# 聚乳酸骨釘骨板與骨斷裂面癒合過程間之交互影響

# Interaction Between Poly-L-Lactic Acid Bone Plate/Screw and Healing Process of Fracture Interface


## 中文摘要

生物可吸收性材之良好生物相容性以及可製程控制之降解特性使其近年來被廣泛研究，且已成功地發展出可吸收性縫線、人造膜、外科敷料、骨填補材等等臨床應用材。本實驗室長期致力於聚乳酸(Poly lactic acid-PLA)系材料的應用研究，不論在基礎性質或製程的探討上均獲致相當成果，且已逐步將其製成骨內復位固定器。本研究目的即希望藉由標準化的下顎骨斷裂模式，觀察以聚乳酸製作之骨釘骨板固定骨斷裂面復位後生物組織變化及材料降解性質變化，並比較以鈦金屬固定斷裂面與斷裂後不固定三者間骨斷面之癒合程度差別。選擇成年紐西蘭公兔，手術區域均爲右下顎骨之骨體中段部份，製造一垂直於骨體長軸的標準化骨斷裂模式，分別以聚乳酸骨釘骨板及鈦金屬骨釘骨板作固定，另外以斷裂後不固定作爲對照組。實驗動物依照 0，1，4，8，12，16，26 週共七個觀察時間點並以灌流犧牲，觀察其骨髓及斷面之組織反應，以及聚乳酸降解性質變化。物化性質測試方面，於取出骨板後予以烘乾一天作質量變化測試，以三點彎曲量測骨板之彎曲強度變化，以瞭解其降解強度變化與斷面癒合速度之關係。再以示差掃描熱卡計測量結晶變化，以及以膠質滲透層析儀測定分子量，觀察聚乳酸之體內降解變化曲線，藉以推測完全降解所需時間。結果發現，聚乳酸骨釘與鈦金屬骨釘植入骨髓內之組織反應相似，均呈現早期的發炎、中期的修復與晚期的骨重塑反應。植入初期鈦金屬骨釘骨板則呈現較佳的固定力，骨斷面癒合較快，且是以類骨質型態直接鈣化完成，在第八週即見不到外凸的骨痂型態，反之聚乳酸組的斷面修復則是先形成纖維軟骨，再鈣化爲硬骨的軟骨內骨生成模式爲主，骨化所需時間較長。但在第十二週修復期後，兩者的斷面癒合狀況接近，均能達到骨質癒合效果。同時發現聚乳酸骨釘頸部及骨板下緣有新生骨組織攀爬生長上去，顯示其較鈦金屬具有更佳骨親合性，能夠導引骨生長至原有骨組織以外處，具有骨導引性。二十六週觀察期間聚乳酸骨板的重量均無顯著變化，而彎曲強度及結晶度則均呈現先升至第八週後再下降的變化，而分子量變化則呈現緩步下降情形，二十六週時僅剩下三分之一。組織觀察與降解物化性之兩者變化關係可推論：結晶度越高，彎曲強度越強，而這種植入後逐漸上升的強度正好提供骨折癒合在前八週最需要的固持力。而八週後骨癒合已經初步完成，此時降解所造成的強度急速下降反而有助於骨成熟，並減少應力遮蔽效應造成之骨質流失及骨釘鬆動。加上它的生物可降解性，更能免除移除骨釘骨板的問題，應用於成長期的患者，不會影響骨骼生長，是一種相當具有潛能的生物材料。

## 英文摘要

The development of bioresorbable materials makes great progress for their property of biocompatibility and bioresorbability recently. And also the radio permeability, heat molding, and no growth inhibition, makes this type of biomaterial useful in clinical needs. There are several bio-resorbable materials get into clinical use, for example the bio-resorbable suture materials, bio-resorbable membrane, bioresorbable dressing materials, bio-resorbable bone defect filling materials etc. The poly lactic acid (PLA) material is one of most popular resorbable material used in the bio-environment. And it can also be used in the condition of reduction and fixation of bone fracture as a fixation plate. Our laboratory college pays attention to this material for a long period of time on the research of its basic characteristics and clinical applications. We developed a new process of processing to improve its strength and degrading performance. That makes this material a great progress in clinical fixation of bone fracture. The purpose of this study is to realize the interaction between the fracture area and the fixation devices, including traditional titanium plate/screw, PLA plate/screw, in comparison to fracture without any fixation device under a standardized in vivo experimental model of mandibular fracture and repair. The male adult New Zealand rabbit was used in this study and the operation site was located at the mid-portion of body of the right mandible. The goal of observation are divided into two parts；the first is the histological observation and comparison for PLLA / tissue and Titanium/tissue at the region of screw insertion and fracture gap performance. The second one is to evaluate the degree of biodegradation of this material at the time intervals we have planned, including the change of weight , three-point bending strength, crystallinity of material，and molecular weight changes。A standard, predictable, and reproducible model of bone fracture was designed to mimic the exact clinical fracture condition on the mid-portion of right side mandibular body of experimental animal. The combination method application of micro-saw and ultra-thin osteotome creates a standardized fracture gap vertical to body of mandible. The PLLA plates/screws and the Titanium miniplates/screws are used to fix the two parts of fracture gap. Fracture of the same area without fixation device was designed to be control group. The observation sacrifice intervals were week 0, week 1, week 4, week 8, week 12, week 16, week 26. The performance of tissue around screws and fracture gap and the physicochemical changes of PLLA fixation devices will be two main parts of observation. The result of the study indicated that PLLA screw/plate have better bone affinity than the Titanium screw/plate. But the latter one offer more primary stability in-between the two fragments of fractured bone. The healing process of these two types of material is similar to each other. That means the fixation ability of PLLA screw/plate is

compactable to traditional Titanium miniplate/screw. The characteristics of lower Young's modulus makes PLA a better application device on the fracture area under the risk of screw loosening for the reason of stress shielding. And the property of bioabsorbability means there is not necessary to remove the plate and screw when they are fixed in child or on-growing adolescence. So there is a great potential of PLA material on tissue regeneration and tissue engineering.