. — = No movement. + = Movement. +++ = High degree of movement.

valuable method of investigation into the combined behaviour of the stump and prosthesis in any movement which the patient is able to make. I have recently been carrying out such examinations on both painless and painful stumps fitted with various types of artificial limbs. Study of such films shows that a mass of useful information may be obtained and that the interaction of stump and prosthesis is often unexpected and complicated.

In the usual method of investigation lead wires are fastened securely in various positions to the skin of the stump before the artificial limb is put on. When the films are projected the wires show clearly the degree of movement between the skin and the prosthesis, and indicate also the amount of stretching of the tissues which results from piston action. If the stump is painful the patient is provided with a "pain indicator" so arranged that by pressing a button at the moment when pain occurs an opaque pointer or a point of light appears beside the shadow of the limb on the fluorescent screen and is simultaneously photographed. In this way it is possible to determine the moment at which pain occurs and to see the movement of the stump within the prosthesis which produces it.

Much valuable information has already been obtained. As might be expected, the relative movement of stump and prosthesis varies considerably, depending on the length of the stump, the type of amputation, and the design of the artificial limb. In many cases piston action is a prominent feature, and in these it is instructive to compare the relative movement of the bone and the soft tissues in the stump. In some cases piston action is replaced or added to by antero-posterior, lateral, or rotary movement. In some types of socket with a short femoral stump the bone actually tends to rise out of the prosthesis when weight-bearing.

The table gives a few facts which I observed in a series of cases, and some of these seem paradoxical.

Illustrative Cases

Case 1164a.—This case shows two outstanding features: (1) that the axis of the artificial limb and the axis of the stump correspond very poorly, and (2) that there is a great deal of piston action. The patient complained of much pain in his stump when walking. After realignment of the artificial limb the axis of the stump and that of the artificial limb were found to synchronize much better, the piston action was eliminated, and the patient said he was comfortable. It is noteworthy here that the piston action and the poor axial relation between the stump and the artificial limb coexisted.

Case 1195a.—This patient complained of a painful below-knee stump. There was no obvious neuroma to be felt. The stump was not tender. Cineradiography showed that there was good co-axial correspondence between the stump and the artificial limb. Piston action was practically absent. This indicated that the artificial limb was satisfactory and that the fault lay in the stump itself. The patient was subjected to an operation for division of the popliteal nerves. The artificial limb was not altered. He was discharged relieved.

Comment

The above are two of the many cases that have been analysed and successfully treated along these lines.

Points noted and studied include: (1) The varying axes of stump and different prostheses. (2) The varying relations between the artificial joint and the natural joint in short below-knee and below-elbow amputations during movement. (3) The relation of the direction of painful and non-painful spurs to the movement of the stump in the prosthesis.

Active research is being continued both to obtain more data on the behaviour of a stump in an artificial limb and also to determine the most suitable type of stump and prosthesis in amputations at various levels. For this purpose not only are more examinations of existing prostheses required but other experimental types of artificial limbs with various stumps should be tried. The problem is not one which can be rapidly solved, as a certain time must elapse before effects become apparent.

Summary

Cineradiography is shown to have great scope in research—for example, the behaviour of stumps within artificial limbs.

The application of cineradiography in the diagnosis and the control of treatment is discussed.

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BIBLIOGRAPHY

- Barclay, A. E. (1935). *Brit. J. Radiol.*, **8**, 652.
 Gianturco, C., and Alvarez, W. C. (1932). *Proc. Mayo Clin.*, **7**, 669.
 Groedel, H., and Franke, H. (1933). *Fortschr. Röntgenstr.*, **48**, 65.
 Janker, R. (1932). *Disch. med. Wschr.*, **58**, 1094.
 Köhler, A. (1907). *Fortschr. Röntgenstr.*, **11**, 218, 292.
 Levy-Dorn, M. (1905). *Ibid.*, **8**, 275.
 Luboshez, B. E. (1929). *Paris méd.*, **1**, 117.
 MacIntyre, J. (1897). *Arch. Skiag.*, **1**, 37.
 Reynolds, R. J. (1925). Thesis, Cambridge University (unpublished).
 — (1934). *Proc. roy. Soc. Med.*, **27**, 985.
 — (1934). *Brit. J. Radiol.*, **7**, 415.
 — (1935). *Ibid.*, **8**, 135.
 — (1935). *Amer. J. Roentgen.*, **33**, 522.
 Van de Maele (1935). *J. Belge Radiol.*, **24**, 265.

ACUTE POLIOMYELITIS

Memorandum by Medical Officers to the Ministry of Health

Notifications of poliomyelitis and polio-encephalitis for the week ending July 12, 1947, are 110 and 16 respectively. The highest weekly figure previously recorded since poliomyelitis became notifiable in 1912 was 82 in 1938. This peak was reached in the week ending Aug. 13, 1938. Having in mind the usual seasonal trend and the fact that a significant increase in notifications rarely appears until the end of July, we may expect the early start this year and the present high figures to be reasons for anticipating an unprecedented prevalence.

So far this year the notifications of polio-encephalitis have been higher than ever before. Bulbar and respiratory paralysis and meningeal reactions preceding paralysis appear to be more common than is usual in poliomyelitis.

Clinical Appearance

Typically there are three phases in the illness recognizable as poliomyelitis. In many cases there is also an initial or prodromal illness followed by a distinct interval of five to seven days before more serious signs of disease appear. The chronology may be tabulated as follows.

		Usual Incubation Period from Date of Infection	Manifestations
Stage A	Prodromal illness	1-4 days	Fever, weakness, perhaps sore throat or diarrhoea, and occasionally pain in chest or limbs
Stage B	Anterior poliomyelitis: Phase 1 (onset)	7-18 days (up to 3 weeks)	Fever, flushed face, furred tongue, considerable headache, sometimes vomiting; drowsiness, irritability, and vague subjective phenomena, increasing stiff neck; sometimes exaggerated tendon reflexes
	Phase 2 (pre-paralytic or meningitic)	10-15 days	Sometimes marked intoxication and coma; pain on flexion of neck and spine; tenderness and hyperaesthesia; sometimes nystagmus
	Phase 3 (paralytic)	13-18 days (up to 35 days)	Hyperaesthesia and weakness of muscle groups going on to flaccid paralysis due to anterior horn cell lesions; diminution in tendon reflexes. There is a marked tendency for paralysis to improve after it has reached its height

The prominent symptoms in all phases of Stage B are referable to the C.N.S. They suggest a certain order of progression, which may be indicative of the progress of inflammation within the central nervous system. There may be intermissions in this progression, and one or both of the later phases may not develop.

An illness probably due to the same virus, in which the lower motor neurones escape and the signs and symptoms are predominantly those of meningeal and cerebral involvement, is notifiable as polio-encephalitis.