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Category	Free Papers	Bone research 1	Moderators	
	General Orthopaedic 10		Kienapfel, H. (Germany); Tranquilli Leali, P. (Italy)	
Time	Number of Abstract	Title	Presenting Author	Authors

11.10	F779	**A new method for evaluation of fracture healing by Echo tracking**	**Matsuyama, J.**	**Matsuyama, J.; Ohnishi, I.; Sakai, R.; Miyasaka, K.; Harada, A.; Bessho, M.; Ohashi, S.; Matsumoto, T.; Nakamura, K.**

The most important issue in the assessment of fracture healing is to acquire information on the restoration of mechanical integrity of the bone. To measure bending stiffness at the healing fracture site, we focused on the use of echo tracking (ET) that was a technique measuring minute displacement of bone surface by detecting a wave pattern in a radiofrequency echo signal with an accuracy of 2.6 μ. The purpose of this study was to assure that the ET system could quantitatively assess the progress, retardation or arrest of healing by detecting bending stiffness at the fracture site.

With the ET system, eight tibial fractures in 7 patients with an average age of 37 years (range: 24-69) were measured. Two tibiae in 2 patients were treated conservatively with a cast, and 6 tibiae in 5 patients were treated with internal fixation (intramedullary nailing: 4, plating: 1, screw 1). Patients assumed supine position, and the affected lower leg was held horizontally with the antero-medial aspect faced upwards. The fibula head and the lateral malleolus were supported and held tight by a Vacufix ®. A 7.5 Hz ultrasound probe was placed on each antero-medial aspect of the proximal and distal fragments along its long axis.

Each probe was equipped with a multi-ET system with 5 tracking points with each span of 10 mm. A load of 25 N was applied at a rate of 5 N / second using a force gauge parallel to the direction of the probe and these probes detected the bending angle between the proximal and distal fragments. An ET angle was defined as the sum of the inclinations of both fragments. In the patients treated with a cast, the contra-lateral side was also measured and served as a control. Fracture healing was assessed time sequentially with an interval of 2 or 3 weeks during the treatment.

None of the patients complained of pain, or no other complication related to this measurement occurred. In the patient (patient:M) treated with a cast, the ET angle exponentially decreased as time elapsed ($y = 1.4035e-0.1053x$, $R = 0.9754$) and the radiographic appearance showed normal healing. Including this case, in all patients with radiographic normal healing, the ET angle exponentially decreased. However, in patients with retarded healing (patient:N), the decrease of the angle was extremely slow($y = 0.2769e-0.0096x$, $R = 0.815$). In patients with non union (patient:T), the angle stayed at the same level.

With this method, noninvasive assessment of bending stiffness at the healing site was achieved. Bending angle measured by ET diminished over time exponentially in patients with normal healing. On the contrary, in patients with healing arrest, no significant decrease of the bending angle was recognized. It

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was demonstrated that the echo tracking method could be applicable clinically to evaluate fracture healing as a versatile, quantitative and noninvasive technique.

2-3-1

放射光を用いた暗視野法による関節軟骨の透視撮影法および断層撮影法の開発

国定 俊之[1]　安藤 正海[2]　杉山 弘[3]　鳥雄 大介[4]
武田 健[1]　尾崎 敏文[1]

【目的】変形性関節症に代表される軟骨変性を正確に評価することは，現在の画像診断法では限界がある．関節軟骨の画像診断に関する研究はいくつか報告されているが，投影法による画像診断法の報告はほとんどない．われわれは，独自に開発したX線暗視野法を用いた関節軟骨のX線撮影を行い，過去に報告してきた．今回，新たに透視撮影法に成功したので報告する．

【方法】大型放射光施設SPring-8(BL20B2)，および高エネルギー加速器研究機構(PF, BL14B)で実験を行った．暗視野法とは，屈折コントラスト法を応用したX線画像である．被写体にX線を照射し，物体で屈折したX線を回折アナライザーによって分離し，屈折X線だけで画像化する方法である．通常のX線画像(吸収コントラスト)では写らない被写体を撮影することが可能である．解剖体御遺体から摘出した皮膚，軟部組織が付着したままのPIP関節，肩関節，膝関節を用いて，表面入射型CCD(浜松ホトニクス社)を用いて，透視撮影，断層撮影を行った．

【結果と考察】今までの原子核板を用いた撮影で，指，肩，膝の各関節軟骨の鮮明な撮影が可能であった．原子核板による撮影は高い解像度であるが，現像に時間がかかるため，条件設定(X線照射角度や撮影条件など)にある程度の時間が必要であった．また，コストが高い点も問題となる．この欠点を改善するために，透視撮影法を開発した．このシステムを用いることで，条件設定がリアルタイムで可能となり，よりよい軟骨の画像がすばやく撮影可能となった．また，断層撮影法の開発も同時に行ってきており，この透視撮影法を用いることで，大幅に撮影時間を短縮することが可能となった．透視撮影により関節軟骨の画像がリアルタイムで得られるため，関節軟骨の動的解析にも有用なシステムであると考えている．さらに，断層撮影にも有用なシステムであり，軟骨変性の局在が画像診断可能と考えられる．現在，このシステムを利用することで，関節軟骨のCT撮影法に開発に取り組んでいる．

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2-3-2

超音波を用いたTime of Flight法による関節軟骨の音速測定

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【背景・目的】超音波による関節軟骨定量診断法を確立するためには軟骨音速の高精度測定が必要である．予備的に豚膝関節軟骨を用いて音速測定を行い，開発した測定法の精度を検証した．

【方法】月齢による音速差を考慮し，生後6カ月と3年の豚を用いた．屠畜後約3℃にて3日間冷蔵保存後，後肢を切断し−20℃にて冷凍保存した．室温において生食により解凍し，大腿骨顆部の骨軟骨片を採取した．これをPanametrics社製の超音波送受信機(NDT-5800)と10 MHzのシングルプローブ(NDT-M311)を用い，脱気水(21℃)内で9点においてRadiofrequency(RF)信号を検出した．信号はオシロスコープ(TDS 3054, Tektronix)を介してコンピューターに記録し，軟骨表面境界，軟骨深層-石灰化軟骨境界(tidemark)に相当する各反射波の包絡線ピークを求め，peak-to-peak法により超音波飛翔時間(TOF: time of flight)を計測した(測定精度：±0.2 ns)．ダイシングソーを用い信号検出点が断面となるような骨軟骨切片を作成(n=3)し，顕微鏡(MM-22, Nikon)により各点における軟骨表面からtidemarkまでの距離を軟骨厚として測定した(測定精度：±4 μm)．また，TOFおよび顕微鏡計測の軟骨厚をもちいて軟骨音速を算出した(測定精度：±5 m/s)．

【結果】TOFは子豚，成豚それぞれ3.455±0.178 μs(平均±SD)，1.355±0.060 μs．軟骨厚は2.567±0.084 mm，1.161±0.037 mmであった．軟骨音速はそれぞれ1488±40 m/s，1717±104 m/sであり，成豚の音速が有意に速かった($p<0.01$，t検定)．また，本測定法の変動係数(CV)は，子豚，成豚それぞれ3.2%，6.1%であった．

【考察】成豚の軟骨音速は先行研究の値に近い値であった．本測定法は精度が高く，実用性が高いと考える．

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2-3-3

変形性膝関節症にお…援診断システムの開…相関

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…川口 浩[2]　中村 耕三[1]

【目的】変形性関節症…疾患であるが，その研…重症度の評価方法も有…法を駆使して，変形性…数の重症度指標を自動…断システムKOACAI…nosis)を確立し，O…スを用いて，その…た．

【方法・結果】立位…ルフィルタによるノ…統計処理による基準…・外側の関節裂隙…内側の骨棘面積(O…に計測するソフト…トROADの計3…た50膝について…評価者間，評価…0.62–0.75であった…あった．続いて，…トの60歳以上の…痛群(1385膝)に…定で解析したと…それぞれ内側mJ…側JSA：＜0.00…FTA：＜0.0001…ィック回帰分析…と最も強い相関…-1.81)，女性1…

【考察・結論】…世界に先駆けて…は簡便に行える…定のように，…療の正確な評…れる．

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