1932

Conception, past and present of the use of foreign materials as an aid in bone repair

Foster Matchett
University of Nebraska Medical Center

THE CONCEPTION, PAST AND PRESENT

OF

THE USE OF FOREIGN MATERIALS AS AN AID

IN

BONE REPAIR

THE UNIVERSITY OF NEBRASKA

COLLEGE OF MEDICINE

Senior Thesis. 1932.

FOSTER MATCHETT, B.Sc., A.B..
Omaha, Nebraska.

---TABLE OF CONTENTS---

FOREIGN MATERIALS IN BONE REPAIR

by
Foster Matchett.

I-INTRODUCTION.

Due to the increasing speed at which people are traveling in automobiles, trains, and aeroplanes, and due to the fact that the city streets, as originally built, cannot be widened and smoothed fast enough to keep up with this progress of man, it leads one to believe that there will be more accidents in the future.

When an accident occurs two questions are asked--Is the person hurt internally, and has he fractured any bones? I shall leave the first worry to the internist. The latter is of chief concern to me.

As a result of accidents, trauma, bones are fractured. The continuity of the bones is also broken by the development of infections localizing in the bones, causing suppurating bone lesions. Growths sometimes develop without a cause, such as cysts of one type or another. Osteomyelitis and Tuberculosis cause two very distressing bone conditions.

To get back to fractures, we find there are some which heal immediately (3 weeks), without any trouble, while others continue to give trouble for months and even years. Compound fractures are examples of the latter. They invariably become infected and heal very slowly, if at all.

Since there is no best treatment for all fractures, and since the horizon is very foggy with reference to the cure or best treatment for the suppurating bone conditions, it has

prompted many men to investigate means for earlier closure and cure of these conditions.

Some simple broken bones do not heal readily, and we do not know why. Some fractured ends of bone will not unite without being absolutely without motion.

For the above reasons, I felt that a study, or a brief review of articles dealing with these topics would give me a fair conception of what has been tried in the past and might aid me in arriving at a starting point for future investigation in the field of orthopedic surgery.

Many times good methods are discovered and enthusiastically introduced to the world and used as a "universal panacea for for all conditions." Of course, in time they fall into disrepute, until some investigator a generation later picks up the broken cord, and evaluates it in the light of present knowledge, without prejudice and gives to the world something of real value.

This work will only touch the high points. It is my plan to give a brief history of Orthopedics with special reference to its bearing on this subject. I shall try to indicate conditions causing bone non-union, pointing out only the main conditions. A review of the various materials that have been used would consume a book, also. So I shall list many without much comment, and describe and discuss the indications and methods of application, and results of the

use of only the important ones.

An understanding of the process of bone union is not without value and interest here. One could hardly go into this without mentioning the way tissues react to the various materials used.

Bone disease naturally brings the two conditions of Tuberculosis and Osteomyelitis to our minds.(90,91)

Since internal fixation seems to have come to stay we must, naturally, discuss the method of Lane of London.(72).

As there is room for discussion, I thought it would not be out of place to put in these men's discussion.

In conditions where cavities exists something must be done to obliterate this if good surgery is to be observed. Only the best and more accepted methods will be discussed here.

Since bone is involved and missing in many instances, naturally the use of more bone to repair the old lesion is not unusual to expect--hence, bone transplantation will be given considerable weight in this thesis. Of the various plugging methods mentioned, the names of Von Moseteg Moorhof(90,91) and Rutherford Morison(92,93) stand out, and seem worthy of special mention.

Statistics mean very little in some medical subjects, but I believe they might aid us in evaluating results, or at least arriving at an understanding of the materials covered.

The authors have all made various summaries and conclusions

which I feel bear close observation and consideration before we try to discredit their works. Some of these will be included.

The material for this thesis was collected principally from the Library of the University of Nebraska Medical College at Omaha, Nebraska. The material was ferreted out by the use of the Index Catalogue of the Library of the Surgeon-General, covering all three series from 1880 to 1931. The Library card index and Cumulative Index(146) supplied leads to articles. Some of my material came as Abstracts sent to me by the E.F.Prior Company(148), the Consulting Bureau of the Tice System of Medicine. This enabled me to use some foreign articles, otherwise not available.

I wish to thank Dr. John P. Lord(78) for the use of his yet unpublished article on, "The Treatment of Chronic Osteomyelitis", and Dr. H.F. Johnson(60) for the use of his yet unpublished new article, "Reconstructive Procedures in Traumatic Lesions of Bone and Joint." Also, Mr. Harold Johnson for his aid in translating a few German articles, I was able, therefore, to cover especially the cases which were reported at the end of Von Mosetig Moorhof's article(90).

My conclusions are based, entirely, on my reading as no original work has been attempted.

FOREIGN MATERIALS IN BONE REPAIR

by
Foster Matchett.

II-HISTORY.

Surgical Operations[101] are depicted on the tombs of the Pharaohs as far back as 2500 B.C.. Until the age of Pericles there were few medical records, and the great Hippocrates begins to lay the firm foundation of Medicine in 460 B.C., nearly 2400 years later.

Hippocrates, priest of the Temple of Cos, is our first Orthopedic Surgeon. He was, evidently, acutely interested in bone and joint conditions, and extremity surgery. He practised extension in fractures, and bones thus treated united in the same time as they do today.

It is interesting[79] to note that so long ago as 50 years before Christ, Posicrates described the injury, recommending reduction of the dislocation first and treatment of the fracture afterwards. Aristion, Heliodorus, Paul of Egina, Guy of Chauliac, and others all recognized the importance of the injury and difficulties encountered in its management.

Time[101] is long, and our art seems fleeting--for about 1800 years, as far as Orthopedic Surgery is concerned.

Religious views as to the sanctity of the body hampered the acquiring of knowledge of the internal anatomy.

Ambroise Pare[101], (1510-1590), first excised the elbow joint in 1536, and described fractures of the neck of the femur, and introduced methods of reducing the dislocations. A careful

study of the works of Pare, and the translation by Theodore Johnson from Latin, discloses the fact that Pare was aware of the occurrence of live maggots in wounds, and their beneficial effects. (51)

Stromeyer(140) says that Hendrik von Roonhuyze, 1625, was the first to practice Orthopedic Surgery, he treated wry-neck and harelip.

Nicholas Andre(140) (1658-1742), coined the term, "Orthopedics" in his treatise of 1741. However, Jean Andre Venel (1740-1791) of Geneva, Switzerland in 1780 founded the first Orthopedic Institute at Orbe Canton de Vand, where he achieved very successful results.

Jean Davis Petit, (1674-1750)(101) gave the first account of the "softening of the bones" and was keenly interested in bone surgery. "One must never attempt to remove a piece of bone too soon--let the sequestrum define itself", says he.

The first written account(29) of an attempt at internal fixation is reported by Guthrie, who credits Lapeyode and Sicre with using wire in 1775. Malgaigne, in his treatise on fractures, published in 1847, describes a metallic griffe or claw-like device which he used with success for fracture of the patella.

Johann Friederick Dieffenbach(101)(1792-1847), of Konegsberg was a pioneer in transplantations and experimental surgery on animals.

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

John Belchier[101] of London, 1742, at this time was the first to study bone repair and bone growth. He was the first to become convinced of the osteogenetic function of the periosteum.

To Hunter we owe our first clear conception of the formation of a sequestrum and an involucrum and of the two divergent processes. Early in Hunter's career he became acutely interested in the growth and repair of bone. He was at the zenith of his career during the American War of Independence.

In works of Surgery[79] printed one-hundred years ago it is interesting to note the very clear description that is found in the text in practically all of these books on the points which are present day essentials in the management of of fractures.

Baron D.J. Larrey[51], 1766-1842, said, "There is one more remarkable species of foreign bodies, which we cannot pass over in silence which we have had opportunity to notice with a majority of our wounded in Syria during the expedition in Egypt-------the maggots promote healing. They cut short the process of nature.

George Friederick Louis Stromeyer[140], 1804-1876, of Hanover, professor at Erlangen Munich, Frieburg and Kiel was the Father of Modern Military Surgery in Germany. He is one of the founders of Orthopedics in recent times.

Jacques Mathieu Delpech (1777-1832) born in Toulonne and graduated at Montpelier, was the pioneer Orthopedic

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

Surgeon of France, and in the opinion of Sir Arthur Keith, the real founder of the specialty.

John Goodson(101), 1814-1867, convinced himself, strictly speaking, that the periosteum is only a limiting membrane, and that its power is inherent in the layer of cells directly beneath it, which are almost always removed with it.

Fredrich von Esmarch(140), 1823-1908, did much to improve the status of military surgery through his contributions on resection after gunshot wounds (1851), surgical technics (1871). He is supposed to have been the first man to introduce th use of pins in bone repair.

John B. Murphy(140), 1857-1916, "-------had remarkable results with bone-grafts, which, curiously did not succeed unless the sliver of tissue used was autogenous--from the patient himself. The graft will in time, reproduce the exact contour of the defective bone, in accordance with Driesch's morphological law of the 'totipotency of protoplasm' ".

The observation of Volkmann (1889) have shown that driving ivory pegs into osteoporotic bones will produce an osteoplastic inflammation and osteosclerosis.

The idea of immobilizing fractures(114) by nailing the ends of the broken bone together is not a new one. It is alluded to by David Prince in treating of the subject of ununited fractures, when he says, (1871)----"Perhaps a bone might be drilled through both fragments and held in apposition

by a rivet of one of these metals".

Berenger Ferand[29] in 1870, credited Rigaud with having first implanted screws of Swedish iron into the Ulna for fractures of the Olecranon.

Buchminister Brown[101], 1819-1891, was, I believe, the first American Surgeon to devote himself entirely to this branch of Surgery.

Lewis A Sayre[101], 1820-1903, of New York, held the first Chair of Orthopedic Surgery in Bellevue Hospital Medical College.

Alessandro Codivilla, 1851-1913, was the first surgeon to call attention to the great osteogenic power of osteoperiosteal grafts for non-union. To him we owe the principle of direct skeletal traction as the most efficient method of overcoming the shortening and securing alignment in difficult fractures.

Professor William Konrad Roentgen's[101](1845-1923), discovery in 1895 was a great aid to orthopedic men.

Shaffer (Camden)[29] said that he noted the clean healthy condition of leg ulcers that were infested with maggots while he was an intern in 1908-1909.

Steinman[62] in an article published in 1911 said, "The direct application of a peg or a nail to a bony fragment is not new." Direct application of the traction on a bone was still more pronounced in the extension forceps devised by Heineke. This method was published in 1910 by Graser.

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

"Somewhat later(62) we conceived of applying the nail to the peripheral fragment and using it for continuous extension. We convinced ourselves on a number of cases that this method is relative non-dangerous, and we published this subject in 1907".

Although the initial work of any importance was begun in 1858 by Ollier, bone transplantation had been attempted many years before that time.

Dr. J.J. Buchanan of Pittsburg was one of the earlier users of the bone grafts and the illustration shown was used in 1912, but had been used a number of years previous to that date.

Lambotte in 1907, described the implamtation of metal screws through the diameter of the long bones fixing the protruding pins in a metallic plate. In his report he asserts he has used the device freely since 1900. Lambotte and Parkhill after 1900, obtained greater success with bars, and their names are indeliby associated with external bone clamps.

Crile, October 23, 1917, said, "The wounds that have done the best are those that contain certain maggots". Dr. Edward Martin of Philadelphia said, "Raise a brood of tame maggots to take care of the wounds".

W.W. Keen of Philadelphia (1918) said that maggots were

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

disgusting but did no harm.

Plugging of bone cavities has been widely used. Mosetig Moorhof was the first to revise it by means of his iodoform paste. Dressmann of the Surgical University Clinic In Leipzig had already used plaster to fill bone cavities. Stachon had had made some experiments on sheep. Also, Oehlecher, in 1923 had removed a giant cell sarcoma and filled the residual cavity with a mixture of plaster and a small quantity of iodoform.

"The treatment of fractures by skeletal traction is not new. While Dean and Professor of Surgery at the Medical College of Indiana 35 years ago, Dr. Joseph G. Marsee practised and taught the use of skeletal traction in fractures of bones of the shaft".

Bielsalski paid Codivilla a direct tribute by describing Orthopedic Surgery--his branch of surgery--as , "---that art which required profundity of knowledge and acuteness and finesse of mind and hand perhaps, more than any other".

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

III-OUTLINE OF FOREIGN MATERIALS

Various materials are used to aid in bone repair. Since the bone conditions are usually the result of growths such as tumors or following trauma resulting in simple or compound fractures or infections subsequent to the above a variety of different materials must be on hand. Some will serve the purpose of simple internal fixation of bone ends, some will replace bone tissue with subsequent absorption, some will obliterate dead spaces while other will work externally in the capacity of sheletal tractions. They will be either absorabable or non-absorbable.

A. Absorbable Materials

I. Bone grafting

(autogenous or Homogenous grafts)

(a) Wafer of Chatro

(b) Intramedullory graft

(c) Bone chips (decalcified)

(d) Chip grafts

(e) Autogenous sterile bone

II. Bone grafting

(Heterogenous grafts)

(a) Bone chips (decalcified)

(b) Bone dust

(c) Bone screws

(d) Bone pegs

(e) Bone plate

(f) Massive graft

III. Non-Metallic Materials

(a) Catgut

(b) Kangaroo tenden

(c) Silk

(d) Ivory pegs and screws

IV. Materials For Plugging

(a) Gums (Balsam of Peru etc)

(b) Waxes (Malten Paraffin)

(c) Sterilized sponges

(d) Iodoform emulsion
(also combined with Balsam of Peru)

(e) Iadoform paste of Von Mosetig Moorhof

(f) B.I.P.P. of Rutherford Marison

B. Non-Absorbable Materials

I. Plates

(a) Lane's plate

(b) Miscellaneous plates including silver and gold

II. Bands

(a) Parham

(b) Parham, Martin and Miscellaneous bands

III. Wire

(a) Silver wire

(b) Iron wire

(c) Magnesia wire

(d) Brass wire

(e) Rustless steel wire

(f) Klapps wire

(g) Phosphorus Bronze wire

(h) Annealed Iron wire

(i) Kirschuers extension wire

(j) Bronze aluminum wire

(k) Copper wire

IV. Pins

(a) Steel pins (long and short)

(b) Allen through and through pins

(c) Shanz's pins

(d) Screw pins

(e) Steinman pins

V. Nails

(a) Horse-shoe type

(b) Gester nail

(c) Donble nail (Bruns)

(d) Steel (6-8-10 penny)

(e) Steel plain pins (veryfine)

VI. Bolts

(a) Adjustable log bolt

(b) Stove bolt type

(c) Bolts with burrs on end

VIII. Bars

(a) Steel

(b) Parkhill Modified bar

(c) Lambotta Parkhill bar
(made of duralumin)

IX. Needles

(a) Phonograph needles

(b) Common straight steel needles

X. Clamps and Tongs

(a) Bone clamp

(b) Steel

(c) Parkhill clamp

(d) Parkhill clamp and Marks Modification

(e) Peters Forceps

(f) Edmondson fracture extension tongs

(g) Beasley-Cannady extension tongs

(h) Miscellaneous (Pearson's, Adam's, Dorrance's, Calipers)

(i) Others by Keatley, Freeman and Lambotta

XI. Miscellaneous

(a) Rubber

(b) Some forms of plugging material

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

IV-BONE REPAIR.

Operative Treatment:

Non-union of fractures is best treated by bone implantation. Ollier's teaching: ".....that the most important osteogenetic cells are those lying between the fibrous layer[109] of the periosteum and the surface of the bone--the so-called cambrium layer of the periosteum"[86].

The operative technique must be based upon a knowledge of the laws of bone regeneration[25]. That method is to be considered most physiological in which the osteogenetic elements of the transplant are afforded the best opportunity for development, and in which the significance of the underlying mechanical laws are properly appreciated.

Dead bone[93] provides a scaffold by means of its Haversian Canals. Mild chronic septic infection is a strong stimulant of inflammatory osteogenesis. It causes widespread osteoporosis, increased vacularity, and abundant callus formation.

First, the operation must be postponed until all signs of infection have been absent for four months. Otherwise healing will occur in only a small percentage of transplants. Second, more than normal precaution[86] must be used in the after treatment, since owing to the extensive loss of bone and to the scar formation fracture of the shaft can easily occur.

The presence of tuberculosis or lues[45], and tendency to

osteomalacia, or lack of proper calcification, and lastly the age of the patient must not be overlooked in bone repair.

The proper instructions relative to hygiene, diet, and generally right living are important.

Reparative processes[5] are aided by exact reposition of the bones, and the principles of cabinet making are applicable to orthopedic surgery. Good mechanics aids repair only when combined with good biology, and sound biological principles can only be applied with due consideration for the principles of mechanics when such a rigid tissue as bone is being aided to repair itself. Such are the resources of nature that repair will proceed in the face of adverse conditions, provided there is a balance of favorable conditions.

Methods of fusing certain joints by chip grafts are neither mechanically nor biologically sound. If osteogenic power is high the operation may succeed, if not it will fail. The osteogenetic potential of a bone cannot be determined in advance. It does not vary directly with such measurable factors as the youth, robustness, or general health of the patient.[5] It is a wise pervision to assume a minimal osteogenetic power, and to plan the operation on that assumption.

Geiger[25] says, "It cannot be too often mentioned that bone surgery does require a special technic. Vigorous aseptic precautions in preparation of the operative field, the surgeon and his assistants is absolutely essential.

From experimental as well as clinical[20] work, we know that

the first effort nature makes in repair of a fracture is always her greatest. Consequently it is essential to give her every aid during the first effort, instead of assuming that it will be an easy matter to correct a deformity.[20]

It would therefore appear that the problem consists of getting these cavities filled with living tissue of any kind at the earliest possible moment. The more such cavities are opened up and exposed to the air, the better will the granulations grow, and the more rapidly will the cavity disappear.

"Union of simple fractures[93] is frequently inversely proportional to their severity; that union following operations on simple fractures in which the periosteum at the ends of the fragments has been extensively reflected, or the insertion of wires or plates, is often greatly delayed". It is very evident that mild septic infection is the greatest stimulant to bone repair.

In the course of a week new blood vessels grow into the old Haversian Canals, and along with them go many osteoblasts which immediately become engaged in the absorption of necrotic bone[93]. As the old bone disappears, its place is taken by new bone laid down by these osteoblasts so that after a lapse of two or three months all traces of the old fragments have disappeared, and the mass consists entirely of new cancellous tissue.

Most of the callus is formed from the inner strata of the periosteum, while the medullary tissue forms the rest. The first[14]

indication of the healing process is the occurrence of a periosteal swelling, which is caused by the proliferation of the osteoblastic cells between which lime salts are deposited. Lacerated portions of the periosteum are scattered around the fracture area and start another starting point for peripheral growth.

In cases of non-union[14] the fragments must be sutured with silver wire or very strong catgut.

The following schema presents the main stages of bone repair:[57]

1-Blood clot. This becomes infiltrated by leucocytes, connective tissue cells, and osteoblasts, and permeated by capillary loops.

2-Granulation Tissue--or Procallus: the appearance histologically is indistinguishable from granulation tissue elsewhere. The majority of cells in it are osteoblastic. By their agency calcium salts are deposited in the intercellular tissue, and thus is formed.

3-Callus or clacified granulation tissue. This will be laiddown where the original blood-clot was. but only at such distance from the actually broken bones surfaces as can be traversed by the osteoblasts.

4-Cartilage[57]; in a large proportion of cases examined at a suitable stage, the transformation of callus into bone can be seen to be preceded by a stage of cartilage. In animals it is very conspicuous.

5-Ossification of Callus; this, which is by far the slowest of all the processes, consists in a production of a homogeneity between the soft callus and the hard bone.

Bones unite[64] because there is enough excess growing power to overcome the atrophy caused by the plates. Fractures may be made to unite by perforating the adjacent ends with multiple drill holes.[7] Probably some of the value from wiring bones or plating bones come from the excitation of the drill holes.[7,93.] "I am able to demonstrate beyond doubt that the drilling of broken bone ends invariably sets up free deposits of callus and brings about union. Multiple drilling of fractures aids in bone repair".[7]

By regarding this subject of physiological and mechanical rest in what I conceive to be its proper professional light[101] the surgeon will be compelled to admit that he has no power to repair directly any injury. It will induce him to acknowledge in all humility that it is the prerogative of nature alone, to repair the waste of any structure. He will then realize that his chief duty consists in ascertaining and removing those impediments which obstruct the reparative process or thwarts the efforts of nature, and thus enable her to restore the parts to their normal condition.

FOREIGN MATERIALS IN BONE REPAIR

by

Foster Matchett.

A-DELAYED AND NON-UNION

Delayed union is not the fault of internal fixation, but in spite of it.(40) The common classes of fractures in which non-union occurs are three types:(32)

1-The Displacement Cases.

2-The Delayed Unions.

3-Those in which there is plenty of callus but the fragments do not unite.

The Causes:

1-Imperfect Setting.

2-Something between the bones.

3-Imperfect fixation.

And then add to these lack of care with regard to the circulation, failure to use massage, etc.

Brickner(21) has elsewhere expressed the belief, that metal bone plates and screws, can of themselves be the cause of subsequent non-union.

Edward Martin states, "As a rule the presence of a plate in place of stimulating osteogenesis between the bone ends, retards it".

Non-union occurs most commonly because of the presence of infection, as does also a delayed union. Non-union and delayed union are also affected by the presence of lues.(31) The causes of failure of treatment in cases treated by septic occlusion were, incomplete drainage, infection, osteo-

myelitis, and sequestra.

Atrophy and non-union may result from lying in bed or from inactivity on the part of the patient.(27)

Many cases of non-union[147], mal-union with symptoms, and compound fractures require operation.

The aseptic regime of general surgery makes possible the treatment of fractures by operative methods, but rigid conformity to established aseptic ritual is essential to success and is postulated in this argument.

The disadvantages[83] of the open treatment of fractures are that it is at times attended by pronounced shock and bleeding, that the utmost care may fail to insure against immediate or remote infection, that union is generally delayed, at times failing entirely.

There may be some truth in the argument that delayed union[143] or non-union is more common in cases treated by the open method, but this should not deter the surgeon if open operation is indicated.

In this series[142] non-union did not occur. Delayed union appeared in two instances, and malunion twice. We have been taught that sepsis tends to delay the healing of the fracture and results in these conditions. It is interesting to note that delayed union occured in clean fractures. Nonunion is almost always caused by too zealous removal of the splintered portions of the bone, leaving a gap which cannot be bridged by the bone. It was prevented in this series by the preservation

of all the bone splinters possible and by the suturing of the soft parts over them so that it would give them the best chance of life. Delayed union is more apt to occur in transverse fractures with very little comminution.

The contraindications to operation[88] must be considered. Infection must be adequately dealt with, sequestra and Lane plates removed, manipulation carried out, neighboring joints loosened up, the blood supply improved, bone atrophy overcome and the general condition of the patient built up.

In the case of non-union[27] prophylaxis is the best treatment. However, all surgeons will have had bad results in fractures, avoidable or unavoidable, a consequence of non-cooperation on the part of the patient of the surgeon, from remission of care, to the minutest detail of treatment, or of his inexperience or lack of comprehension of mechanical prinsiples involved, and the importance of their proper application.

Jones[27] has said there is no such thing as non-union, aside from syphilitic disease, but that there is frequently non-union.

In addition to the classical causes of delayed union[27], such as Syphilis, Scurvy, Malposition, Interposition of soft parts, infection, and interference with the circulation, we have to consider the loss of substance, either from primary trauma by shell fragments, or from operative procedures, the necrosis of poorly nourished fragments, and the destruction of the nerve supply. Fragments having periosteal and muscular attachments should not, under any circumstances, be removed.

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

Another operative procedure which, in the hands of 95% of all surgeons results in delayed union is the introduction of plates[7].

A gratifying[8] number of successes in fractures of the leg and thigh have been obtained by the use of Orthopedic Splints. In a number cases of delayed union of the leg, union has gradually become complete while the patient was using the limb under the protection of a suitable splint[105]. It is thought that the slight irritation caused by bearing the weight on the limb favors ossification.

Peterson[108] believes that the treatment of non-union should be aided by giving patients bone forming elements, such as: (1) Calcium carbonate; (2) Calcium lactophosphate; and (3) Sodium phosphate. Phemister has emphasized the value of yellow phosphorus in the treatment of these cases.

In the treatment of non-union, Potts, Buchanan, Henderson, Robertson, Meyers, Campbell, and Miller have considered ice the mainstay of local therapy, immobilization followed by massage, baking and other procedures calculated to produce a local hyperemia, in the part affected.[108]. The value of constitutional treatment is recognized, also.

If the patient is not in favor of being up and about then the surgeon may apply Bier's hyperemia treatment, Jones "hammer and dam" treatment. This hammering the site of fracture with a rubber hammer furnishes a stimulus which in a way serves

the same purpose as the physiological function.

The production of venous stasis[27] by means of a Martin bandage[27] provides an increased blood supply which favors repair, a condition obtained when the leg is allowed to assume its normal position in walking.

According to Stimson, delayed union is more common in the upper than the lower limbs, and lack of physiological stimulus and blood supply may be the explanation.. Given a fair approximation of long standing and a delay in ossification, the introduction of a bone graft--never a metal plate--is indicated. No matter if one does favor metal plates for fresh fractures, he should never employ them in an old fracture, because of the chance of a much longer delay, or fatal infection[27]. If the fracture is fairly simple and transverse, the cortical graft designed by Albee is to be preferred.

It is advisable in every possible case to take the graft from sound bone at the site of fracture, thus simplifying the operation and reducing chances of infection.

"I do not hesitate[132] in the case of the tibia to open up a wound which has not yet healed and with a flat chisel split each end into numerous longitudinal pieces and again close the wound to its original size. I have done this on several occasions now and in each instance union has occurred and there has been no ill effects in any of them".

The writer's treatment is as follows; In the displacement cases, ends of the fragments are squared or fitted and held with

plates. In some, also, small grafts are used. In delayed union[32] nutrition rather than correction is the problem, freshening up the ends, sometimes small grafts. In the non-unions, chip-grafts preferable from the inner aspect of the shin, dredged into line of fracture. In after care, rest until the beginning of aseptic repair, then massage, baking and diathermy, and finally exercise through functional use.

Repair[27] of the fracture must be sacrificed to the general good of the patient should the occasion arise.

B-SUPPURATION.

Metal introduced into the tissues[3] is in most respects the direct antithesis of the bone graft. It favors infection, absorption, and disintegration of tissue. Complete absence of foreign bodies[77] in the wound means better union, because callus formation is not hindered. Failure to remove foreign material[31] has, in some cases, made it necessary to amputate the limb, and has caused death.

"We have never yet yielded to the temptation to introduce foreign bodies into the wounds, such as wires, plates, and screws".[93]

E.B. Mumford[95] says, "As for infection, I am of the opinion that it comes from faulty technique or from some other cause, and not from the foreign body itself".

"But roughly speaking we[77] have found that traumatized and infected, or either simply traumatized or infected bone, if no foreign bodies were present, would stand almost three times the amount of infection or trauma, or both, that would harm bones where foreign bodies were present."

"The great number of infected compound fractures treated by the writer[77], in his four year's of service in the Army, during the late war confirmed completely the experimental results and the 'No foreign body and light fitting case technique' has given most satisfactory results. Complications noted when other methods were followed are due to the presence of foreign bodies used in the process of osteosynthesis. It

follows, then, that foreign bodies prevent healing."

"If a good aseptic condition has been secured[52] and the fixation devices be made of silver, whether it be wire, or screws, or nails, or plates secured by screws, suppuration may not ensue".

"In order to find the definite cause of infection the author[139] made numerous studies on bone operations in this clinic. He found that the pus around a foreign body was always sterile, therefore it could be either a simple bacterial infection, the germs of which were dead, or a non-bacterial suppuration of a foreign body. This latter assumption was hardly reconcilable with the fact that this suppuration appeared months, even years after the implantation of the foreign body. Furthermore, it was observed that metal objects of the same kind, even in the same patient, sometimes healed uneventfully, and at other times caused suppuration".

Wood and rubber invariably give rise to suppurative inflammation. Clinical experience[114] and experimental investigations have demonstrated, sufficiently, that bone and ivory pegs if implanted under aseptic precautions, do not act as foreign bodies, and never give rise to suppuration. It has also been shown that these pegs produce osteoplastic inflammation that materially hastens the process ofrepair.

If infection does develop, it is treated by the Carrel-Dakin method.[142]

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

Where wounds are found to be infected by the streptococcus it is necessary to open the wound widely, and it is desireable to treat the wound by the Carrel-Dakin Method[31].

Again, "Irrigations of warm Dakin's Solution are helpful".[142]

The explanation of failures in the treatment of chronic osteomyelitis[93] is to be found in the presence of a non-collapsible cavity.

Many cases of chronic osteomyelitis[78] may be excavated, saucerized, and antisepticized, and closed by plastic proceedings, and immediate or early healing effected, thereby reducing hospitalization to a minimum. Pedicle flaps with adequate circulation are imperative in large cavities. These should be deeply covered with thick skin with flaps accurately sutured, but patulous where necessary to provide drainage. Plastic methods of various types may be employed to accomplish these results.

Many materials have been used[82] for example--blood clot, fat, bone chips, and sponge. But the best results have been obtained with sliding flaps of the adjacent skin, fascia, fat, or muscle.[97]

The use of bone chips has been advocated as a means of filling bone cavities on the assumption that each fragment of bone is the nucleus of bone production.

MAGGOTS:

The skin is washed off with sterilized water (salt, normal) simply to remove the grease and dust from around the wound. No

sterilization or chemical of any other nature is used on the part to be operated upon. No gloves are used. One, therefore lays bare the infected bone, and cuts through the cortex, and opens wide the medullary cavity. All the sequestra and granulation tissue are removed.

Maggots have been found to be a tremendously useful adjunct to the thorough surgical treatment of chronic osteomyelitis, and in our[10] opinion, are far more successful in securing permanent healing of these extensive wounds than any other method tried by us. Maggots, by their digestive action, clear away the minute fragments of bone and tissue sloughs caused by operative trauma in a way not accomplished by any other means. They cause wounds to become alkaline, and in this way diminish growth of pathogenic bacteria. They seem to have other, more subtle biochemical effects within the wound itself, and perhaps cause also a constitutional reaction mimical to bacterial growth. There is no risk to the patient. The post traumatic or post operative general condition of the patient is better in maggot treatment than in the older forms of treatment where infection was combatted by chemicals or other types of dressings. There is less absorption and less toxic reaction. In open Tuberculous abscesses, with or without secondary infection, wide exposure followed by maggot treatment has proved surprisingly effective in a small number of cases.[10]

V-SPECIAL TOPICS

A-PLUGGING:

Bones need internal support and cavities must be obliterated. The reasons are chiefly two:[6]

1. The danger of fracture if the cavities are in a long bone which is subjected to muscular strain and has to support body weight.
2. The long time necessary to obtain a cure, which is attended with hideous scars and sometimes with certain amount of loss of function.

Materials[6] for this purpose were introduced by Neuber, Durante, Delanger, Manclaire, Blancard, Beck Delbert etc.

It has been recognized that cavities and tunnels in bone, when opening on the surface of the body, heal slowly or not at all.

In treating infected bone cavities the following conclusions may be drawn.

1. That complete removal of all the infected bone lining the, cavity, of all foreign bodies and of every particle of dead bone is essential.
That in the great majority of cases the cavity must be obliterated to insure healing

UNNA'S PAINT:

I have found this method of treating osteo if the long bones is much more satisfactory than any other, even including the Moorhof wax plug.

MATERIAL:

Take a double boiler, fill the outer basin 1/3 full of

ordinary water, then place 10 ounces of sterile water in the inner boiler and 4 ounces of ordinary grocers sheet gelatin. Place inner receptacle in outer receptacle and put over a slow fire, leaving it on until gelatin is dissolved, then add 10 ounces of glycerine and then 4 ounces of zinc oxide gradually- constantly stirring.

BISMUTH PASTE:

The technic employed is the therapeutic application of the paste is practically the same as that in the diagnostic method. There are two Formulas I and II. This material[13] is used to advantage in fistula developing from sequestra.

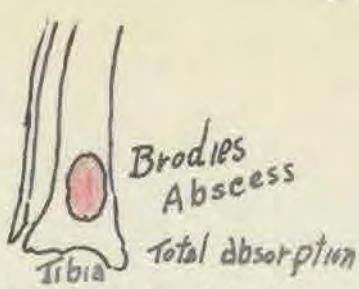
	Formula I	Formula II
Bismuth Subnitrate (arsenic free)	33%	30%
Vaseline (yellow or white)	67%	60%
Paraffin (melting point)		5%
White wax		5%
	100%	100%

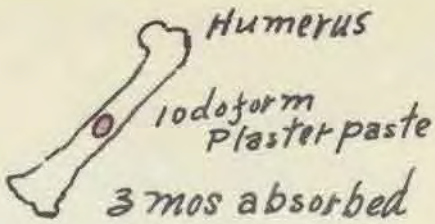
IODOFORM PLASTER:

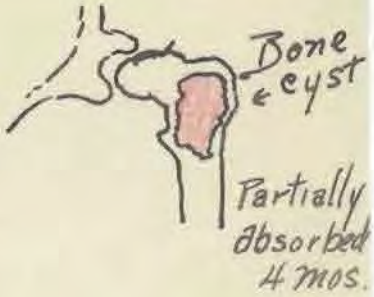
Plug[6] made of plaster with addition of a small quantity of iodoform. A number of cases successfully treated in this way were presented before the congress of Italian Orthopedic society, held in Rome October 1928. The paste molds itself exactly on the cavity walls and the heat it develops while solidifying increases its antiseptic power. Soft tissues are carefully sutured above in two or more layers.

Examples of use-radiograms:

Next page.







BALSAM OF PERU:

That certain tunnels and cavities near points[84] some form of plugging may be indicated. Landerer[115] has recently called attention to the value of Balsam of Peru in the treatment of tubercular abscesses. He maintains that this drug acts beneficially by stimulating the tissues to renewed activity.

PARENCHYMATOUS INJECTIONS:

I have recently made a number of such injections into the neck of the femur in cases of coxitis with osseous foci, and with results that encourage me to continue this method of treatment. A 10% emulsion of iodoform or Balsam of Peru should be employed for this purpose. This treatment will undoubtedly prove of great benefit. The packing of such cavities[104], with iodoformized, decalcified bonechips is an important element in the prevention of a local recurrence and general infection.

FOREIGN MATERIALS IN BONE REPAIR
BY
Foster Matchett.

VON MOSETIG MOORHOF IODOFORM PASTE.

The material which is used for the plugging[91] (Iodoform), consists of a mixture of 60 parts of the finest pulverized iodoform, and 4o parts each of spermaceti and oil of sesame, a wompound which at ordinary room temperature forms a stiff yellow mass. At 50°C (112°F) the substance becomes fluid, and on allowing it to stand and cool the oily constituents separate above while the heavier iodoform sinks to the bottom.

Professor Moorhof began his studies and researches on b one cavities about 1900. He first used an iodoform paste of the consistency of putty, but soon, the conclusion was reached that to achieve success, a hermetically sealed and perfectly filled cavity was essential. This could only be obtained by pouring in a fluid substance which would solidy in situ. It is a 'sine qua non'[91] that the cavity should be dry. The walls of the cavity to be plugged should contain no diseased tissue, and should be perfectly aseptic. The plugging material which is poured in, sets in situ, in a few minutes. The superficial soft parts can be united then, after a previous complete arrest of all bleeding by ligation. No special drainage is required, if the cavity is well plugged and well filled. There can be, obviously no blood nor discharge. "-------drainage[91] a narrow strip of silk folded fourwise may be inserted between the lips of the wound.

It may be either pressed up and expelled by the new connective tissue formation, which brings about the final obliteration of the cavity as the latter grows into the mass. Or it may be consumed if no channel of escape exists owing to a primary healing of the intervening soft parts. Hence it follows that the absorption of the filling substance by the granulations naturally takes place extremely slowly and constitutes the reason why there is danger of intoxication. The large cavity or its enormous extent, is therefore no contraindication to plugging or filling.

Iodoform bone plugging[91] thus protects the granulations from septic disintegration, which must necessarily occur with the persistence of the cavity, and be maintained as the suppuration. The "locum tenens" preserves the the entire granulation; nothing, therefore is lost and organic restoration is accomplished more speedily and complete. Defects in the bone disappear, and the normal shape and size of the bone are restored in a given time. The length of the time required for the complete reorganization of a bony defect is variable and depends upon the walls, thickness and the cubical extent of the cavities.

For example, no trace of the plugging material which was used to fill a necrosed cavity in a tibia, approximately the size of a hen's egg, was discernible in a skiagram after the lapse of one year. The patient was discharged, fit for work six weeks after the operation, with a completely healed wound

in the soft parts. Ill effects of the operation such as intolerance of the plugging, and a subsequent necessity for its removal, Professor Moorhof has never witnessed, and his experience extends over some 220 cases.

During the first day or two after the operation an increased frequency of pulse and a slight rise of temperature are sometimes observed, which as a rule completely subsides on the third day.

At the commencement of his studies Professor Moorhof[90-91] employed iodoform plugging solely for the plugging of cavities in bones. Subsequently, however, he extended its application, also, to cavities, the walls of which were not exclusively constituted of bony substance, but were bounded after the removal of smaller bones, partly by soft parts and partly by bone, cartilage, etc., for example, the cavity resulting from the extirpation of the calcaneus, after resection of the wrist, and invariably with the same gratifying result.

If one stops to consider that the iodoform bone plugging is only enlisted to serve as a temporary stop-gap, and solely for the obliteration of the dead space, then the justification for the procedure will be appreciated and understood. The indication for the use of plugging therefore, are of tolerably wide lattitude, and their number is by no means exhausted.

It is only the chronic cases[91] of circumscribed osteomyelitis which are adapted for plugging, as for example, the strictly limited osteomyelitic granuloma, which in certain cases gives rise to an encapsulated abscess in the bone. Another chronic

condition where plugging is indicated is when a cavity is formed as the result of acute necrosis. The everted bulky skin, muscle-periosteal flap is sutured in its original position again, and it heals readily by primary intention. Before suturing the flap in position all existing sinus tracts are thoroughly curetted and then left to serve for drainage.

Operations recommended areas follows:

1-Wrist joint

2-Elbow joint

3-Shoulder joint

4-Ankle joint

5-Knee joint

6-Hip joint

7-The face

8-The mediastinum.

The following cases were treated by Von Moorhof:

79 cases of osteomyelitis,

108 cases of tuberculosis with fistula,

2 special orthopedic cases,

2 fillings of antra of Highmore, and

4 dental cysts.

This presents a total of some two-hundred-five cases. And Moorhof states in his conclusion that in no single instance has he to report a failure. From this appendix[90] one case has been selected which has immediate reference to the illustrative reproductions of skiagrams.

FOREIGN MATERIALS IN BONE REPAIR

by

Foster Matchett.

Treatment of Osteomyelitis;

(Dr. Moorhof[90]---translated from German) Kicked in head

Case I: Child, 8 yrs. Easter 1899. Consequent swelling of left lower jaw breaking through with projection of bone pieces.

Present status; November 4, 1899 left lower leg shows livid area on skin with fistula communicating with medulla of bone.

Diagnosis; Osteomyelitis of Mandible (traumatic).

Operation; Opening of a cavity size of hazel nut, and cavity was filled with granulation and a tooth imbedded.

Treatment; plugging.

November 14, 1899; healing by primary intention; Dressed; operated again; operated first Nov.8, 1899 and completely healed Nov. 18, 1899.

Case VI-[91] Patient was a stonemason aged 28 years. In July 1902 he had an abscess on the lower part of the right leg which was incised. At the end of October a fistula formed with copious secretion. When see Nov.22, a sinus was present leading down to raw bone. A diagnosis of osteomyelitis tibiae was made. On Dec. 5 operation was performed, with subsequent plugging with iodoform paste. The cavity in

the tibia was the size of a hen's egg. On December 14, the dressings were changed. The wound healed by first intention. The patient was discharged March 11, 1903.

Case II-Tuberculous Processes.[90] Forty-two year old conductor, after several years swelling in the region of the right breast, and for six months a steady increase of the tumour. Present status; June 27, 1903. An apple sized tumor in the pectoralis media extending to the nipple, right next to the sternum. Diagnosis; Granuloma of sternum. Operation; Extirpation of the soft part of the granuloma with resection of the fifth rib, and part of the breast bone. Plugging the size of a 5 Kronen defect in the sternum. Loosening of the pericardium resulted. Operated July 7, completely healed July 18, 1903.

Many other case histories were translated each with a successful result. Due to lack of space only a general statement as to their entire success is made.

Of these the more widely known is the iodoform compound[93] oil of sesame, and spermaceti advocated by Moorhof. Morison

in 1906 reported a large number of cases treated by this method with uniformly good results. Such results, unfortunately, have not been obtained by others, and the method now is very seldom used.

There has recently been a revival of the search for a suitable antiseptic substance with which to fill the cavity, and some good results have been reported after the use of Beck's Bismuth Acid Vaseline Paste.

After sterility of the bone cavity[97] has been secured such substances as Moorhof's paste for implantations may be tried.

Dr. Edward H. Ochsner[100] states, "I have found this treatment of the long bones much more satisfactory than any other including the Moorhof wax plug", in referring to Unna's paint.

"Moorhof's wax (iodoform.....[82]) with correct technique achieved much success. It has recently been eclipsed by Bismuth, iodoform, paraffin, paste".

FOREIGN MATERIALS IN BONE REPAIR

by

F oster Matchett.

"B.I.P.P." 93 (Bismuth, Iodoform, Paraffin Paste) (of Rutherford Morison)

In order to prevent the suppuration which so frequently follows the introduction of foreign materials[93] into septic cavities, many varieties of antiseptic pastes, gums, and wax have been employed.

Hamilton[93] experimented with sterile sponges in the bones of animals. These sponges aided the filling of the cavities. It was later applied to septic bone cavities in man, but not very successfully.

Other surgeons have tried. They used sterile plaster, iodoform gauze, various kinds of pith cork, antiseptic cotton, gutta percha, catgut, paraffin, agar, and other organic substances with poor results. Bone dust and decalcified bone chips of Senn were tried but results were poor.

In sterile cavities[93] bone grafts would work. Moorhof had the best success of the times[91]. In 1906, the writer[93] reported a number of successful cases by this method. It is possible to close infected wounds with impunity. The largest and most obstinate can heal after treatment with B.I.P.P.. The paste is made by Hunter, as follows:

Iodoform 16oz.

Bismuth subnitrate 8 oz.

Liquid paraffin 8 fl. oz. or q.s..

The powders are mixed together in a mortar, and the liquid

paraffin incorporated. The quantities of the liquid paraffin required varies according to the bulk of the powders, the bismuth, in particular being liable to a considerable variation in bulk. A sufficient quantity should be added to make a paste. It is then advisable to rub down the paste in small quantities at a time on a slab with a spatula. This to insure freedom from grit and dry particles of powder. Dress the wound. This dressing requires no change for days or weeks if the patient is free from pain and constitutional disturbance. However, should discharge come thru, the same may be applied as a further covering. The most striking advantages[92] of this treatment have been observed in cases of compound fractures of the long bones.

FOREIGN MATERIALS IN BONE REPAIR

by

Foster Matchett.

B-BONE TRANSPLANTATION.

The indications for bone transplantations are as follows;

1-To correct the deformities resulting from defective development, such as aplasia of the bones of the extremities, of the nasal bones, and of the mandible.

2-To effect union in un-united fractures,[16,3,22,81,85, 112, 34] no matter how remote the occurrence of the fracture, no matter whether of congenital or purely traumatic origin.

3-To restore or supplant such parts of the bone as may have been dislodged or destroyed by fractures[4], as in the case of fracture through the anatomic neck of the humerus or femur[136,56,130] etc..

4-To replace bone which has been removed because of its having been the seat of non-malignant neoplasm, such as a cyst, a myeloma, or osteitis fibrose cyst..

5-To replace bone which was removed because of having been the seat of encapsulated malignant disease, such as chondrosarcoma, or fibrosarcoma.

6-To replace bone[136] which has been destroyed by an infection[64], such as osteomyelitis, tuberculosis, etc[4].

Hitzrot has said that,[48] "The most striking contraindications for operations on broken bones are: Inexperience on the part of the surgeon, unsuitable surroundings, and insufficient equipment". Caution agaisnt too enthusiastic adoption of the open method in

the treatment of fractures, as a routine means of dealing with simple fractures.

Whenever satisfactory results may be anticipated[97] by the use of ordinary surgical measures[4] bone grafting if contra-indicated. No operation is satisfactory unless it achieves such mechanical efficiency[57] that the bone is left by it as strong as it was before fracture.

The bone graft satisfys the above, giving to the bone:

1-True vital continuity.

2-Forms a mere scaffold for osteogenesis.[4,85,116]

3-Forms an aseptic slowly absorbable foreign body.

4-It forms a septic foreign body.

Rigid asepsis[97], a satisfactory technic of operation, and proper immobilization after operation are prime factors in obtaining satisfactory results.

The essentials of a satisfactory bone graft are as follows:

1-That it shall contain living osteogenetic tissue.

2-That it shall be viable in its new site.

3-That it shall be strong enough to do the work assigned to it.

The only appreciable difference between the effects produced by autogenous[104] and heterogenous or boiled bone, is that in the former the whole process is more rapid. It not only stimulates the bone with which it is contacted to increase osteogenesis[48,97]

but it proliferates bone on its own initiative. According to Henderson[136] autogenous graft is the best. Practically all failures can be traced to technical errors, such as too small a graft, infection, or inadequately fixed bone approximation of the graft to the fragments.

Heterogenous[93] boiled bone fragments are of value. Although heterogenous and boiled bone when introduced into living tissues contain no living cells, and are therefore quite devoid of osteogenetic power, they act as an irritant to the surrounding living bone of the cavity wall, stimulating it to osteogenetic activity, and keeping it in this condition for several months until the dead bone had been absorbed.

The inlay method brings into close apposition, each of the four elements or layers of the graft (periosteum, compact bone, endosteum, and marrow substance) to their corresponding element and marrow substance.[4]

in over three hundred, of three-hundred-fifty cases the graft was removed from the patient's own tibia, and in none of these cases had there been any trouble with the tibia from which bone was removed.[4]

Intramedullary beef bone pegs[22,11,143,97,132,111] are merely foreign bodies to provide fixation and are not as much in favor as formerly. Intramedullary metal pegs should not be used.

"Beef-bone screws and plates offer a convenient form of fixation for recent fractures. I use the bone screws with a great deal of satisfaction in spiral oblique fractures of the

shaft, fractures of the patella, internal malleolus, olecranon process, and in the head of the humerus. With the proper instruments the screws are easily placed and ultimately entirely absorbed. The beef-bone plate also is usually completely absorbed. The massive graft[143,24,70,112] is a large piece of bone which may be taken from the flat internal surface of the tibia and has all the layers of bone. The irregular medullary portion of the graft is removed and the pieces saved, leaving the graft flattened in the form of a bone plate. Beef-bone screws[143, 4,136] are excellent for this purpose. They are easily prepared, readily absorbed, and no time is wasted in preparation at operation. Albee and Campbell secure fixation by preparing autogenous pegs[22] at the operating table. Some recommend a bulky[116] graft especially in a field where infection may show up.[44,3,81] The rib[44] graft satisfys this. The fibula is satisfactory to use also although it is not indicated in old people[34]. Since bone grafting is contraindicated in the presence of infection[97] we usually have to wait about 6 months to graft[132]. These grafts must be held for close approximation of the osteogenetic cells. They must not move[58]. We have to provide that the periosteum[58] is in proper position with the adjoining periosteum.

Sometimes catgut[111] is used, sometimes kangaroo tendon[4] and sometimes soft iron wire[116]. The osteogenetic cells lie in the so called cambium layer[85] of the cancellous tissue[85,4].

FOREIGN MATERIALS IN BONE REPAIR

By
Foster Matchett

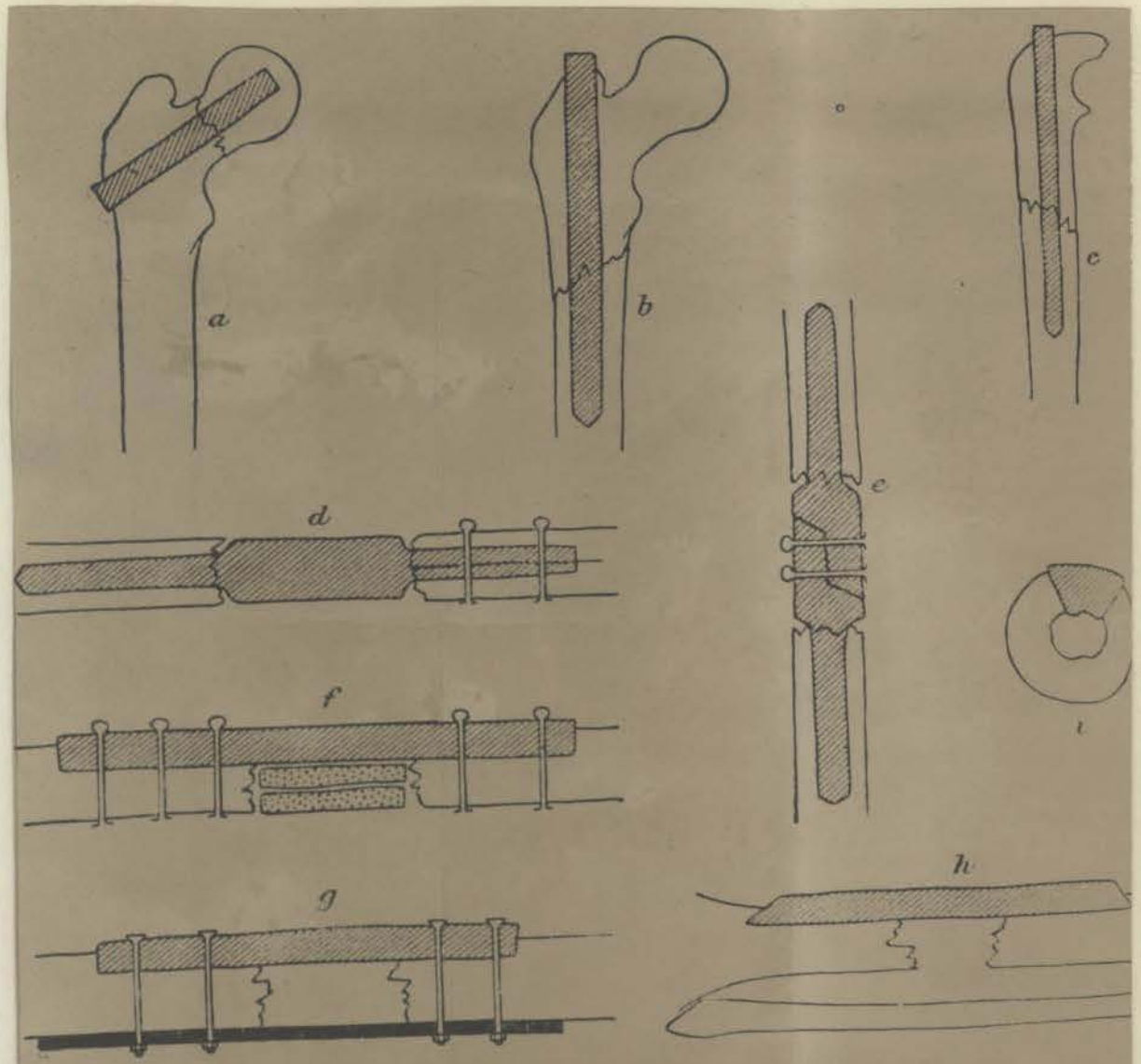


FIG. 7.

Showing methods of fixing and fitting a graft: (*a*) Graft driven into trochanter neck, and head of femur; (*b*) Graft driven into medulla of upper third of femur from trochanter; (*c*) Graft driven into medulla of proximal part of ulna from olecranon; (*d*) Graft tightly fitted into both fragments of a fracture. At one end the shaft ha been split for its reception, and then pinned together; (*e*) Graft tightly fitted in both fragments of a fracture—the graft has been cut by a fret-saw in a Z manne and pinned together afterwards; (*f*) Graft fitted as a cortical strut and fixed by pins— the fragments marked by dots have been cut from the shaft and used to fill up gap between the main ends of the bone; (*g*) Graft fitted as a cortical strut and bol to a plate on the opposite side of the bone; (*h*) Inlay graft fitted and fixed witho metallic sutures; (*i*) Section of the inlay graft, showing its wedge shape. (From th *British Journal of Surgery*.)

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

The wafer of Chatro[64] is used in some conditions. With good approximation the thickness of the callus[33] is hald to a minimun.

The Dowel pin is used in bone work especially in sacro-iliac joint conditions[71]. Sometimes pins are used to hold fragments of the patella[136] togehter.

The Inlay graft of Albee[112] is cut with a sliding two blade rotory saw[54]. The uses is often in Potts disease[136]. When bone grafts are put in place the usually die and are absorbed[116,126]. This is especially true of the Heterogenous graft[33,97]. Boiled Herterogenous grafts will not stand the strain of bone gaps[116].

Some men like to cutup the medullary substance of a deep graft and put it into the cavity to be covered[24].

In the presence of Carrel Dakin treatment osteogenesis is stimulated[28]. If the end of the heterogenous bone peg is not solid in endosteum absorption of the entire peg takes place. One thing we are sure of and that is that bone when fractured or injured follows Walffs Law.

"Changes in form and function will be followed by certain definite changes in the internal architecture and other secondary alteration of their external conformation in accordance with mathermatical laws". So no matter what type of a graft we choose or how we apply it the end result will be what nature thinks best.

FOREIGN MATERIALS IN BONE REPAIR

by

Foster Matchett.

The following report of a research problem seemed to be of particular interest to me for a possible future research problem[26].

A remarkable case[26] operated upon by Professor Delrez ——

.....in which an intact patella with the patellar ligament and part of the quadriceps tendon was removed from a man at autopsy, fixed in 80% alcohol for 3 days, and then transplanted to the knee of a man who had his patella removed in debriding a shell wound. The dead patella was not only tolerated, but normal function was restored to the knee and in the roentgenogram[26] taken 4 years later the patella appeared to be perfectly normal. After 34 days the graft cannot be distinguished microscopically from the normal living bone of the host. In cases where the graft was transplanted to an animal of the opposite sex there was no rehabilitation and the graft was absorbed. The idea of the persistence of the graft[26] and its repopulation by living cells from the host is very different from what we believe happens even in living autogenous grafts. The work is of fundamental importance and deserves repetition and confirmation.

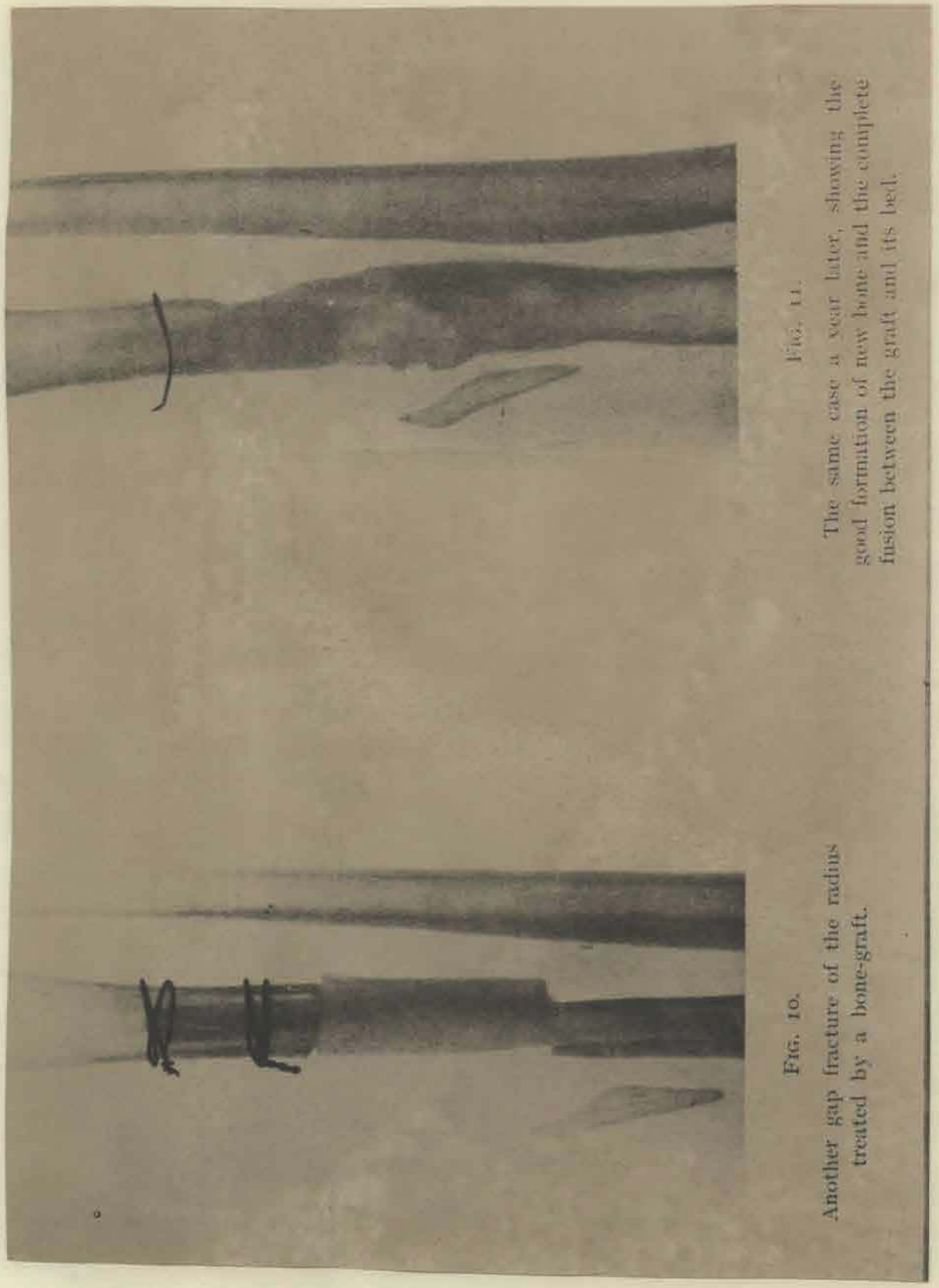


Fig. 10.

Another gap fracture of the radius treated by a bone-graft.

Fig. 11.

The same case a year later, showing the good formation of new bone and the complete fusion between the graft and its bed.

FOREIGN MATERIALS IN BONE REAPIR 51,

by

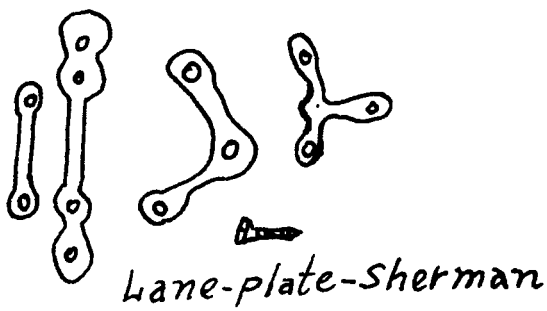
Foster Matchett.

C-METALS

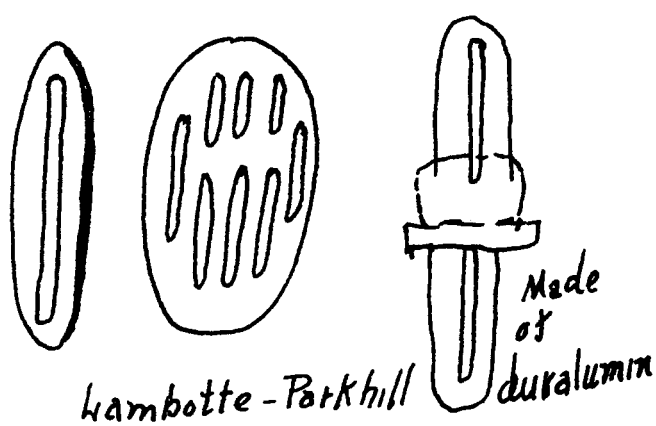
1-PLATES.

Steel plates,[9] (Lane's plates--Sherman's Vanadium--steel plates) are used to hold the bone fragments together. These plates may be long or short, having anywhere from one to four holes on either side for fastening them to the bones.

The Lambotte plate[16] is a popular one for use in fractures of the femur and humerus, because it fits well the convexity ot the bones. The material in the Lambotte[29] Parkhill plate is duralumin which has the lightness of aluminum, and the tensile strength of carbon steel.



Lane-plate-Sherman



Lambotte-Parkhill

As you know, Lane's plates technic[7] implies that nothing except steel instruments thoroughly boiled shall touch the inside of the wound. No fingers, however carefully gloved, no needle and thread which has touched the fingers, and nothing but the steel goes through the skin.

Lane's plates[99-123] offer a highly satisfactory, safe and efficient means for securing the direct fixation of bony fragments in properly selected cases. They are particularly desireable

in severly comminuted fractures, and where the introduction of other fixation materials is likely to further increase the trauma. It seems then, that the Lane plates offer a satisfactory means of fixation in selected cases.[15]

Dr. Wm. Darrach[45] said that bone transplantation was the preferable method, but in fresh fractures the field was small compared to the cases where the metals could be used, because of the larger exposure required in doing the inlay work.

Metallic fixation[64] of broken bones might hold them in a pus cavity in some instances until union took place. Metallic plates, wired,[45] stay in place. Thirty-seven of 48 metal plates were in situ more than six months. Eight plates were removed out of forty-eight inserted, and only two because of infection, should not condem the metallic plates. "We have taken out plates unnecessarily[136] finding them clean and dry and firm, although some because of suppuration. In one instance a woman returned recently, who was plated five years ago".

When a metallic[16] substance is used to retain the bony fragments, the natural question arises; How long will we be able to leave the foreign body in position? This varies to a great degree, with the kind of fracture we encounter, whether simple or compound, or whether infection has resulted from operation. In all simple fractures where it is possible to keep perfect alignment with the aid of a metal plate, it is not necessary to remove it unless irritation of the part follows.

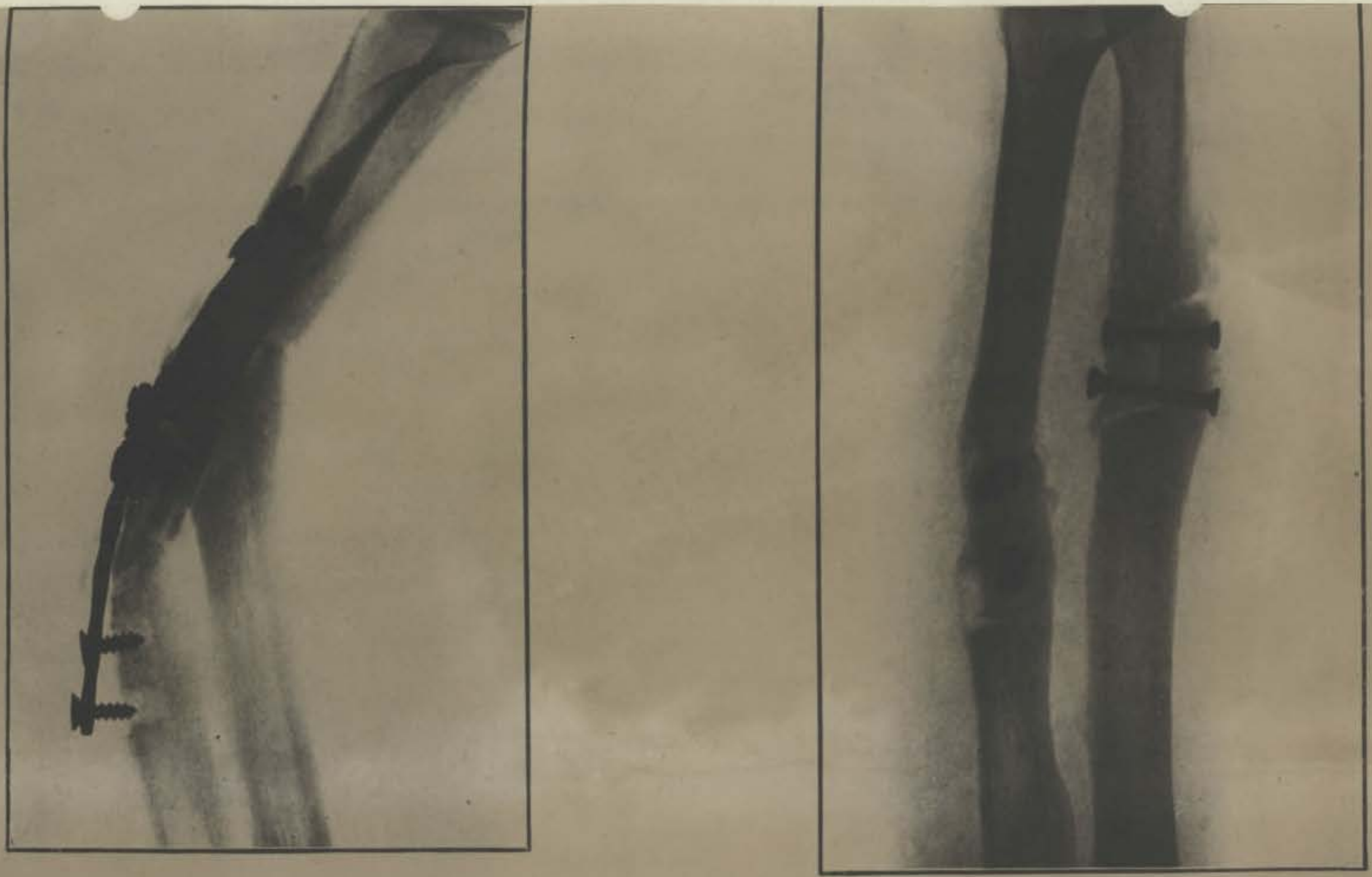


FIG. 1.

The bones of the forearm of an officer which had been well plated three months previously. The screws have become loose and there is no union. In the second figure the same bones are seen after a bolted step cut operation. Six months later he returned to active service. (From the *British Journal of Surgery*.)

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

If infection supervenes the metal substance must invariably be removed.

The fractures which most commonly require plating are those of the tibia, and femur, and less frequently the humerus[37]. Still less frequently is it required in the case of the fibula, the forearm bones, and the clavicle. The author[37] has found Lane's simple flat plate with straight parallel edges, to be the most convenient. As a rule, he uses one with four holes; in some cases a three-hole plate suffices.

At the operation of removal[37] the screw nails may be found holding as firmly as when first introduced, or they may be found loose enough to be picked out with the dissecting forceps. The difference depends on the reaction of the bone to the presence of the foreign body.

Fixation of the fracture is even more important in compound fractures than in simple. Movement means added traumatism. and subsequent infection.[132]. In the old septic fractures of the soldier's it is rare that the metallic plate can be made to stay clean and hold.[64]

Lane plates[46,107] are at times so very valuable as to be practically indispensable, but they are open to the one big objection that they are somewhat dangerous in the presence of infection. Even where short plates, with 2 or 3 holes are used, the screw wound in the bone is badly adapted to drainage if infection is present, and the plate itself, inhibits drainage.

FOREIGN MATERIALS IN BONE REPAIR

by

Foster Matchett.

Dr. Perkins believes in the removal of 90% of the materials put in. Temporary fixation of the fracture with the Lane plate is good but it should be removed in five or six weeks.[20]

Andrews followed the Lane non-touch method, but in spite of his religious care in this respect, infection resulted.[7]

Metal bone-plates and screws may be the cause of non-union[21]. Bone plates do, unquestionably cause bone atrophy.[64] This atrophy is limited to the immediate neighborhood of the plate, the rest of the bone growing well and uniting. There is no question of bones plates increasing the risk of sepsis. When applied to actively septic fractures[121] they are positively dangerous.

Dr. Z.B. Adams of Boston, says, "In regard to the metal plates[145,64] everyone was agreed that treatment by metal plates[77] was not the best way to treat delayed union[126]. Low grade osteomyelitis was even caused by the plate".

The plate of choice is that of vanadium steel as designed by Sherman[83].

The best rule for the surgeon is to regard every case as contaminated unless he is positive that such is not the case.[121]. To leave a foreign body permanently imbedded in a wound borders upon bad surgery.

The indications for the removal of foreign bodies are:[98] when they produce mechanical irritation, pressure, or when they are located within the infected field. Metallic foreign bodies

cause very little trouble in the tissues.

The bone atrophy[64] which resulted in delayed union or non-union was due more to disuse than to any other factor.

For the repair of fractures[97] an operative technic involving metallic plates (Lane), wires, screws, etc., has had a large sphere of usefulness in the treatment of recent fractures, but has often failed when applied to old lesions. At best, the introduction of any non-absorbable foreign material is far from ideal.

"Frund[47] believes that he has traced the cause of septic suppuration around metal objects, implanted in the body in bone operations, to the Galvanic current arising between the two metals, of which most such objects, (nickel-plated, or gilded) are composed. Such a current is possible if there is a defect in the metal coating, through which the lymph can pass. The metal salts formed are the immediate cause of the aseptic suppuration. He has had much less trouble since he has used only such nails as he had carefully examined for such defects in the nickel coating, and he has no cases of suppuration around nails since he has used nails of rustless steel, that is, composed of a single metal."

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

2. BANDS.

"The band of Parham-Martin, made of annealed steal, is passed around the fracture, the tongue end being passed thru a slot at the other end of the band, the band tightened and clamped about the fracture by a special instrument, and the surplus metal cut away. It is occasionally used for splinting oblique fractures".[9]

The advantages which have come in the use of the broad metal band to the author[45], are as follows:

(1) The simplicity, ease, and rapidity of application.

(2) The slight amount of traumatism to bone and soft tissues.

(3) The band seldom has to be removed.

(4) It can be applied to any type of fracture, the Collins band being substituted for the Parham-Martin band in cases of transverse fractures.

(5) It does not prevent the formation of good firm bony union.

(6) It can be used in fractures complicated by infection or syphilis.

(7) It can be used in patients of any age.

(8) It will give such firm fixation of the fragments that extension is not necessary, and motion in the joints can be begun at an early date.

(9) The firm fixation makes it almost "fool proof" so that the after treatment and care is not so tedious.

The objections which have been presented are that the bands act as any foreign material, leading to delayed union, and thus have to be removed, and also that an excessive callus frequently occurs. "In my cases there has not been any cases of delayed union, and the band was used successfully in one case of delayed union of twenty-eight week's duration. In only two cases has the band been removed, one complicated by syphilis, and one by infection. It was also, only in the syphilitic case that an excessive callus was noted".[95]

Case 1--E.B. Compound comminuted fracture of clavicle. Injured August 1923, in automobile accident. Operation 42 hours after accident. Parham-Martin Band. Mild infection on third day after operation. In this case the interesting feature was the reduction of the fracture. The patient was brought to the edge of the table, and the arm on the injured side allowed to hand down. The fragments of bone fell into normal anatomical position and the band easily tightened.[95].

Case 12--S.E. Fracture of the tibia, comminuted. Operation Jan. 1923. Parham-Martin band. Two days after accident, of stepping off curb causing fracture. No infection. Back to work seven weeks later. Wassermann ⊕ plus. Excessive callus.[95]

Case 13--F.B. Fracture of the tibia, compound, comminuted. Patient fell out of a cherry tree July, 1923. Operation at once. Debridgement. Parham-Martin band. Wound closed without drains. No infection. Patient returned to work at end of the eighth week. Good motion in ankle. Wassermann 4 plus.[95]

Case 11--J.C. Fracture of the tibia, comminuted. Operation July 1923. Parham-Martin band. No infection. Good functional result. Patient September 14, 1923, using a cane.[95]

I felt that the above cases would give some idea of the use of the Parham-Martin bands, and bands in general.

Kidner[64] believes bones, screws, and pegs act as irritants. He feels that metal bands have the same inherent weakness.

Osgood recommends the use of the Parham band in oblique fractures.[88]

Lewin[77] says, in presenting a case, "Reluctantly, therefore two Lane plates were applied and held in place by two Parham-Martin bands. Screws could not be used. A spica case was then applied". And later in the summary he writes, "The writer begs indulgence for the use of 'hardware' in the operation of this case. He believes the end justifies the means--viz--the perfect consolidation of a pathologic fracture in a bone having Paget's disease".

FOREIGN MATERIALS IN BONE REPAIR.
by
Foster Matchett.

Temporary fixation of a fracture with the Parham band is very satisfactory. It is removed in five or six weeks just to play safe.

Never bury any foreign substance at the primary dressing of compound fractures, because they never heal while a foreign body is present.[20]

Referring to a failure, yet paying tribute, Dr. Andrews says, "This illustrates the imperfect success attending the use of the Parham-Martin band--the most perfect of the metal appliances".[7]

Dr. Ensminger of Inadianapolis, says,[95] "As for infection, I am of the opinion that that comes from faulty technique, or from some other cause, and not from the band itself."

Dr. H.R. Allen (Indianapolis):[95] "Some years ago an Indianapolis physician took his wife to Johns Hopkins for examination. An x-ray of her hip showed a metallic band surrounding the cylindrical part of the shaft of the femur, but she did not know how it got there. Finally her mother explained that it was a gold band put on by my father almost fifty years ago, when this woman was a little girl".

Undoubtedly if a band is properly placed, and the proper material used, it has its place.

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

3-WIRE.

Dr. Weiss says,[150] "Sometimes wire extension is resorted to and surgical reposition is also occasionally employed"

Dr. Graves said in his article,[142] "There 10 infections in the 80 compound fractures. Three were slight, not requiring removal of the stitches. Three infections occurred in wounds in which foreign bodies were introduced; two in which the bones were wired with silver wire, and the other in a wound in which a Lane's plate was used."

Dr. E. Denlgre Martin, of New Orleans says,[107] "The best wire to use is what is known as annealed iron wire or bronze aluminum wire." He sometimes uses plates, wires, and sometimes a band.

Dr. Herman Gessner[107] of New Orleans tries to reduce and not use metals, or else, use a heavy silver wire.

Silver wire, although the best agent we possessed for many years for fixing fragments and maintaining approximation, yielded its place to kangaroo tendon, which has stood the test of time. Dr. John B. Murphy has introduced phosphor-bronze wire for this purpose.

Wire is used[96]: to hold small bone fragments together, and to hold bone transplants in place. It is used in comminuted fractures and in fractures of the lower jaw. In oblique fractures of the clavicle, and in fractures of the patella. We do not advocate it in long bones, as in shaft of humerus, femur, tibia, or both bones of the forearm. In these we are advocators

of the use of the Lane Plate, applied after Lane's no-hand contact method. We make this assertion[96] after and enormous experience in both military experience in France and in civil surgery. Silver and copper wire are placed around a bone and soldered. Better approximation and less trauma to the surrounding tissue results. It is easily removed.

In 1927 Kirschner[138] published details of his method of obtaining direct continuous skeletal traction by piano wire passed through the bones. The method was developed with the purpose of obtaining the benefits of the Steinman pins without the dangers of infection. In using Steinman's pins it was found that there were three factors responsible for infection, namely, the large diameter of the pin used, the necessity of preliminary drilling of the bone to receive the pin, and the lateral slipping of the bone along the pin after the traction had begun. It had also been demonstrated that the danger of infection was directly proportional to the area of the cross-section of the pin used, and it was to reduce this hazard to a minimum that Kirschner suggested the use of the piano wire 1.5 mm. in diameter. To eliminate the dangers in preliminary drilling of the bones, Kirschner prefected a device for drilling the sharpened wire itself through the skin, soft tissues, and bones. This procedure lessens the trauma, abolishes the necessity of skin incisions and preliminary drilling of the bones, and insures such an accurate fit

between wire and bone that lateral slipping cannot occur, ...After the wire has been introduced its ends are clamped to a 'U' shaped steel bow or 'Stirrup' and the wire is put under tension by a special screw mechanism. The limb is carefully prepared as for bone operation.[138] A local or general anaesthetic may be used. Spinal anaesthesia is very useful in fractures of the leg bones, or thigh bones. In fractures of the leg bones, the wire is passed transversely through the calcaneus, or through the tibia and fibula just above the malleoli. The correct insertion of the wire is greatly facilitated by the use of the Schoemaker director. "The various forms of extension tongs[137] have been very efficacious and their use has not deserved the unfavorable criticism it has provoked."

"The small steel wire drill with suitable spreader to hold wire and prevent bending offers advantages over other methods of skeletal traction."

Burkle says,[23] "The method of wire extension which was introduced by Klapp has displaced the traction clamp more and more since it was simplified by Kirschner. When properly adjusted the traction on the bone gives excellent results."

Klapp[67] says, "Direct traction exerted on the bone was at first carried out by means of a peg or nail and in the course of the last few years, wire has been used for this purpose. The objection to this method of treatment is the experimental

demonstration that the wire, similar to the nail, may wonder somewhat from its original place and thereby lead to infection".

Koch[69] concludes from his experimental research that Klapps wire methods represent progress in the extension treatment of fractures. The small diameter of the wire tends to protect against infection but the method is less adapted to spongiosa bone.

In fractures of the shafts of the forearm, the fragments often displace themselves, even in the unpadded plaster of Paris casing, or in continuous extension. Boehler[136] therefore passes, after reduction of fractures of the forearm shafts, especially is associated with a marked displacement, a rustproof wire through both bones above the peripheral radio-ulnar joint, and another through the upper end of the ulna, after which an unpadded plaster dressing is applied, casing in the extremity from the proximal phalanges of the fingers to the upper third of the upper arm. When the plaster is hard, the protruding ends of the wires are fixed by screws, and these are plastered in by several turns of plaster, to prevent their rotating in the bone. In this manner, the fragments are immobilized with regard to each other and with regard to the plaster casing, and no secondary displacement is possible.

Kurlander calls[70] attention to a new addition to the surgeons' armamentorium--namely rustless steel wire, the use of which so far as he has been able to ascertain is original

with him, in America at least.

Steel and silver wire breaks at the knot, and in most instances wire has been inserted with much difficulty. Kangaroo tendon is notorious for breaking at the knot. The rustless steel wire is quite flexible and the ends may be knotted with a reasonable degree of twisting force without breaking. The heaviest size that writer has used is 0.03 inch in diameter for heavy work. It has a very strong breaking point (100 lbs.). A wire of this particular size[70], and hardness is of use in the internal fixation of long spiral fractures of the femur and tibia, and also to secure fixation in arthrodesis of the knee, in lieu of metal plates, screw, etc.. The finest type, 0.013 inch in diameter has a breaking point of 22 lbs.

After healing of the wound the wire sutures are removed in the usual manner, as this wire is thin and soft and may be easily cut with a pair of scissors. It has many advantages over the use of metal plates, screws, etc.. It may even be left in if necessary without serious consequences, usually.

"Wiring is open to the same objections that metal plates are", says Kidner[64]. It causes atrophy by pressure, inhibits bone growth and is prone to infection.

The most conspicuous feature[59] is that the use of foreign material such as steel plates, wires,nails, screws, and bands, has been practically abandoned.

Probably some of the value of wiring[7] bones or plating bones comes from excitation of the drill holes.

Properly placed wire sutures[57] or bolts seldom give any trouble, and if rarely they have to be removed. It is the loosely placed wire, or the screw whose functional grip soon loosens which have brought metallic fixation materials into disrepute.

In simple drainage[31] we find, likewise, the same causes of failure, with the additional one of introduction of plates and wire.

The small bones of the ankle and wrist demand special study. These cases require little more than retention in some form of wire, and nature will give the desired results, says Foster.[45] In case of non-union[14] the fragments must be sutured with silver wire or very strong catgut.

The trochanter is displaced downwards upon the shaft and attached to its denuded cortex by pegging or wire.[129]

The same procedure was followed as in the first operation, except that the patella was drilled and two pieces of silver wire[66] used for fixation through the drill holes. A new osteoperiosteal graft was placed in contact with the cut surface of the patella and a third piece of silver wire run through the patellar tendon, and the insertion of the quadriceps tendon reinforcing the fixation.

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

4-PINS

STEINMANN'S PIN:

"Steinmann's method of skeletal traction[138] by rigid metal pins was a great advance in the treatment of fractures. Unfortunately, infection followed so often that this method found few supporters." The use of metal tongs was a further advance on the Steinmann pin, but it also had its disadvantages and was applicable only in the treatment of fractures of the bones of the leg and thigh.

"Fractures of the femur[133] are reduced by skeletal traction obtained by driving a Steinmann pin through the upper end of the tibia, just below the insertion of the patellar tendon. The traction on the lower fragment[41] should be direct[17] bone traction[138] and this is accomplished by the Steinmann nail driven through the lower end of the femur one-half inch above adductor tubercle a Ransohoff or Syms tongs may be substituted for the nail.

The nail extension[11] is especially useful in these fractures as a substitute for the plaster of Paris bandage which is of disadvantage in functional respects, since extension with adhesive tape does not enter into consideration here on account of the short surface which presents itself. In isolated cases, the nail extension was also welcome because a plaster of Paris extension would have been impossible on account of existing crural ulcer.

(1) Site of pin: At calcaneus[30]. (Illustration 11). Point of insertion on outer side, at the connecting line, between external malleolus and point of heel, at a distance of 2 fingers' breadth from the malleolus. This site for the pin is selected by Baumberger for all fractures of the bones of the leg.

Formerly the nail extension was also carried out at the lower end of the tibia. (Introduction from the inside, 2 fingers' breadth above the ankle, so that the point of the nail perforaces the skin in front of the fibula). Within recent times, the author selected the calcaneus as a site for the nail in more than 30 cases. A "cutting through" of the calcaneus as was observed by Anschutz and Heinemann was never observed by the author, although in several cases weights up to 10 kg were attached.

Injuries to nerves and vessels are also more easily avoided at the calcaneus than at the lower end of the tibia. No such injuries ever occurred in the many cases of nail extension in which the calcaneus was selected as the site for the introduction of the pin.

No 11

Abb. 11.

The most serious objection[49] to this apparatus is that the pin is introduced into traumatized tissue, and might lead to infection, but thus far the writer has had no trouble of this nature, although the apparatus has been applied on the day following the fracture.

NAILS, STEEL PINS, ETC..

Steel is the best material for nails and should be preferred to ivory, not only because steel nails can be rendered sterile by boiling but because they can be extracted much more easily.[14] Some fractures must be pinned.[45] The need for a small but easily applied pin[124] for the retention of obstinate displaced fragments in small bone injuries, have been found to be very satisfactorily met by the use of the small phonograph needle. "By placing the needle in a good holder[124] and pushing it, not driving it, through the bone". This method assures the pin of a firm seating or transfixation, and it is seldom necessary to remove it although placed in the presence of infected tissue as in open fractures. The needles are applicable in oblique fractures about the hands, feet, patella, and clavicle, and other small bones, and in many instances they may be pushed thru the skin, making no more than a needle pucture wound.

by

Foster Matchett.

Dr. J. Stanley Welch[127] uses a strong steel probe, acting between the displaced fragment ends to reduce the fracture. Then this probe is retained in situ in the plaster cast. It is removed later.

Fixation by steel nails proved unsatisfactory. Smith-Peterson[136] recently devised a nail, and not round, but consisting of three sides about three millimeters wide, joined together each at an angle of 120 degrees. The hip joint is exposed, and the fragments are accurately reduced. Then the nail is inserted from the region of the trochanter through the neck of the femur and into the head of the femur, thus riveting the fragemnts with each other.

Leonard Freeman discusses the values of the external bone clamp as against the inetrnal bone plate. The ideal method[46] would consist in the use of something which, while holding the bones firmly and not irritating the tissues, would rapidly undergo absorption, thus leaving no foreign body to delay union, and later infection. The external clamp is, easily applied, does not come into contact with the line of fracture, because, as Martin says, "As a rule the presence of a plate instead of stimulating osteogenesis between the the broken bone ends, retards it", and it gives greater immobilization. It is easily removed. The disadvantages in the use of the external clamps, are: the size and weight; danger of infection; cannot be used in cases near the ends of bones. Both plates and clamps have their legitimate uses.

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

The external clamps are used in repairing femurs.[46] The clamp is used in compound fractures, where there is danger of infection. Remember that both have to come out, so be careful which you use.

FOREIGN MATERIALS IN BONE REPAIR

by

Foster Matchett.

KANGAROO TENDON.

Silver wire although the best agent we possessed for many years for fixing fragments, and maintaining approximation, yielded its place to Kangaroo Tendon[25] which has stood the test of time. If there is any doubt about the ability of your splint to retain the fragments in proper alignment full length, then some form of internal splint should be put on when feasible, and this is best accomplished by fixation with kangaroo tendon inserted through appropriate drill holes[132].

Chromic gut or kangaroo tendon are frequently chosen as preferred material in holding fractures together. There are cases in which the Parham-Martin band is particularly adapted and success follows.

Dr. Kidner[64] said, "Metallic sutures in the patella pulled out". He now uses chromic catgut or kangaroo tendon, putting in double mattress sutures on each side.

A catgut[64] or other absorbable loop thrown around the ends of the bones often helps to steady the bones.

IVORY PEGS.

An ivory intramedullary peg[14] is better than nailing. The ivory pegs become so decalcified after a little while by the carbolic acid in the tissues that they become rough.

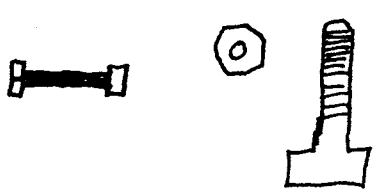
Case I--Private P. 4 mos. after pegging. An ivory peg six by $\frac{1}{2}$ inches wide was used. This peg is

still in place six months after operation. The wound healed by first intention. Note that at both ends of the peg erosion and absorbtion are taking place.

Case 2--Lieutenant T. Two weeks after the femur has been bolted by 2 3/16" bolts.

BOLTS.

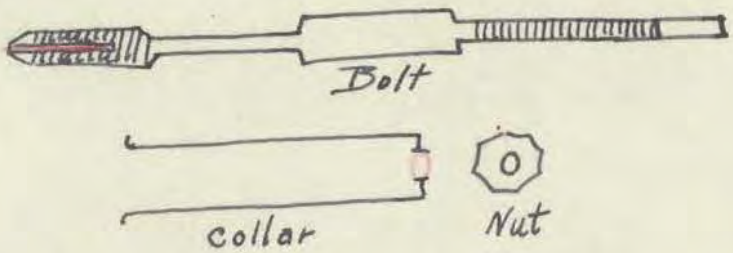
Properly placed wire sutures or bolts[57] seldom give any trouble, and only rarely do they have to be removed. Long screws[8] held in the cast may hold the ends of the bone in apposition. The screw is left in place about 14 days. At this time it is removed with ease and safety, so that the fragments will hold since consolidation has already occurred.

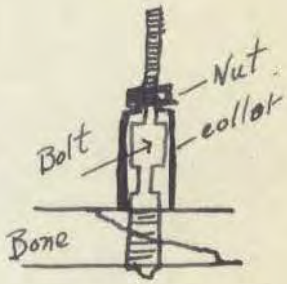


LAG BOLTS.

The objects of the method to be described here are, anatomical reposition of fragments, their maintenance in position until healing has sufficiently well advanced to assume permanency, and the removal of the internal fixation apparatus without secondary operation. It is best suited to oblique

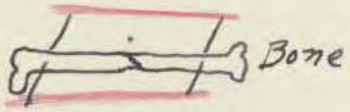
fractures of the long bones, but may be used to advantage in numerous other types.





Less callus formation[68] than by any other method has been observed, a feature which is especially desireable in fractures near joints. No cases of failure to unite have been encountered although diabetes and syphilis have been present in some cases.

THE ALLEN PIN.



Dr. H.R. Allen recommends interfixation with a new type of through and through pin. He claims he never gets infection. He says, "I am inclined to believe my good fortune in this regard has been influenced by the technique employed." He goes on to tell how he scrubs the field and prepares it in general. He says, again, "They do not compress periosteum or bridge across fractured areas." They are placed remote from the fracture unless desired to traverse it. They are not adjustable but at all times provide excellent outside control over inside conditions. "Of all safe drainage materials, nothing surpasses silver and all known methods of drainage nothing surpasses through and through. These protruding nails are secured to an outside straight edge made of low melting alloy. After union occurs, they have served their purpose, and are removed without operation.

FOREIGN MATERIALS IN BONE REPAIR

by

FOSTER MATCHETT.

VI-STATISTICS:

1-Bismuth paste results:

Sinus.	Duration	Outcome.
1 Spondylitis	2 yrs.	Closure 4 yrs.
18 " " "	16 yrs.	Died yr. after
3 Tuberculosis Knee	7 yrs.	Closure $2\frac{1}{2}$ yrs.
1 " " " os ileum	3 yrs.	Closure 3 yrs.
1 " " " ulna	$\frac{1}{2}$ yr.	" " 2 yrs.
1 " " " Metacarpals	1 yr.	" " 2 yrs.

2-Bone transplantation[54] has been performed on 413 cases in 8 years. 166 Tb. of the spine. 50% cured or arrested. 29% improved, and 21% unimproved. 9% died. 2.6 % operative mortality. In un-united fractures:

79.3% successful.

18.8% failures.

1.7 % died.

3-Plates. A questionaire[64] was sent out in the summer of 1918 to 35-40 prominent English, French, Italian, and American Surgeons and revealed that only one was still using the bone plates in freshly infected fractures.

4-Autogenous Bone Grafts. During the year 1923 there were 158 bone grafts done on 135 patients in the orthopedic section of Walter Reed Hospital[66], for non-union and loss of substance in the extremities.

Types of grafts;[66]	Successful	Unsucc.	Unknown	Total
Inlay	78	37		115
Intramedullary	17	15	1	33
Osteoperiosteal	5	2		7
Peg (not Intramedull)	2			2
Transplant.	1			1
	103	54	1	158

FOREIGN MATERIALS IN BONE REPAIR
by
Foster Matchett.

b.[66]

Bones	Number	Success	Unknown	More than 1 gr
Clavicle	1	1		
Humerus	33	18	1	4
Radius	16	11		
Ulna	10	9		2
Radius and Ulna	6	4		
Metacarpus	1	1		
Femur	6	3		
Tibia	60	50		9
Patella	2	2		1
Metatarsus	1	1		
	135	103	1	16

c.[66]

Grafts	Successful	% Succ.	Unknow.	Fail.	Pt.
Group 1--non-infected					
29	27	13%		2	28
Group 2--Chronic osteitis Healed.					
129	76	59%	1	52	107
158	103	65%	1	54	135

d.[66]

The cause of failure in fifty four cases was:

	Grp. 1	Grp.2.
Infection	0	22
Atrophy	0	15
Fracture of plates before 7th mo.	1	7
Fracture after 7th mo.	1	6
Faulty fixation of patella	0	1
Death from shock	0	1
	2	52.

5. Ununited fracture of neck of Femur--end results by Free Albee, 1909--1928.

a. Bone peg 90% the results were excellent or good.

b. Reconstruction operation 75% excellent or good.

A. By "Excellent" he means--Nearly normal mobility, normal stability, use of neither crutch nor cane, and strenuous post operative

activities, such as dancing, sailor's duties, carpenter's activities, and ability to walk several miles without pain.

B. By "Good" results he means: nearly normal mobility, normal stability, use of neither can nor crutch, a resumption of usual activities, absence of pain and fatigue.

6. Open operations.

St Luke's Hospital operated 37%[2].

7. J. Torrance Rugh, in 1928 said: "In our experiments (1928)[110] several series of tests were made with 16 metals, including platinum, copper, gold, sheet aluminum, galvanized iron, Monell metal, brass aluminum casting, (20% Zinc), bronze annealed steel, carbon steel, nickel brass wire, silver, lead and tin. The only outstanding facts observed were that annealed steel, carbon steel, aluminum casting, and lead showed the effect of oxidation at the end of 24 hours, and the steel and aluminum after 48 hours, were covered with heavy crystals from the actions of the organisms upon them or the chemical result of bacterial growth upon the media."

8. In civil life 11.85% of all fractures of bones of the shaft are open fractures and many of them best treated with skeletal traction.[137]

9. Report of the stabilizing operations on the foot. (75 questionaires).

Summary: Metal plates, wires, screws, nails, are objectionable and unreliable.

Silk ligatures--the same.

Bone grafts--the same.

10. Scudder says: "There has been a 14% increase in open reductions since 1929".[42]

By
Foster Matchett.

VII-DISCUSSION.

It is surprising to note that at the Mayo Clinic more metal is used than beef-bone pegs[143] in malunion of the femur. Dr. Henderson wishes to remember that traction may be used on a child or an adult but the same type of traction will not always work on both.[143]

Guthrie[52] believes it is better to first try to reduce all fractures then operate later. He speaks about a double prong nail (Brun's) as being very effective by driving a prong on either side of the fracture line. The Steinback silver plate is valuable as has been proved by four successful cases.

Any of the so-called refractures due to plates is mythical.

Dr. Kidner sticks to the idea that the less foreign material used the better.[64]

Dr. Young speaks of the various types of open operations and still admits that under his direction only 5% have been operated.

Some types of tissues will tolerate foreign materials fairly well--others will not.

Since pus and exudates are found around imbedded foreign materials and since experiments in which metals have been used to kill bacteria, and have proved of no value we are forced to conclude that the Galvanic theory ofsuppuration[139,110] which varies with the state of health of the individual is a very good logical explanation of the cause of the more or less spontaneous suppuration around imbedded foreign bodies.

VIII-SOME CONCLUSIONS:

Most of the conclusions that I shall draw here are my own deductions. Only these statments which have not already been conveyed to the reader will be made.

1-The climate of surgical opinion concerning the treatment of fractures and delayed union is exceedingly foggy.

2-The Obee operation if of value for fractures of the hip.[50]

3-The best results seem to come from the use of massive bone grafts[54].

4-Relief of pain always follows internal fixation, and deformity is kept down to a minumum. Internal fixation should always be done on compound fractures[20]. Internal fixation is absolutely indicated in many instances and will give little trouble if properly placed.

5-The plate is the material of choice[40,12,143,107] along with the circular band. Both have many uses. Both[20,97,141] should be removed in 5 or 6 weeks after union has started[20] Neither increases the infection[20]. Plating may delay union, but the end results are better[120]. The steel tin combination plate of Lane should be studied further. The plates or bands do not become covered with callus.[20]

6-If open operation[143,147,151] is indicated, do not delay[25]. In the case of compound fracture of the femur at any location, or fracture at the head of the femur, open operation is indicated.[147]

7-More stress should be laid on the value and importance of external fixation.[20]

8-Edge wedging of fractured bones is worthy of trial.

9-Non-union may be greatly influenced by a deficiency in the bone forming elements of the blood.[108]

10-Open operation and plating is justifiable in properly equiped institutions and in the hands of a very careful surgeon.[120]

11-Even the best and most careful surgeons will have cases of delayed and non-union.[120]

12-The suspension and traction treatment deserves careful trial.[139]

13-The older the patient the poorer the results expected.[143]

14-Results tend to be better from the anatomical and functional standpoint, where open reduction or open operation is followed.

15-Subperiosteal resection is condemned.

16-Pegs should be put into the head and neck of the femur early.[130,150,147]

17-Periosteum covered cortical substance is superior to spongiosa for transplant[135].

18-Open reductions are on the increase.[42]

19-Delayed and non-union are on the decrease.[42]

20-All fracture cases are emergencies.[42]

21-Non-union may be somewhat avoided by early accurate

reduction and immobilization[64].

22-Copper, brass plates, and screws irritate and produce serious pathological changes. Silver plates and iron plates are not irritating.

23-If we could all develop the same touch and dexterity[45] the same degree of muscular control, the same eye for line, and the same self-confidence, we would get the same results.

24-Bone work is delicate and the tissues develop infection very easily. It necessiatate the finest technique known in surgery. Successful technique in bone surgery is unexcelled in delicacy and precision even by the gentleness recognised as necessary in handling cerebral and abdominal tissues[147]. This conception of bone cautions us aginst the blind manipulative traumata of repeated attempts at reduction, and points to the operative treatment as the ideal in many cases of fracture.

25-The following topics appeal to my interest, and I feel would be worthy of further investigation at some future date.

a-von Mosetig Moorhof's Iodoform Paste.

b-Maggots in treatment of suppuration.

c.B.I.P.P.

d.Galvanic Theories of Tissue Suppuration.

e-Massive bone transplants taken at autopsy and immediately implanted.

26-A conscientious treatment of bone lesions, keeping always in mind the welfare of the patient with special reference to functional results is best. Put yourself in the patient's place and do what you would want done to yourself under those circumstances.

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