膝關節面間生醫替代材料之應力分析（I）

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一、中文摘要：

膝關節面植間入 Polyetherene Orthoplastic 替代品，因受力造成磨耗面產生碎粒雜質而被骨髓吸收，則衍生出常久性問題，如關節面鬆脫及感染等問題。本計劃乃針對上述"膝關節面植間入 Polyetherene Orthoplastic 替代品"作應力分析。試圖探討此生醫替代材料作為臀、膝替代品時之間密合性及其應力關係。

英文摘要

Debris resulting from damage to the surface of polyethylene components of total joint replacements has previously been shown to contribute to long-term problem such as loosening and infection. Surface damage has been associated with fatigue processes due to stresses arising from contact between the metal and polyethylene components in this.

In this study we will use the PE components of total joint replacements. and we try to use elasticity and finite-element solutions to find out these stresses under in vivo loading and check the stress concentration of the contact area .

二、計劃緣由與目的：

膝關節面植間入 Polyetherene Orthoplastic 替代品，因受力造成磨耗面產生碎粒雜質而被骨髓吸收，則衍生出常久性問題，如關節面鬆脫及感染等問題。本計劃乃針對上述"膝關節面植間入 Polyetherene Orthoplastic 替代品"作應力分析。試圖探討此生醫替代材料作為臀、膝替代品時之間密合性及其應力關係。在過去的文獻中，很少有「關節接合面曲率」方面的研究，歸究其原因，大都是受限於逆向工程的發展，即曲面掃瞄及曲面重建技術之不夠成熟所致。在關節面間最常看到的就是關節矢狀面、冠狀面及水平面上的曲率變化分析。本研究中，我們希望藉由關節接合面上的主曲率分佈情形，來探討其關節運動姿態及接觸點處密合的關係。另一方面從力學觀點探討可知，最大曲率處往往亦是應力集中的區域，因此相較於其他曲率的分析，主曲率之研究較具有客觀性及物理上的意義。

三、研究方法及進行步驟：

1. 掃瞄實驗系統的設置：

我們利用三次元掃瞄量測系統精確取得膝關節接合面的表面點資料，以重建曲面。本實驗所使用的「光

電式三次元掃瞄儀」如圖 1 所示。本掃瞄儀的解析度介於 0.2~1.5 之間，為兼顧精度與計算效率我們採用 0.5mm 的解析度。

2. 膝關節整體元件包含：有一 convex 之金屬元件施力於一 concave，定厚度之 metal—backed of polyethylene 如圖 2 所示。
3. 分別將膝關節各部位固定於基座上，如圖 1 所示。固定骨頭試件於三軸定位掃瞄機的掃瞄平台上，
4. 由實驗的觀察及理論數值分析顯示受力造成磨耗面產生碎粒雜質，如關節面鬆脫及感染等問題。本研究乃針對上述"膝關節面間植入 Polyetherene Orthoplastic 替代品"作應力分析。試圖探討此生醫替代材料作為膝替代品時之間密合性及其應力關係。
5. 接觸應力隨施加之*外力*增加而增加。
6. 接觸應力隨表面曲率之*不密合性*增加而增加。

四、 結果與討論：

1. 關節運動姿態與接合表面主曲率線分佈
   i. 關節運動姿態量測結果與骨頭表面綴合、主曲率線計算結合在一起，我們可模擬膝關節的接合姿態，並尋求接合姿態與表面主曲率線的關係。
   ii. 大體上，由圖 3 的各個姿態下膝蓋骨與上膝蓋骨的主曲率線圖，我們發現膝關節的動作的路徑隨下膝蓋骨與上膝蓋骨的中央表面之最小曲率線走勢近似。
2. 關節的密合性
   所謂關節的密合性係指兩關節面間曲率的相似程度。它與接觸位置節面間的主曲率。
3. 接合面的主曲率佈直接提供了接合面應力集中分析上的重要資訊。
4. 本研究提供了如何選擇膝關節面間的生醫替代材料之重要資訊。

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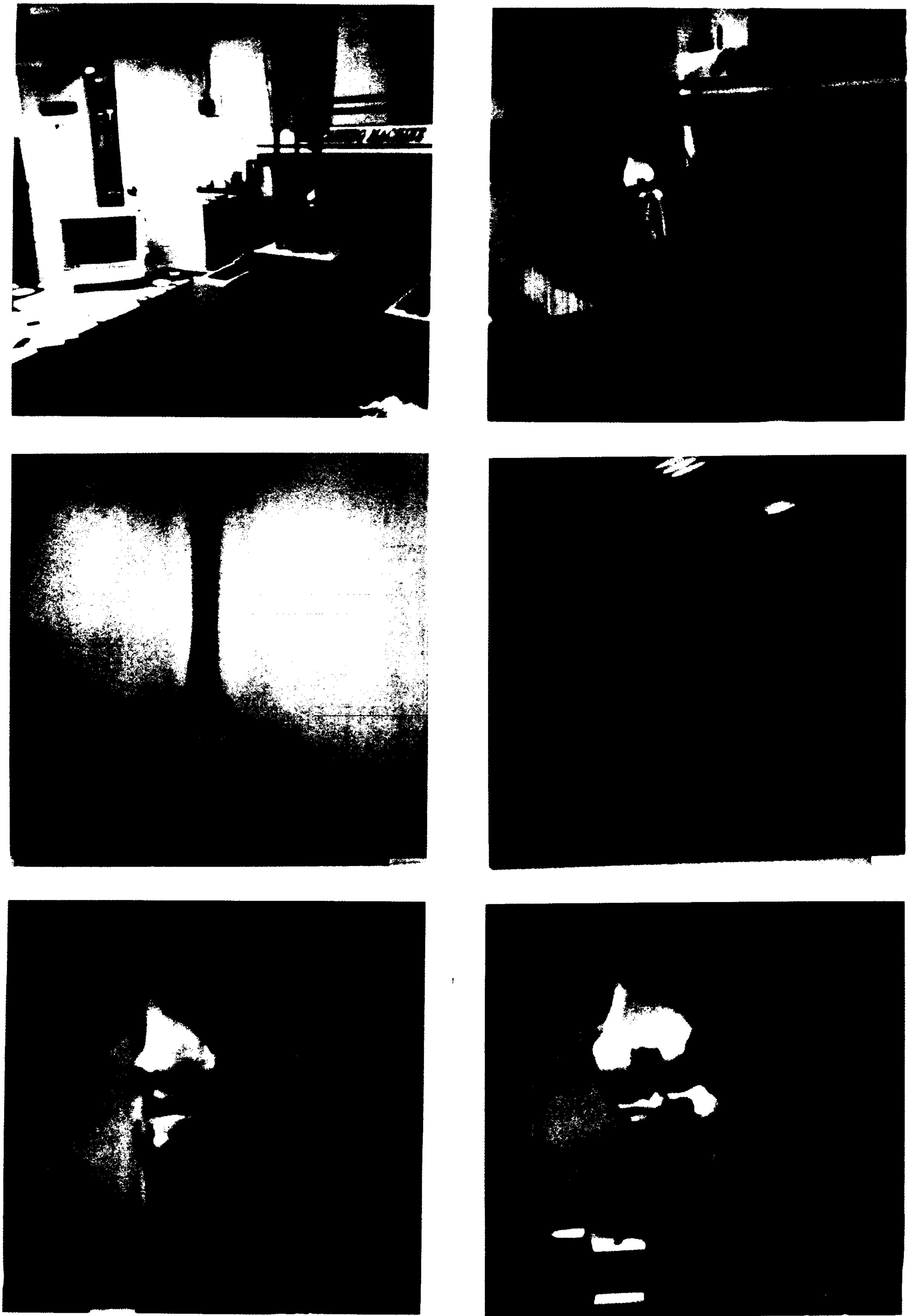
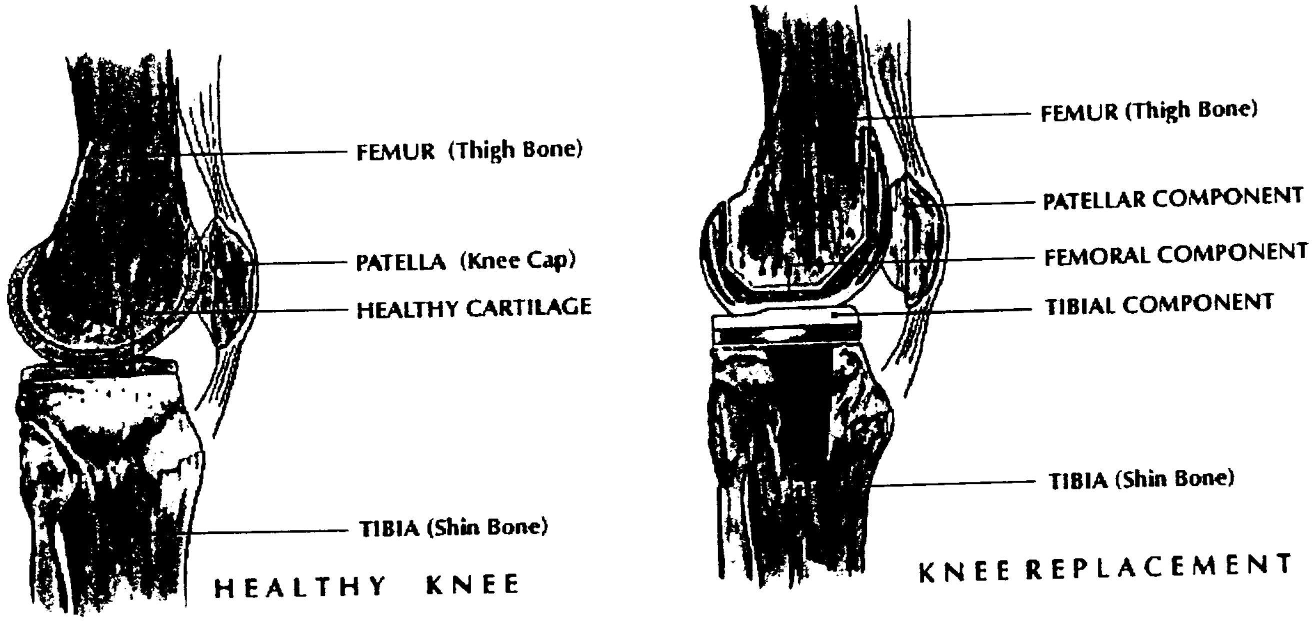


Fig. 1



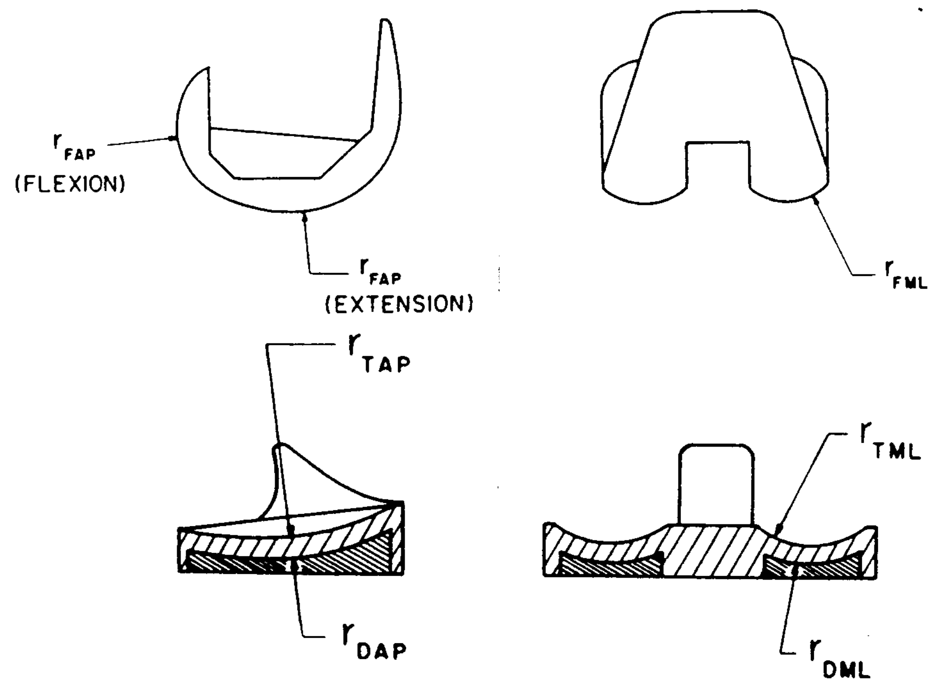


FIG. 2

The contacting surfaces for the total knee replacement were described by four radii: r_{FAP}, the radius of the femoral component in the anterior-posterior direction; r_{FML}, the radius of the femoral component in the medial-lateral direction; r_{TAP}, the radius of the tibial component in the anterior-posterior direction; and r_{TML}, the radius of the tibial component in the medial-lateral direction. The distal surface of the metal-backed polyethylene is described by radii r_{DAP} and r_{DML}, for the anterior-posterior radius and the medial-lateral radius, respectively. Note that the radius of the femoral component in the anterior-posterior direction has two values: one for contact in extension and one for contact in flexion.

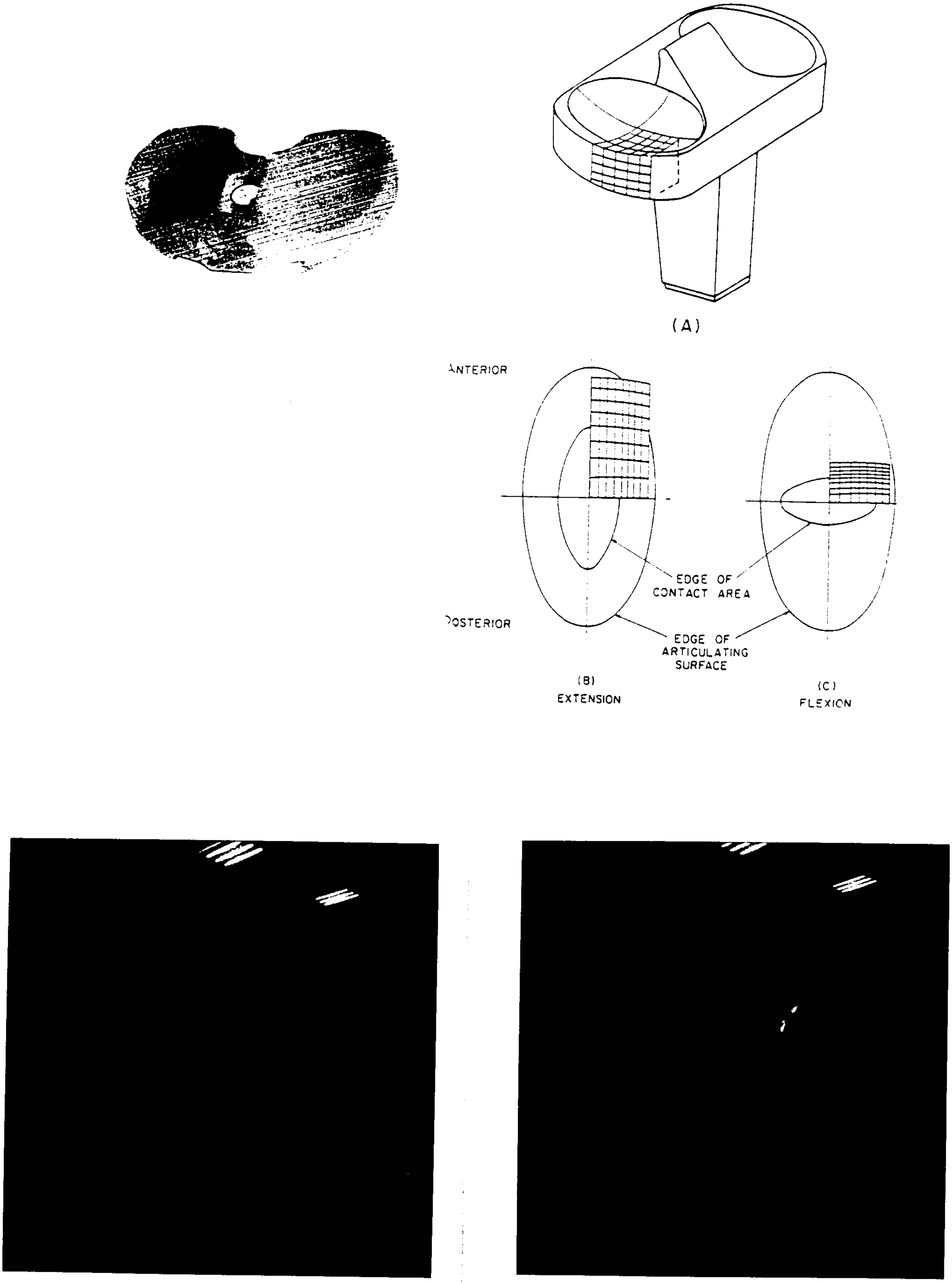

(A)
ANTERIOR
POSTERIOR
EDGE OF
CONTACT AREA
EDGE OF
ARTICULATING
SURFACE
(B)
EXTENSION
(C)
FLEXION

Fig 3