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Bending Properties of Implants, Rate of Femur Fractures and Implants Failure in Ostoesynthesis, Reported at the Komfo Anokye Teaching Hospital, Kath, Kumasi-Ghana

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ABSTRACT

This paper does a retrospective study of the reported cases of femur fractures and implants failure at the Accident and Emergency center, of the KATH, between 2009 and 2010. Also the paper does a comparative analysis on the bending properties of the implants received at the orthopaedic department of the accident and emergency center of the KATH. The study reveals that, the highest case of reported fractures and failure of implants is on the femur. Also most failures occurred due to early weight bearing. To ascertain the causes of failure, due to bending, the four-point bent test was done on the samples. Three out of the twenty five stainless steel plate implants, used for fixation of a femoral fracture, failed due to bending at the hospital. One out of the three different sources, where the hospital receives its implants, had the bending properties of its implants, below the others. Typically, it recorded lower modulus of elasticity and proof load.

Keywords: *Plate implant, corrosion failure, fatigue, stainless steel, femur shaft.*

1. INTRODUCTION

The femur shaft fracture injuries are often one of the several major injuries experienced by patients [1]. At the Komfo Anokye Teaching Hospital Kumasi, Ghana, KATH, this type of injury is normally treated operatively using plate and screws. The stainless steel plates act as bridge across the fracture gap, and shield the fracture site against stress as the bone heals. Exposure by these plate implants to the biomechanical and biochemical forces, and interactions b/n the implants and the biological environment, may lead to failure due to mechanical or biomechanical reasons. Fatigue damage is one of the major reasons for failure of austenitic stainless steel screws and plates. Local loading conditions produce the bending stresses.

Dynamic loading in the presence of body liquid can also cause surface attack by fretting, which leads to fretting corrosion and wear at implant junctions, such as screw heads and plate holes. These types of attack can be relatively mild and often occur only on the microscopic level. However, the wears do not interfere with the function of the implant or the healing of the bone. A combined attack of bending with stress corrosion can also cause implant breakdown.

Various types of forces act on the implant and the bone. In the intact musculoskeletal system, the acting forces are balanced. When a bone is fractured, the balance of forces is destroyed, and the muscle forces pull the bone fragments in different directions. During operative reconstruction of a fractured bone, attaching the fragments to orthopaedic implant stabilizes the fracture. If the bone is perfectly reduced, the entire implant is supported by bone, the acting forces are again in equilibrium, and only relatively small and uncritical loads are exerted on the implant. However, if the bone is not perfectly reconstructed, and if fracture gaps are present, or fragments of bones are missing, the weight-bearing forces are not completely balanced, and the loads may be unevenly distributed. As a result, bending and torsional stresses can concentrate in areas of implant where bone support is missing.

The objective of this work is to report the rate of femur fractures and failure of the plate implants used to fix these fractures. In addition, this report investigates the bending properties of the femoral shaft plate implants at the (KATH).

2. MATERIALS AND METHODS

2.1 Rate of Femur Fractures and Failure of Implants

Orthopeadic Trauma records from May 2009 to April 2010 of KATH was studied to find the rate of femur fractures as well as failure of implants at the KATH. Cases of interest included, plating, re-plating or failure of implant cases, the age limits eighteen years and above. Dynamic hip screwing (DHS) and plate removal cases and were also recorded.

2.2 Sampling of Implants

Twenty-five implants removed from 25 patients were collected over a period of four months. Out of this number three got bent and only one was completely detached due to atigue *in vivo.* Three different companies were identified, and all the failed implants were from the same company. The number of samples selected for each company was 4, yielding a total of 12 samples in the whole study.

2.3 Four-Point Bending Test

The four-point bending test, measures the bending stiffness and bending strength from a single cycle bend test on a metallic bone plate. This test is used to determine values for the mechanical response of bone plates to specific bending loads and provides some insight into the mechanical response of the subject bone plate.

In conformity with the ISO 9585 Method, the bone plate was positioned on a four-point bend fixture shown in Figure 1, installed in a Universal Testing Machine. The bend fixtures used were 12 mm for both the inner and outer cylindrical rollers respectively. The inner rollers were placed at one third points from each end of the supports as shown in Figure 1. The equivalent bending stiffness was calculated according to the following equation [21]:

$$EI = \frac{(4h^2 + 12hk + k^2)Sh}{24}$$

Where: EI is the bending stiffness or flexural rigidity (Nm^2);

h is the distance between inner and outer rollers (m)
k is the distance between inner rollers (m)
S is the slope of the load versus deflection curve (N/m)

The equivalent bending stiffness equation accounts for the holes in the plate. [21].

Bending Strength=0.5 P h

Where:

Bending Strength is in (Nm);
P is proof load (N);
h is the distance between inner and outer rollers (m).

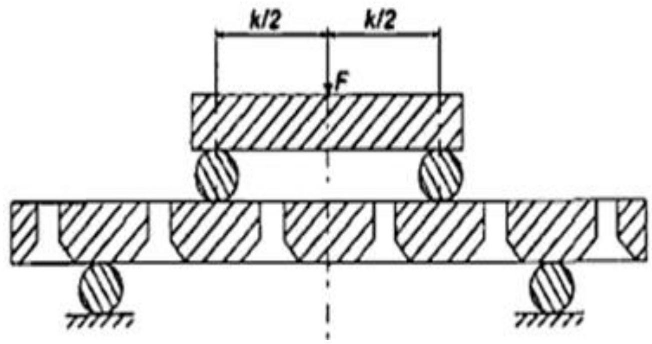

Figure 1: General arrangement of four-point bend test

3. RESULTS AND DISCUSSIONS

Cases related to plating are recorded as shown in Table 1, out of about 1000 cases received at the orthopaedic department of the KATH, open reduction and internal fixation cases recorded 351 cases with the following distribution; tibia and fibula contributed 50 plating cases, the femur contributed the highest number of cases, thus, 250 plating cases; out of which the shaft of the femur contributed to 136 cases. The radius and ulna on the other hand contributed 16 plating cases, and the humerus contributed to 17 plating cases, the number of cases for the fracture sites are shown in table 2.

Failure of implants or re- plating recorded 19 cases, 16 of which are failure of femur plates. And thirteen out of the sixteen femur plates were on the femur shaft. Tibia plate failures recorded the remaining three cases.

Table 1: Plating Cases at the KATH [Curtsey KATH]

Month	*Plating*	*Re-plating*	*Dynamic Hip Screwing*	*1) Plate Removal*
May-2009	*19*	*-*	*3*	*2) 1*
June-2009	*32*	*-*	*7*	*3) 12*
July-2009	*19*	*\2*	*6*	*4) 10*
August-2009	*40*	*3*	*7*	*5) 9*
September-2009	*27*	*1*	*3*	*6) 8*
October-2009	*30*		*9*	*7) 4*
November-2009	*30*	*4*	*7*	*8) 16*
December-2009	*40*	*1*	*6*	*9) 11*
10) January-2010	*30*	*1*	*4*	*11) 4*

February-2010	*24*	*-*	*1*	*12) 7*
March-2010	*36*	*1*	*6*	*13) 7*
April-2010	*24*	*6*	*3*	*14) 7*
Total	*351*	*19*	*62*	*15) 96*

Table 2: Fracture Sites

Bone	Plating	Failure
Tibia and Fibila	50(14.2%)	3(15.8%)
Femur *Femur shaft*	250(71.2%) *136(54.4%)*	16(84.2%) *13(81.25%)*
Radius and ulna	16(4.6%)	-
Humerus	17(4.8%)	-
Others	18(5.1%)	-
Total	351(100%)	19(100%)

3.1 Results of Four-Point Bending Tests

Load and displacement data were analyzed at specific intervals to determine the stiffness of the plate implants. The load-displacement graphs plotted for single cycle at these intervals yielded a curve as shown in Figure 2. The stiffness of the bone plate was calculated from the slope of the force displacement curve. All results of the four-point bend tests can be found in Appendix A.

The flexural rigidities, bending modulus of elasticity and bending strength of the various plate implants were calculated using the ISO 9585 test method formulae. The summary of these values are shown in Table 3. Company B, whose implant failed recorded the lowest flexural rigidities, bending modulus of elasticity and bending strength.

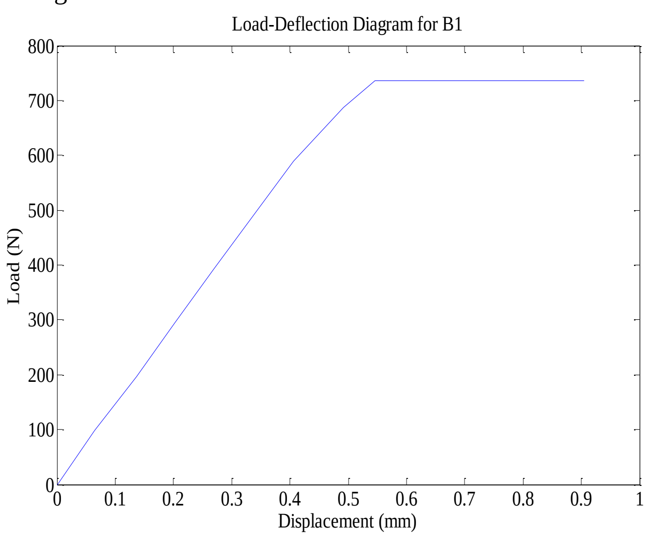

Figure 2: A typical Load- Deflection curve of a plate implant from one source

Table 3: Summary of four-point bending test results

Serial Number	Bending Modulus of Elasticity, E (GPa)	Bending Stiffness/ Flexural Rigidity, EI	Bending Strength, M (Nm)
B1	178.2	27.844	11.03625
B2	175.8	27.513	12.21345
A1	191.7	29.953	16.4808
A2	192.3	30.047	16.92225
C1	191.8	29.969	17.658
C2	190.9	29.828	17.21655

4. CONCLUSIONS AND REOMMENDATIONS

This study attempted to assess the quality of the plate implants, received from the various sources at the KATH, in the treatment of femur shaft fractures, from the mechanical engineering point by performing tests such as four point bending test, material composition and microstructure examination. Based on our finding, it was confirmed that the highest case of plating as well as failures of implants reported at the KATH, is on the femur.

Avoidance of early unprotected weight bearing in patients who are obese may help to minimize the incidence of implants failure. This is more important in plated comminuted fractures of weight bearing long bones where rigid fixation delays union and increases the probability of fatigue failure of the implant before union. In conclusion, we advocate cautious ambulation and graduated weight bearing with special consideration for the fracture configuration, the fixation method and the weight of the patient. This should lead to a low rate of implant failure which may cause the populace to embrace operative fracture treatment in a setting where patronage of traditional bonesetters is still very high.

Finally, based on the results and main findings of the study we recommend that, bending test should be done on any consignment of implants received, at any given point in time, at the hospital before usage. To avoid using low quality implants, this could cause devastating effects to patients. Also, the hospital should stop using plate implants from source H, until it is proven that their implants meets the standard requirements.

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