COMPARISON BETWEEN

CARBON, TITANIUM AND CONVENTIONAL A-O PLATES

An Essay Submitted for Partial Fulfilment For

M.S . Degree in Orthopaedics

By

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بسم الله الرحمن الرحيم

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INTRODUCTION

When we deal with plates that differ largely in bending stiffness, we must expect marked difference in bone healing.

Natural bone healing passes in two main phases; bone union and bone remodelling. Bone union starts by haematoma formation and traumatic inflammation; followed by demolition and granulation tissue formation. An initial scaffold is then built by woven bone and cartilage. This is replaced later on by lamellar bone.

Bone remodelling sets on until a bone similar to the original one is formed.

Each type of the plates we are dealing with affects both phases of bone healing in its own pattern. This will be demonstrated in the following chapters.

MECHANICAL CONSIDERATIONS

In order to understand the remodelling of a diaphyseal bone fixed by a plate, the mechanics of both the plate and the bone have been the subject of increasing scientific interest. The literature in the field is extensive and the terminology sometimes confusing and inconsistent. For this reason, certain mechanical terms used in the present study in accordance with general usage in engineering are briefly defined below. **Pelle Netz. (1979).**

Forces, are vectors, i.e., they have both magnitude and direction. Common technical terms are ; tensile forces which increase the distance between two points in a body on a line in the direction of the force, compressive forces opposite to tensile, and shearing forces which displace one layer with respect to another parallel to the plane of the layers.

Strain , is the relative displacement of one point in regard to another. Strains could be tensile, compressive or shear.

Stress, is force per unit area on an imagined surface in a body. Stresses can also be tensile, compressive or shear. It has units such as dynes/cm^2, Newtons/m^2 or pounds/$inch^2$.

Dyne : That force which if applied to 1 gram mass, gives it an acceleration of 1 cm/sec/sec

Poundal : That force which if applied to 1 pound mass, gives it an acceleration of 1 foot/sec/sec.

Newton : That force which if applied to 1 kilogram mass, gives it an acceleration of 1 meter/sec/sec.

Kilopond (Kp) : The most recent unit of force is the force required to give 1 kilogram mass an acceleration of 9.80665 meter/sec/sec or force of 9.8 Newton. This force is equivalent to the weight of 1 kgm mass under standard earth gravity, it represents the force with which this mass is attracted toward the centre of the earth, (Cochran, G., 1971).

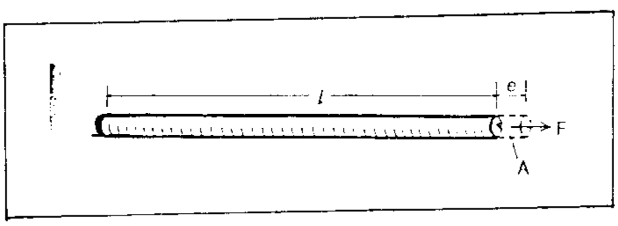


Fig. (1)

Tensile stress and strain in an elastic wire of original length, L, and area, A, shown when the wire is subjected to tensile stress, F. Mears and Rothwell (1979)

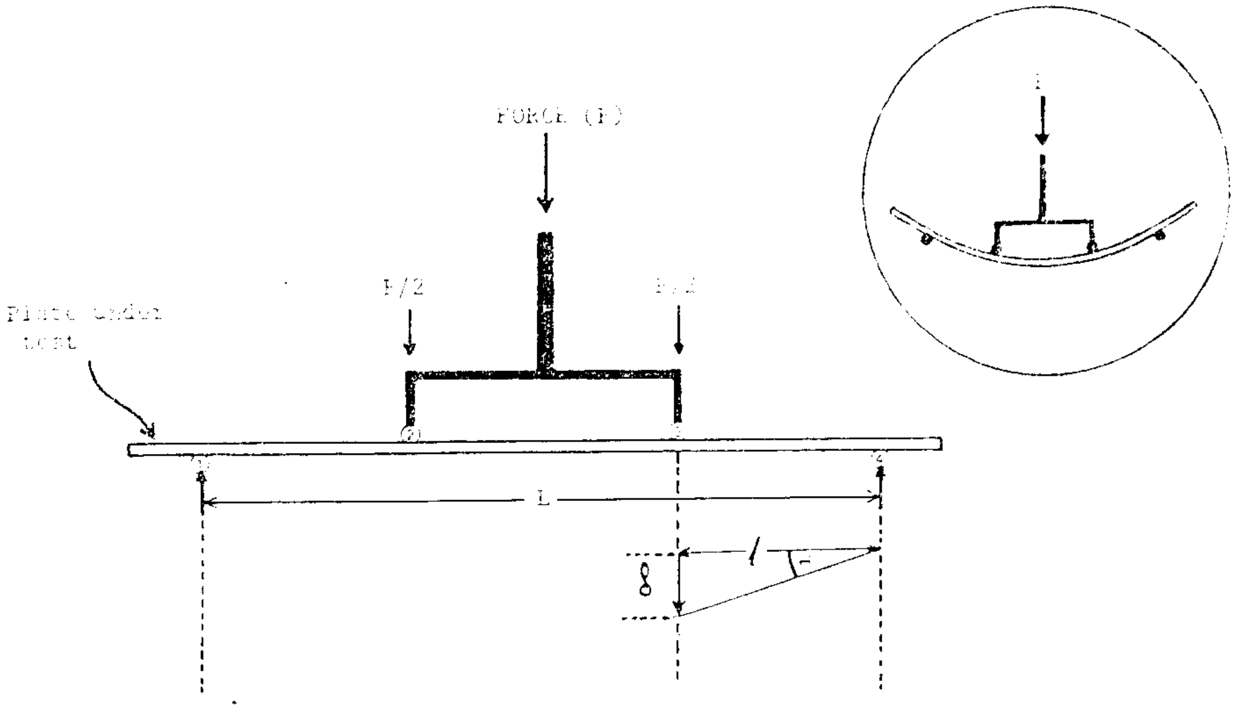


Fig. (2) : Diagram to illustrate the method of four-point bend testing based upon the proposed British Standard Specification for static mechanical testing of straight bone plates.

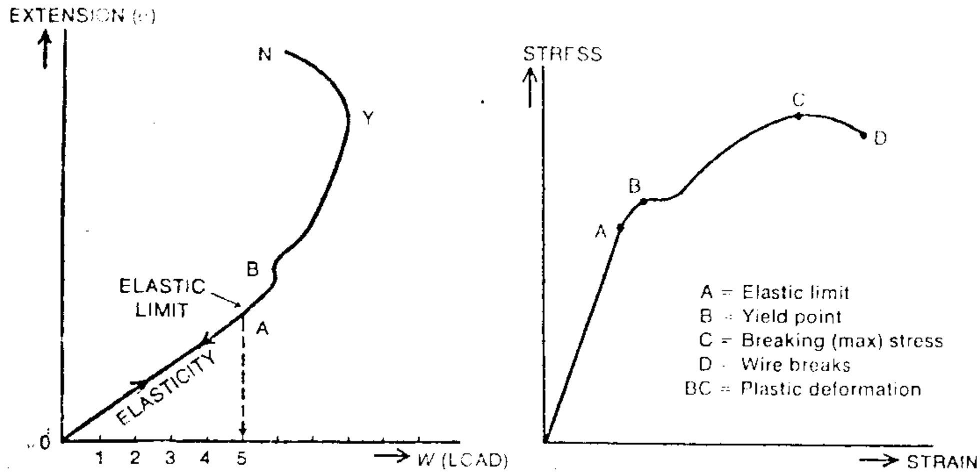
Tayton and Bradley (1983)

The force which twists a body is called torque. The load necessary to displace the load point a unit length in the direction of the load is called the stiffness of a body and is expressed in force per unit length.

Bending stiffness of a plate is calculated by means of the four point bending test by dividing bending moment over total angulation and is expressed in newton-meters per degree. **Tayton and Bradley (1983).**

Time-independent deformation which disappears upon release of load is called elastic deformation. The ratio stress per unit strain is called Young's modulus of elasticity = $\frac{F/A}{e/L}$ and is expressed in units of stress. Mears& Rothwell (1

Most materials are elastic for small loads. For materials subjected to an increasing stress, there may exist a point (before fracture) in the stress strain relationship from which, on release of stress, the strain no longer returns to its original state. The stress at which this phenomenon begins is called the elastic limit of the material. If the remaining deformation is independent on time, the material is plastic. A material which after a certain amount of elastic deformation deforms plastically is called elastic plastic. When the load exceeds the elastic limit, as indicated by the slight kink at B, the material becomes



Figure(3) Graph *A* plots extension *vs.* load; graph *B* plots stress *vs.* strain.

Mears and Rothwell (1979)

plastic and is shown by sudden increase in strain. The breaking stress (c) of the material is the force at failure per unit area.

<u>Hardness</u> ; the term hardness is used in practice to describe two mechanical properties. It is a measure of the resistance to abrasion, the ability of one material to scratch or be scratched by another. In Moh's scale of hardness, a series of standard materials is arranged in order, with talc at number 1 rising to diamond at 10. Each material will scratch any material lower in the table. Materials under test can be assigned a position in the series by similar scratch tests.

More frequently, hardness indicates resistance to indentation. In the usual form of test, a material is indented by a ball (Brinell test) or by a pyramidal diamond (Vickers test) or by a conical diamond (Rockwell test). The hardness is defined as some convenient function of the area of the indentation and the load is usually expressed in kg/mm^2. High values indicate hard materials and low values, soft materials.

Strength has been defined as the resistance of a material to an applied stress. Tensile strength alone has remarkably little significance or descriptive value, for example mild steel and cotton lie within the same range of tensile strength, but these materials are dissimilar in partically every other respect, Mears & Rothwell (1979).

Conventional A-O Plates

Principles of A-O rigid plating

Application of conventional A-O Plates

Secondary effect of rigid plating on :

- Bone mass
- Biomechanical properties of bone
- Bone graft

Conventional A-O Plate

The chief aim of the A-O method of fracture treatment is the full recovery of the injuried limb.

In every fracture, there is a combination of damage to both the soft tissues and to bone in addition to certain local circulatory disturbances, certain manifestations of local inflammation as well as pain and reflex splinting. These factors will be manifested by chronic oedema, soft tissue atrophy, osteoporosis and joint atifness. Every type of fracture treatment must, therefore, deal not only with the fracture but also with the associated local reaction.

Full, active, pain free mobilisation should be the guiding principles of fracture care. It results in rapid return to normal blood supply to both the bone and the soft tissue. It also enhances articular carilage nutrition by the synovial fluid, and when combined by partial weight bearing, it greatly decreases post traumatic osteoporosis by resorting an equilibrium between resorption and bone formation.

A satisfactory internal fixation is achieved only when external splinting is superfluous and when full active pain free mobilisation of muscles and joints is possible. This is best achieved by stable internal fixation which will last for the whole duration of the bone healing. Stability means not only lasting adaptation of the fragments but also the prevention of any microscopic movement between the bone fragments.

Over the past 20 years, inter-fragmental compression has proved itself to be the most dependable method of immobilisation. Thus, pain free convalescence, shortened hospitalisation time and shortened period of disability are advantages of the A-O method. Rapid recovery of the injuried limb is accomplished by :

1- Anatomic reduction of fracture fragments.
2- Stable internal fixation designed to fulfill the local biomechanical demands.
3- Preservation of blood supply to bone fragments and the soft tissues.
4- Early active pain free mobilisation of muscles and joints adjacent to the fractures. Muller et al. (1979).

Pattern of Bone healing :

The characteristic feature of union of bone without rigid fixation is the formation of periosteal and endosteal callus. In the fracture gap, there is initially the formation of connective tissue and cartilage which is then secondarily replaced by bone.

In 1963, Schenk and Willenegger were able to demonstrate histologically, first in dogs and subsequently in human materials that primary vascular bone union did occur in healing of fracture. The experiment of Schenk was carried out on a transverse osteotomy of a dog radius which was then rigidly immobilised with a compression plate. The human material came from fractured bones which had been immobilised by means of lag screws and neutralization plates.

Gallinaro et al., 1971 were able to demonstrate primary bone union in rabbits. Thus, those investigators demonstrated that they were dealing with a universal biological principle of bone healing which occurs in the presence of absolutely rigid fixation.

When the fracture gap is closed by rigid compression plate, periosteum forms appositional bone paralleling the the fracture (in case of contact healing, this stage is not needed). Then revascularisation of the fracture area takes place by means of cutting cones of vessels that slowly channel through the area of dead bone.