Disclosure:

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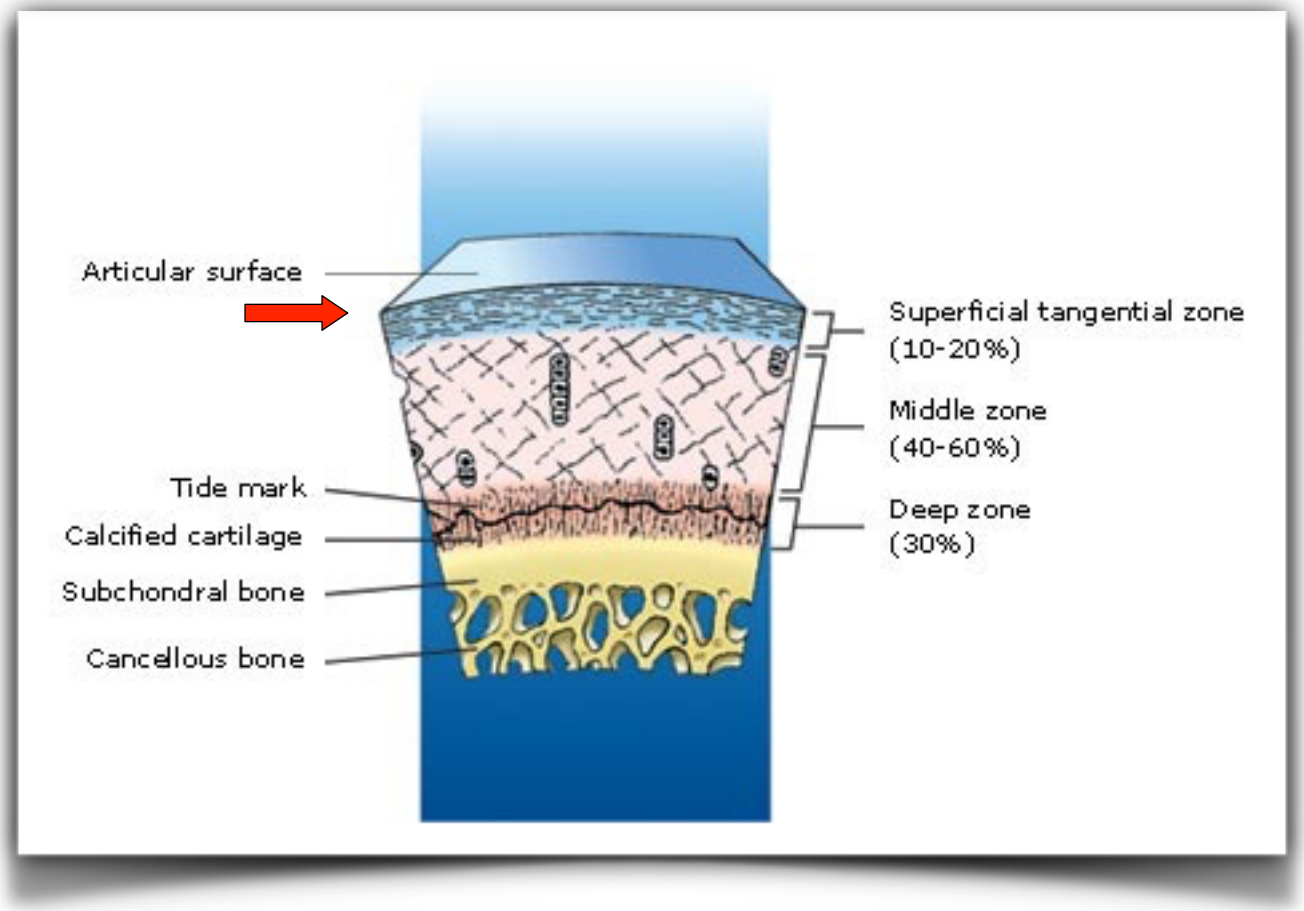
What is Lamina Splendens and What Does it Do?

Prof. Vladimir Bobic, MD, FRCSEd
Consultant Orthopaedic Knee Surgeon
Chester Knee Clinic @ Nuffield Health, The Grosvenor Hospital Chester, UK

Structure of Articular Cartilage: Superficial Zone

Articular cartilage + Subchondral plate + Trabecular bone = biologically and functionally inseparable OsteoChondral unit which absorbs and distributes loads across the joint.



But, what about the articular surface? The surface which undergoes a lot of friction and does the actual hard work of endless articulation with other surfaces!

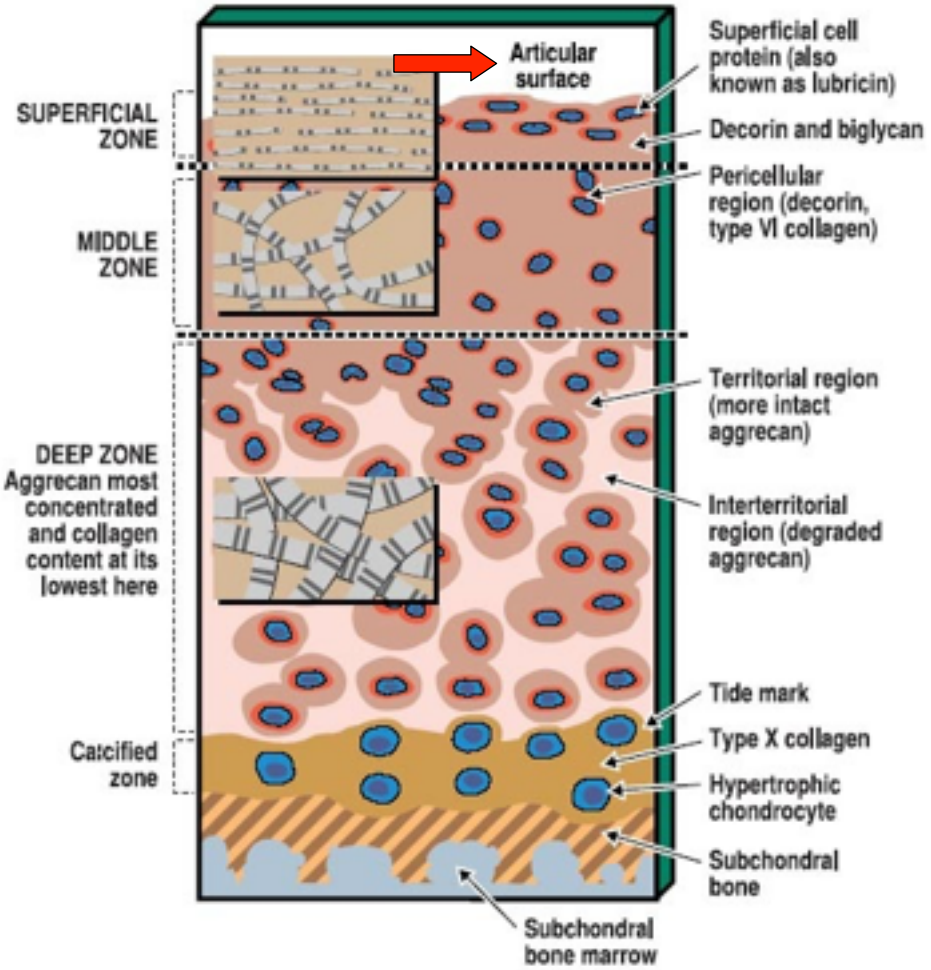


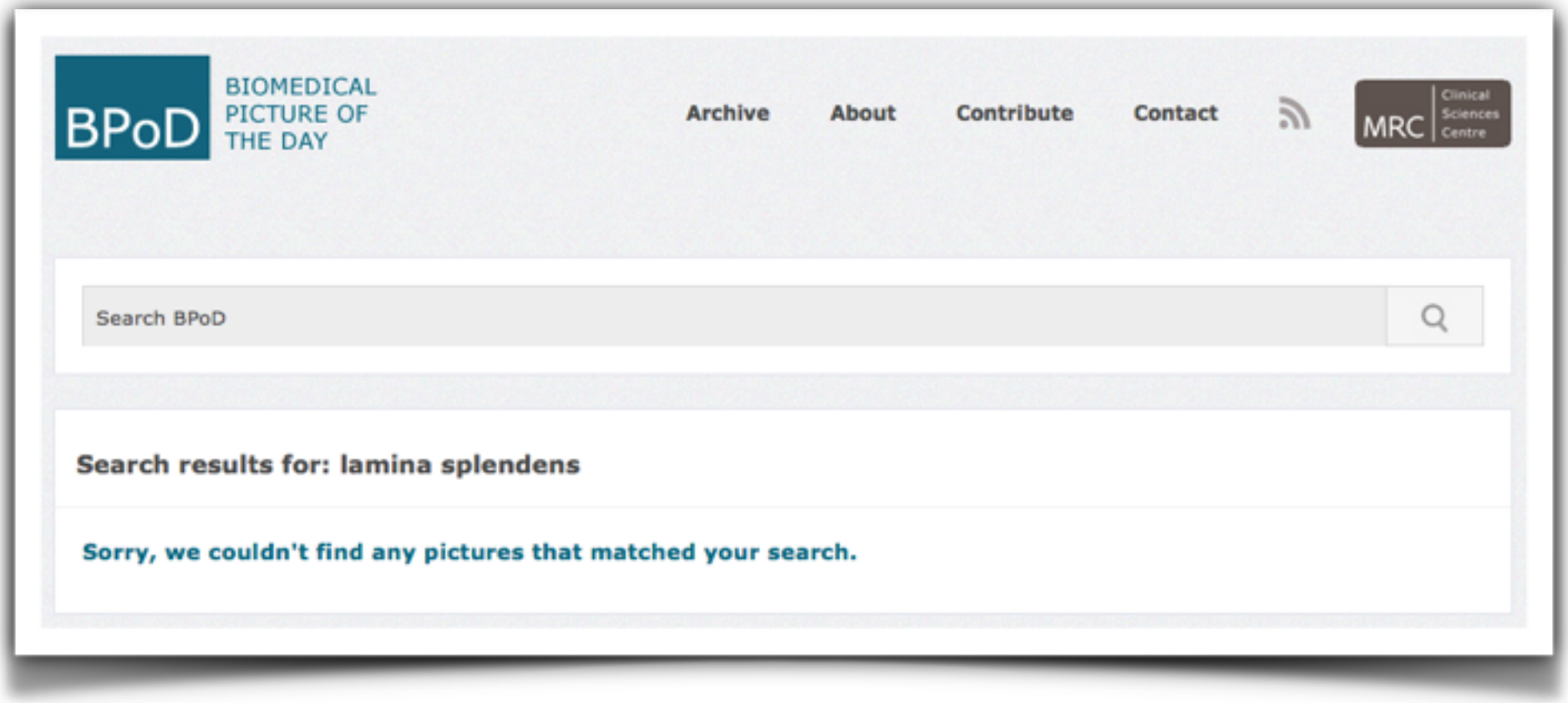
Fig. 1

Diagrammatic representation of the general structure of human adult articular cartilage, showing the zones and regions as well as the relationship with subchondral bone. The insets show the relative diameters and organization of the collagen macrofibrils in the different zones. Special features of molecular content or properties are also indicated. (Reproduced, with modification, from: Koopman WJ. *Arthritis and allied conditions. A textbook of rheumatology.* 14th ed. volume 1. Philadelphia: Lippincott Williams and Wilkins; 2000. p 228. Reprinted with permission.)

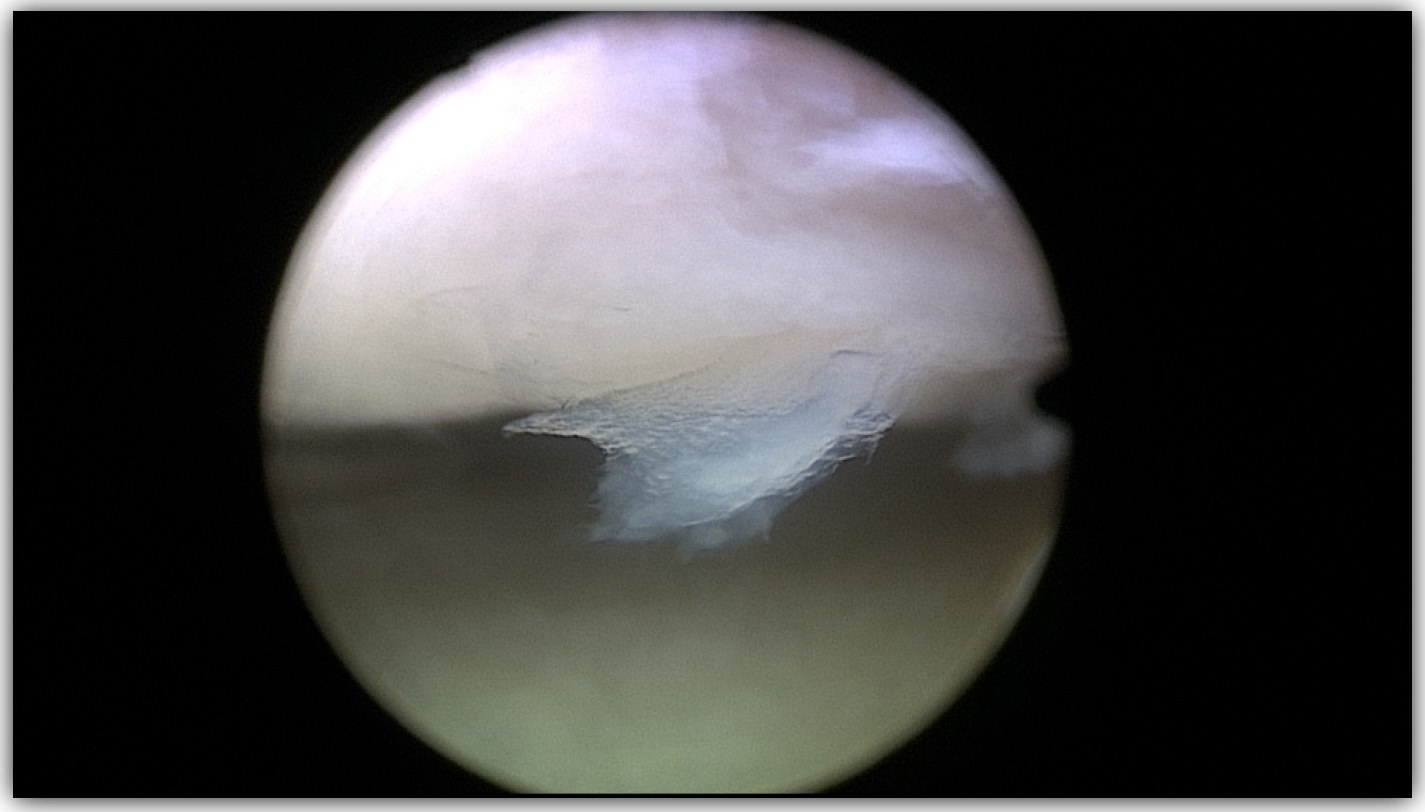
What is Lamina Splendens and What Does it Do?

What’s in a Name? Lamina Splendens or Superficial Zone or Gliding Zone or …?
"*A rose by any other name would smell as sweet*”. William Shakespeare

How Does Lamina Splendens Look Like?

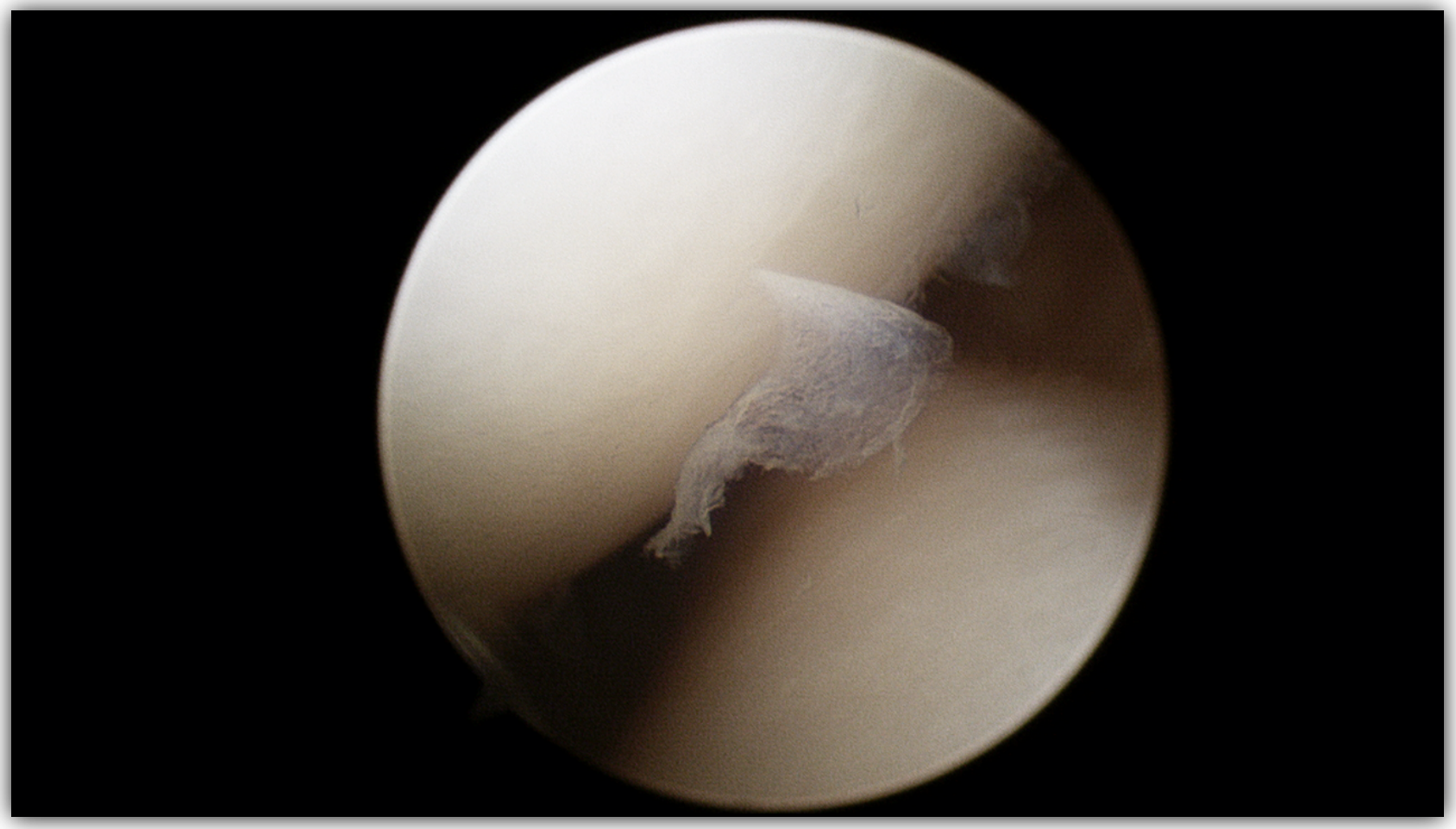


Arthroscopic Appearance:



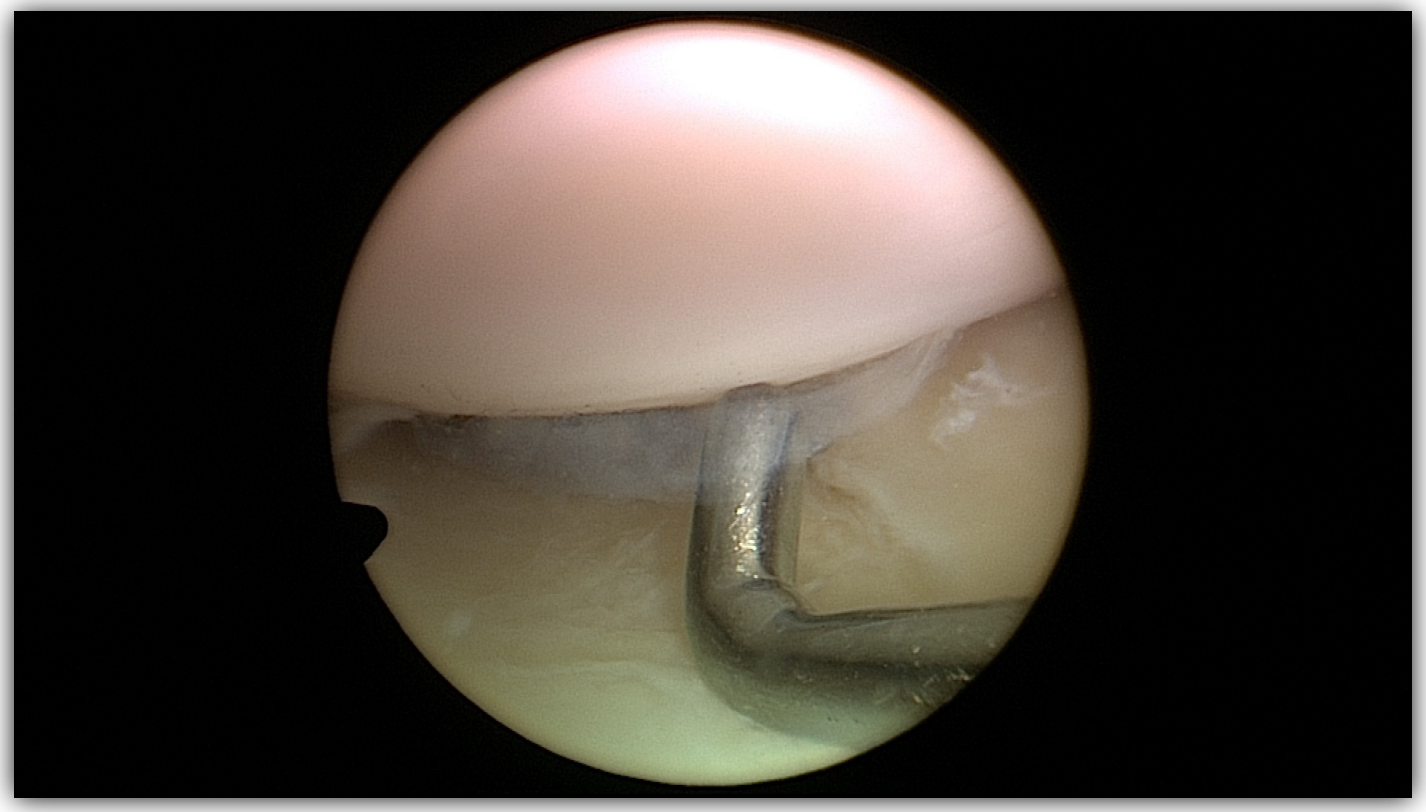
Is this the lamina splendens? Or just a chunk of semitransparent “surface layer”?

Arthroscopic Appearance:



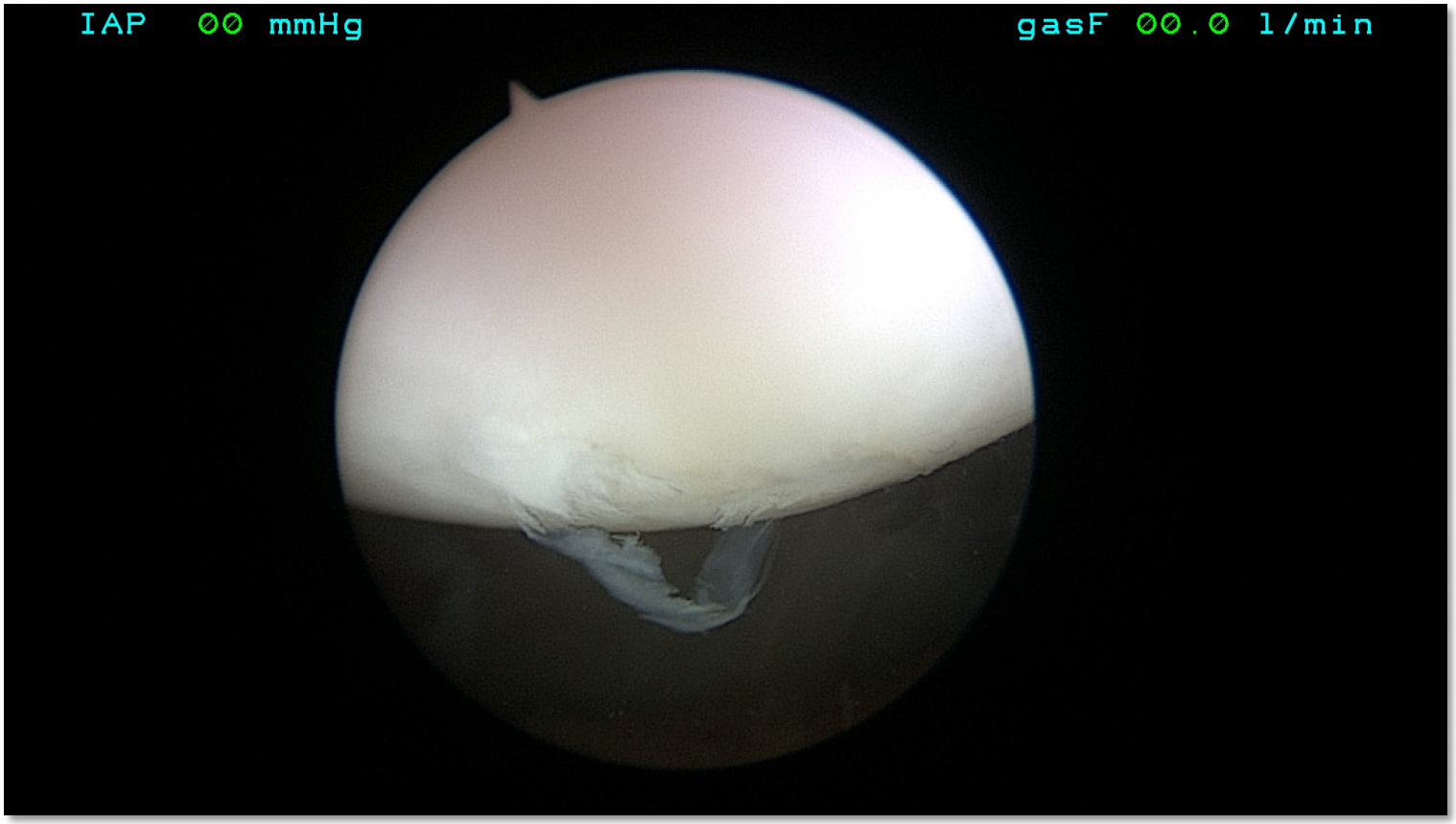
Is this the lamina splendens? Or just a small flap of semitransparent “surface layer”?

Arthroscopic Appearance:



Is this the lamina splendens?

Is this Lamina Splendens? Looks like a cling-film …



Like a cling-film? On top of tough articulating surface? Not really!

The structure of the LS must be very different to withstand a lifetime of weight-bearing, movement and friction

What's in a Name: Lamina Spenders or Surface Amorphous Layer?

- MacConaill (1951) observed **a bright line at the surface of the articular cartilage using a phase contrast microscope and called it the 'lamina splendens'**.

- Sokoloff (1969) and Aspden & Hukins (1979) have **disputed the existence of the 'lamina splendens'** concluding that it was nothing but **an optical effect produced by phase contrast microscopy.**

- However, some researchers using conventional **SEM or TEM** (Weissetal. 1968; Weiss,1982; Jeffery et al.1991) considered that the **observed surface layer might correspond to the 'lamina splendens'** of MacConaill.

- Setting aside the question of the 'lamina splendens', **the surface amorphous layer observed using the cryo-SEM is "believed to correspond to the non collagenous layer on the articular surface"**

- **Basically, very confusing ...**

Does it really exist?

62 THE LAMINA SPLENDENS OF ARTICULAR CARTILAGE: FACT OR ARTIFACT

D.R. SHACKLETON, A.M. NAHIR, M.E.J.BILLINGHAM, LUCILLE BITENSKY, J. CHAYEN and I.HELEN MUIR

Divisions of Cellular Biology and Biochemistry, Kennedy Institute, Bute Gardens, London W6 7DW and Pharmaceuticals Division, I.C.I., Macclesfield

When studied by phase-contrast microscopy, the surface of articular cartilage often appears very bright. This led MacConaill (J.Bone Jt. Surg. 33B, 251-257, 1951) to suggest it was bounded by a discrete 'lamina splendens'; others have dismissed this as an optical artifact caused by a change of refractive index (RI) at the edge of the cartilage. We have investigated this problem in blocks (4 x 4 x1mm) of normal articular cartilage taken from the dog tibial plateau. They were chilled; mounted on to chucks, the surface of which could be rotated and varied in two planes so that the orientation could be checked; and sectioned in a cryostat.

Cytochemical tests showed that the lamina was strongly PAS-positive and contained a high concentration of reducing groups. Especially in oblique sections, it contained elongated cells embedded in it. It was not an optical artifact in that it remained visible, by phase-contrast microscopy, even when the RI of the mounting medium matched that of the cartilage; it was strongly birefringent with the sign of birefringence opposite to that of the main collagen bundles of the cartilage; and by interference microscopy, it was clearly visible, with a mass /unit area up to double that of the matrix. Similar results have been observed in relatively normal human articular cartilage. These results confirm the existence of a surface lamina of articular cartilage.

"Lamina Splendens: a layer of fine filaments at the very surface of the gliding zone

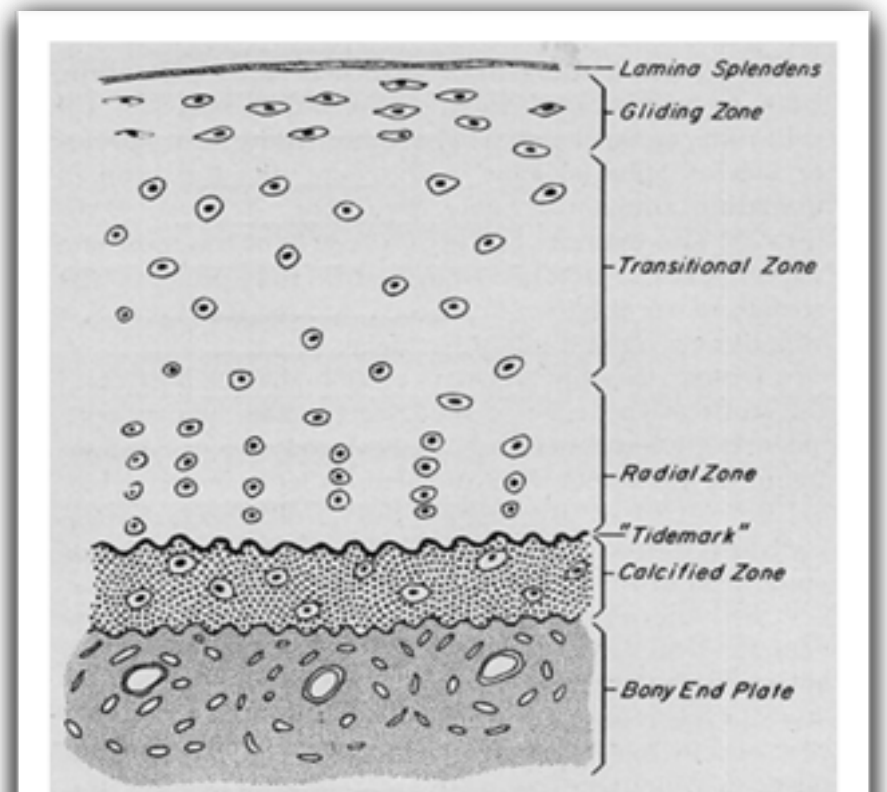


FIG. 5-19 Graphic representation of the various zones of adult articular cartilage. Note the *lamina splendens*, a layer of fine filaments at the very surface of the *gliding zone*, in which the cells are elongated and tangentially arranged. In the *transitional zone* the cells are rounded or ovoid and appear to have a random distribution, while cells on the *radial zone* are arranged in short columns. The "tidemark" separates the radial from the *calcified zone*, in which the cells are heavily encrusted with apatitic salts. The mature cortical bone of the end-plate shows haversian systems directed parallel to the joint surface (rather than along the long axis of the bone, as is seen in the shaft).

Henry J Mankin: The Articular Cartilage. Chapter in: "Textbook of Small Animal Orthopaedics" by Charles D. Newton and David M. Nunamaker, J.B. Lippincott, 1985

EM of Lamina Splendens or "a skin"

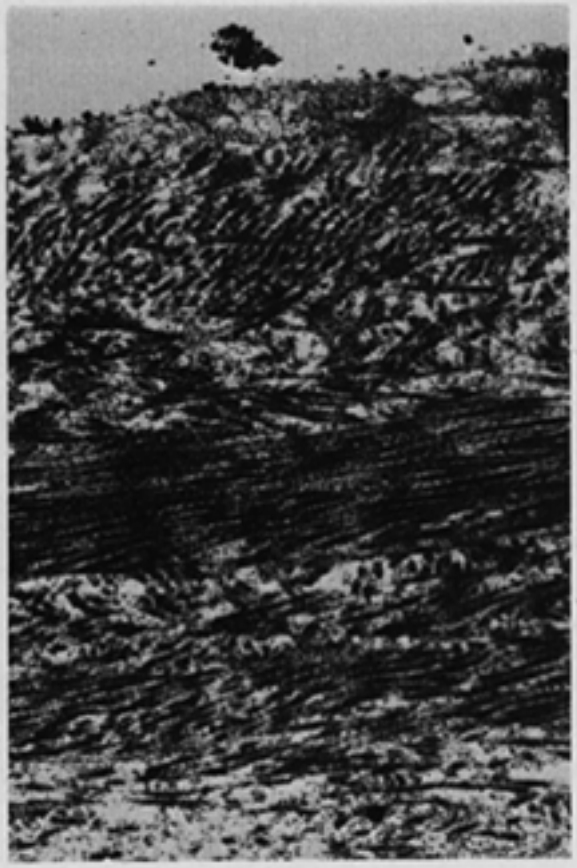


FIG. 5-20 Electron micrograph of the surface of adult articular cartilage shows the fine fibers and filaments of the lamina splendens and the parallel bundles of collagen of the tangential zone. Note that the bundles of collagen run parallel to the surface and form a "skin." (original magnification × 21,000) (Courtesy of Charles Weiss, MD)

Henry J Mankin: The Articular Cartilage. Chapter in: "Textbook of Small Animal Orthopaedics" by Charles D. Newton and David M. Nunamaker, J.B. Lippincott, 1985

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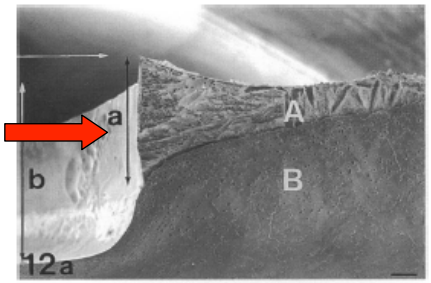
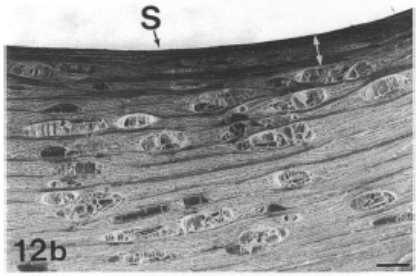
Cryoscanning electron microscopy of loaded articular cartilage with special reference to the surface amorphous layer

SENEKI KOBAYASHI[1], SO YONEKUBO[2] AND YASUKO KUROGOUCHI[2]

[1] *Department of Orthopaedic Surgery, Shinshu University School of Medicine, Matsumoto , and* [2] *Precision Technology Research Institute of Nagano Prefecture, Okaya, Japan*





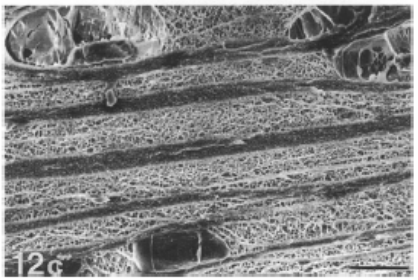


Fig. 12. (*a*) Cryoscanning electron micrograph of the articular cartilage indented with 3 MPa of pressure for 2 min. A horizontal arrow indicates the indented region. Symbols as in Figure 4. Bar, 100 µm. (*b*) A high magnification view of the intended region of the specimen shown in (*a*). Stripes run almost parallel to the articular surface (S). The closer to the articular surface, the wider and the darker the stripes become, with the widest and darkest one just beneath the surface (double headed arrow). Bar, 10 µm. (*c*) Higher magnification view of the central region of (*b*). The dark stripes are composed of densely packed collagen fibrils. They produce a striped pattern with the collagen fibril networks remaining between them. Bar, 5 µm.

articular surface became indistinct on macroscopic observation. Cryo-SEM of the fracture face of the specimen revealed that the bulge of the surface layer had moved into the previously indented region (Fig. 13). It retained the streaked appearance at its thickest portion.

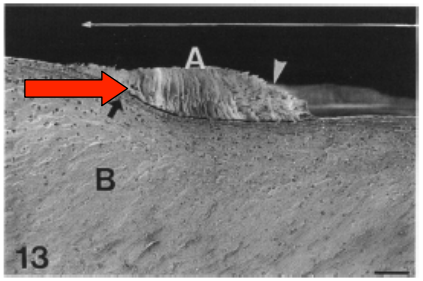


Fig. 13. Cryoscanning electron micrograph of the articular cartilage immediately after removal of the indenter from the specimen indented with 1.2 MPa pressure for 1 min. The expanded surface layer (A) has moved into the previously indented region (horizontal arrow). It shows the streaked appearance in the thickest middle portion and the foliate appearance in the relatively thinner portion (arrowhead). The collagenous main part of the cartilage, previously under the indenter, has recovered from its compressive deformation more rapidly in the marginal area within the indented region (short oblique arrow) than in the central area. Bar, 100 µm.

Two seconds after removal of the indenter, the previously indented region was covered by a thick surface layer (Fig. 14*a*). The layer was thicker in the marginal area of the indented region than in the centre. The surface layer lost its streaked appearance and mainly presented the foliate appearance (Fig. 14*b*). The thick surface layer, as well as the recovery of the underlying main part of the cartilage from the compressive deformation, made the previously indented region barely recognisable to the naked eye when observed before freeze-fracturing.

One minute after removal of the indenter, the main part of the cartilage had recovered from the indentation so well that its residual displacement could hardly be measured. A thick surface layer, mainly with a foliate or streaked appearance, covered the previously indented region (Fig. 15). Its mean thickness was 54.5 µm with a range of 8–103 µm (n = 11). The layer was usually thickest, frequently with the streaked appearance, in the centre of the indented region.

Indentation of human articular cartilage

Nearly identical changes occurred after indentation of the human specimens as took place in the pig knee joints. The specimen from case 1 (a 37-y-old woman) showed a similar bulge of the surface layer around the indenter after indentation with a pressure of 1.2 MPa

SEM of Lamina Splendens: "distinctly different layer"

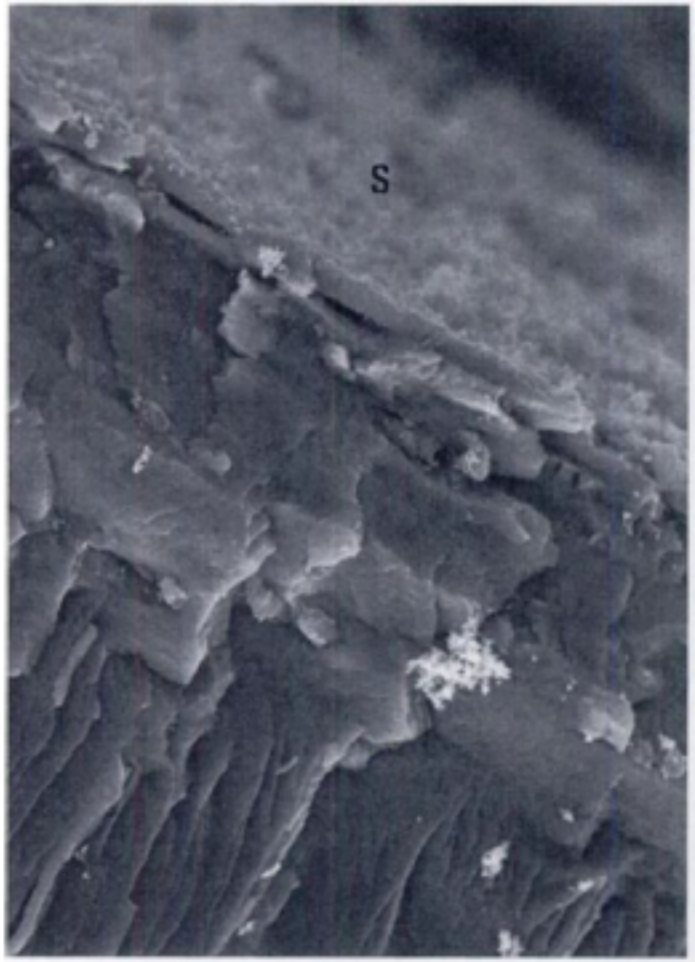


Fig. 1a

Fig. 1b

Figure 1a – SEM of the cracked surface of human articular cartilage (×450). The most superficial structure is distinctly different from the layer deep to it, and its narrow edge is seen below the letter S. Figure 1b – High-magnification SEM of the superficial layer (×9000). It consists of a layer of densely-packed collagen fibrils running parallel to the articular surface.

Teshima R et al: Structure of the most superficial layer of articular cartilage. JBJS Br 1995:77-B: 460-4

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Cryoscanning electron microscopic study of the surface amorphous layer of articular cartilage

SENEKI KOBAYASHI[1], SO YONEKUBO[2] AND YASUKO KUROGOUCHI[2]

[1] *Department of Orthopaedic Surgery, Shinshu University School of Medicine, Matsumoto, and* [2] *Precision Technology Research Institute of Nagano Prefecture, Okaya, Japan*

(*Accepted 11 April 1995*)

ABSTRACT

In order to elucidate the structure near the articular surface, frozen unfixed hydrated articular cartilage with subchondral bone from the pig knee was examined using a cryoscanning electron microscope (cryo-SEM). This method is considered to reduce the introduction of artefacts due to fixation and drying. An amorphous layer, without a collagen–fibril network or chondrocytes, covered most of the surface of the cartilage. This layer was termed the *surface amorphous layer*. It showed various appearances, which were classified into 4 groups. The average thickness of the layer did not differ among the 8 anatomical regions from which the specimens were taken. The thickness of the layer was found to correlate with the type of appearance of the layer. The 4 appearances associated with thicknesses in descending order are: 'streaked', 'foliate', 'spotted', and 'vestigial'. The surface layer observed in the cryo-SEM was thicker than that observed by a conventional SEM. This difference may be attributable to dehydration of the specimen used in specimen preparation for the latter technique. The layer was also observed in articular cartilage taken from human and rabbit knees. The layer was found to be unstable and to have very variable features. Its thickness and appearance may be influenced by various factors such as dehydration, fluid absorption or mechanical stress.

Key words: Knee joint; pig; rabbit; human.

INTRODUCTION

The most superficial portions of articular cartilage demonstrate distinct changes in the early stages of osteoarthritis including decreased histological staining (Meachim et al. 1965), increased water content (Brocklehurst et al. 1984) and diminished tensile modulus (Akizuki et al. 1986). These early changes of the superficial part of articular cartilage may play an important role in the pathogenesis of osteoarthritis.

The structure of the articular surface has been the subject of considerable debate and remains controversial despite the numerous investigations published on the subject (MacConaill, 1951; Weiss et al. 1968; Clarke, 1971; Gardner, 1972; Ghadially et al. 1982; Ghadially, 1983; Clark & Rudd, 1991; Jeffery et al. 1991). This controversy may be due to the remarkably high fluid content near the articular surface (Maroudas et al. 1969; Lipshitz et al. 1976; Brocklehurst et al. 1984) and the changing configuration of the articular surface as a consequence of dehydration (Gardner & McGillivray, 1971; Ghadially et al. 1982; Ghadially, 1983; De Bont et al. 1984; Clark & Rudd, 1991). It is therefore necessary to observe the structure near the articular surface in the hydrated state.

In the present study, in order to elucidate the structure near the articular surface, we examined unfixed and hydrated articular cartilage specimens using a cryoscanning electron microscope (cryo-SEM). This technique reduces the introduction of artefacts due to fixation and drying, and retains water, electrolytes, and other small molecules within the specimen.

Correspondence to Dr Seneki Kobayashi, Department of Orthopaedic Surgery, Shinshu University School of Medicine, Asahi 3-1-1, Matsumoto, 390, Japan.

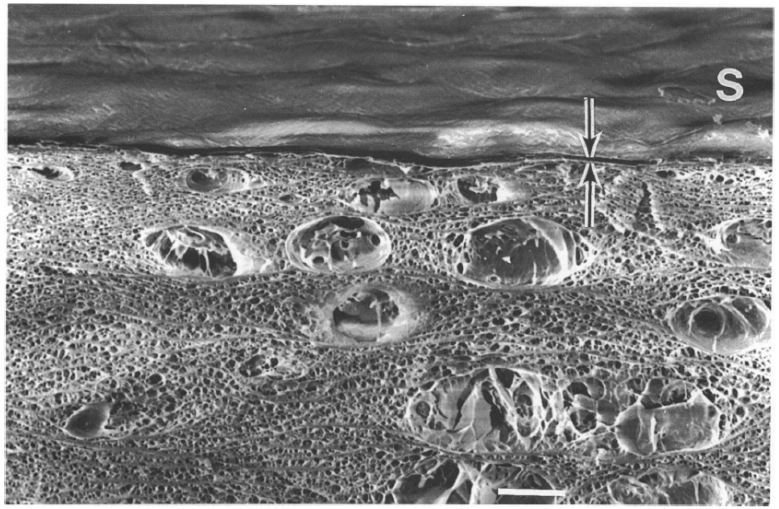


Fig. 12. Cryoscanning electron micrograph of femoral cartilage from F2 which has been exposed to room air (temperature, 23 °C; humidity, 70 %) for 1 h. The surface layer (arrows) is 1 μm in thickness. S, articular surface. Bar, 10 μm.

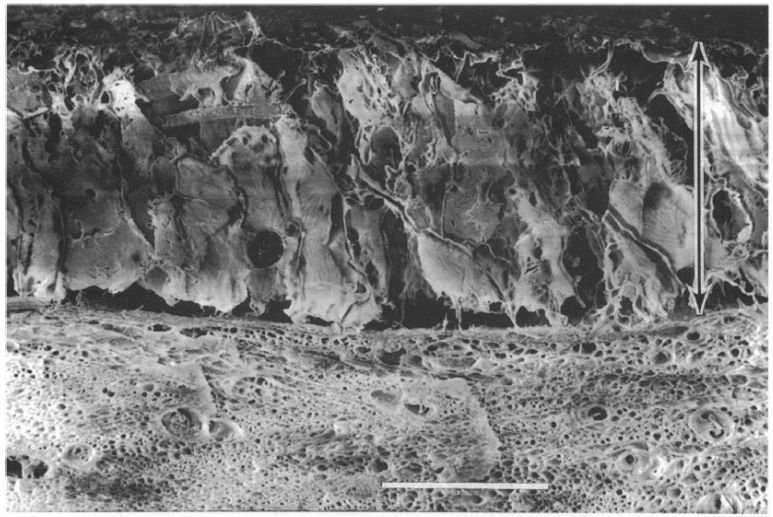
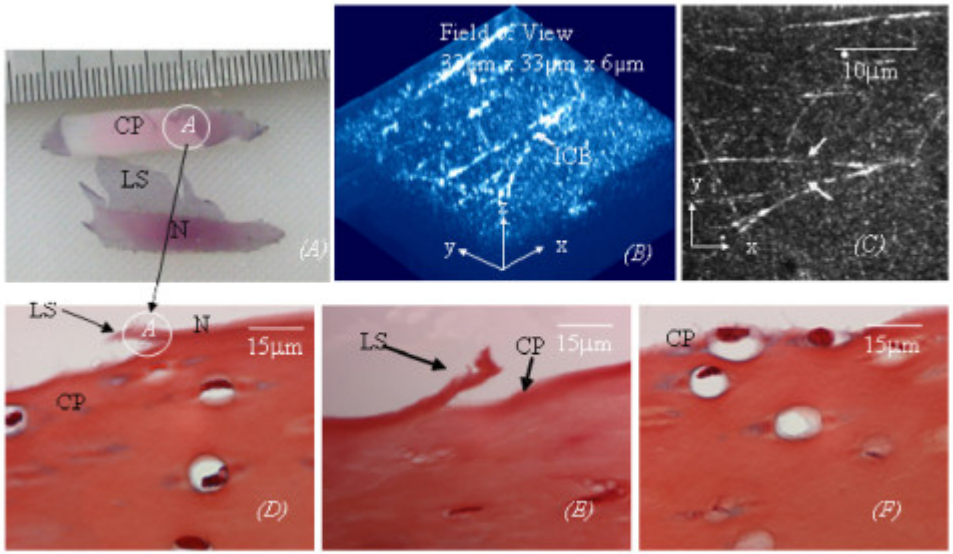


Fig. 13. Cryoscanning electron micrograph of cartilage from the lateral femoral condyle (F4) in case 1 (an 11-yr-old boy). The surface layer (double-headed arrow) has a foliate appearance. Bar, 50 μm.

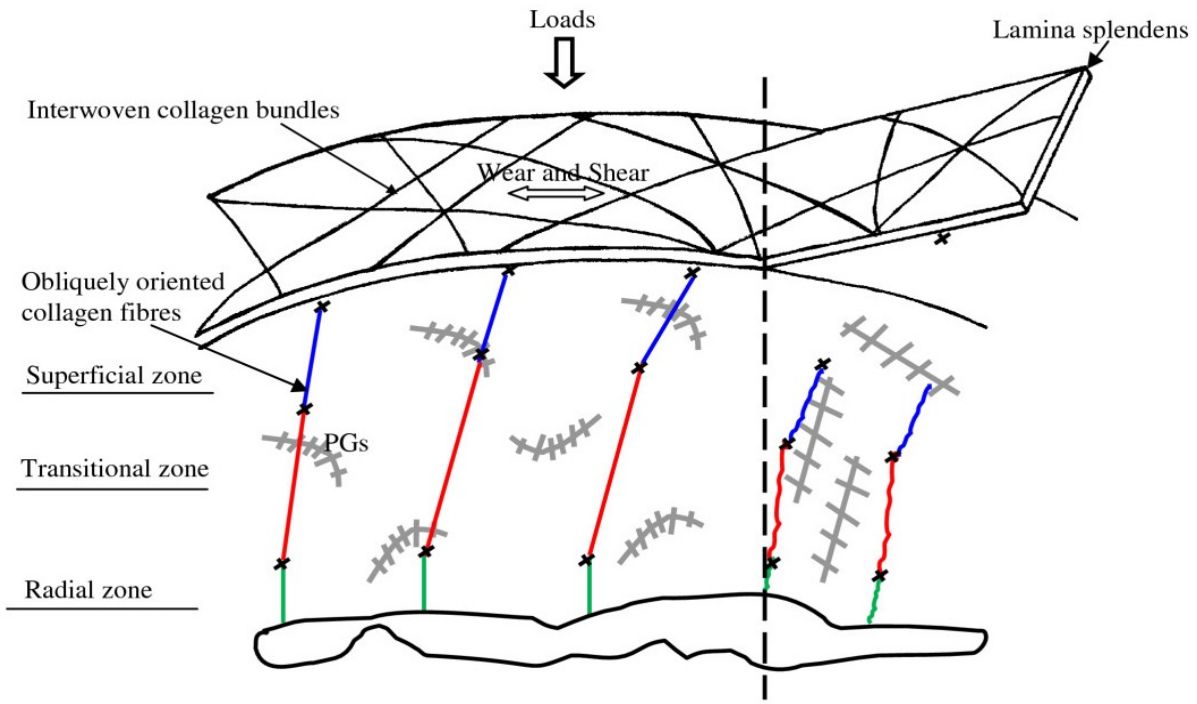
What is Lamina Splendens?



(A)*. A semitransparent membrane corresponding to the lamina splendens (LS) was physically peeled off from normal articular cartilage (N) of a cow femoral head (unloading region).(B)*. A 3D image of the lamina splendens shows the collagen network within it is compromised of unique interwoven collagen bundles (ICB). *(C)*. The corresponding MBI of the collagen network in LS in Fig *(B)*. *(D)*. Traditional histology shows the site where the lamina splendens was separated from the normal (cow) cartilage. *(E)*. **Traditional histology of early arthritic cartilage from a human femoral head shows disrupting the articular surface in early OA is a process similar to physically peeling off the lamina splendens.** *(F)*. Traditional histology of normal cartilage physically peeled the lamina splendens (indicated as CP (cartilage peeled lamina splendens) in Fig 2*(A)*) shows **loss of the most superficial layer of articular cartilage can expose some chondrocytes near the surface to the joint cavity.**

Wu *et al. Journal of Orthopaedic Surgery and Research* 2008 3:29

What is the Purpose of Lamina Splendens?



A schematic structure of the collagen network in AC shows that the interwoven collagen bundles in the lamina splendens integrate the obliquely oriented collagen fibres and those in the deeper region to form a 3D collagen scaffold, which anchors to the subchondral bone.

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What is the purpose of Lamina Splendens?

- It is well accepted that the 3D collagen scaffold arched on the subchondral bone of AC.
- It reinforces the swelling pressure of proteoglycan (PG) gel to provide the AC with loading capacities and considerable tensile strength to withstand for wear and shear stresses.
- The tensile strength and lateral integrity of the interwoven collagen bundles permitted peeling off the most superficial layer from AC.
- **Peeling off the lamina splendens where the interwoven collagen bundles reside reduces the wear and shearing resistance of the AC.**
- It also leads to change of the osmotic pressure in AC and gradually release of PGs to the joint cavity.
- This basically agrees with the suggestion that the **lamina splendens is a relatively independent layer with limited connections to the underlying cartilage.**

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What is the purpose of Lamina Splendens?

• Furthermore, the collagen fibres changed from oblique orientation to perpendicular orientation after peeling off the most superficial layer of AC could be associated to the remodelling of the osmotic pressure and subsequent expansion of the proteoglycans in the AC.

• Previously, oblique collagen fibres have been reported to run between the articular surface and subchondral bone and they have further been suggested to be compatible to the requirement of entrapment of proteoglycans and strengthen the tensile properties.

• Therefore, the oblique collagen fibres contained by normal AC may also have contributed to the normal mechanical function of AC.

• Conversely, the perpendicular collagen orientation found in majority of early OA cartilage may contribute little to retain proteoglycans and enhance the tensile property of the cartilage to wear and sharing stresses.

Wu *et al. Journal of Orthopaedic Surgery and Research* 2008 3:29

Superficial Zone and Lubricin:

Original Article

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http://cart.sagepub.com
SAGE

Lubricin: Its Presence in Repair Cartilage following Treatment with Autologous Chondrocyte Implantation

Sally Roberts[1,2], Janis Menage[1], Carl R. Flannery[3], and James B. Richardson[1,2]

Abstract

Objective: To determine if lubricin was present in the surface layer of repair cartilage formed after autologous chondrocyte implantation (ACI). *Design:* Forty-three biopsies of repair tissue were taken from patients who had been treated with ACI 8 to 68 months previously (mean of 18.0 ± 14.4 months); 30 had flaps of periosteum and 13 of Chondro-Gide®. Cryopreserved sections were stained with hematoxylin and eosin, toluidine blue, and immunostained for lubricin and type II collagen. The quality of repair tissue was scored via OsScore, and clinical improvement in patients was assessed via change in Lysholm score. Normal/control cartilage was studied for comparison (n = 5). *Results:* Patients' Lysholm scores improved from 48.1 ± 17 preoperatively to 69.5 ± 21.5 posttreatment. The thickness of repair tissue was 2.9 ± 1.7 mm compared with 2.3 ± 0.6 mm for control cartilage, with an OsScore of 6.7 ± 1.6 (8.9 ± 1.2 for controls). Ninety-eight percent of biopsies had staining for lubricin, with 84% having some in the surface layer (60% of periosteal treated and 100% of Chondro-Gide treated). The improvement in Lysholm score was not significantly different in patients with lubricin present at the surface compared with those without. *Conclusion:* Lubricin was present in almost all samples of repair tissue formed post ACI, often in the surface layer, resembling the distribution that is seen in normal cartilage. The presence of lubricin in the upper layer is likely to have implications for the functioning of the tissue because, via its mucin-like repeats, it appears capable of reducing the friction that could arise in articulating joints.

Superficial Zone and Lubricin:

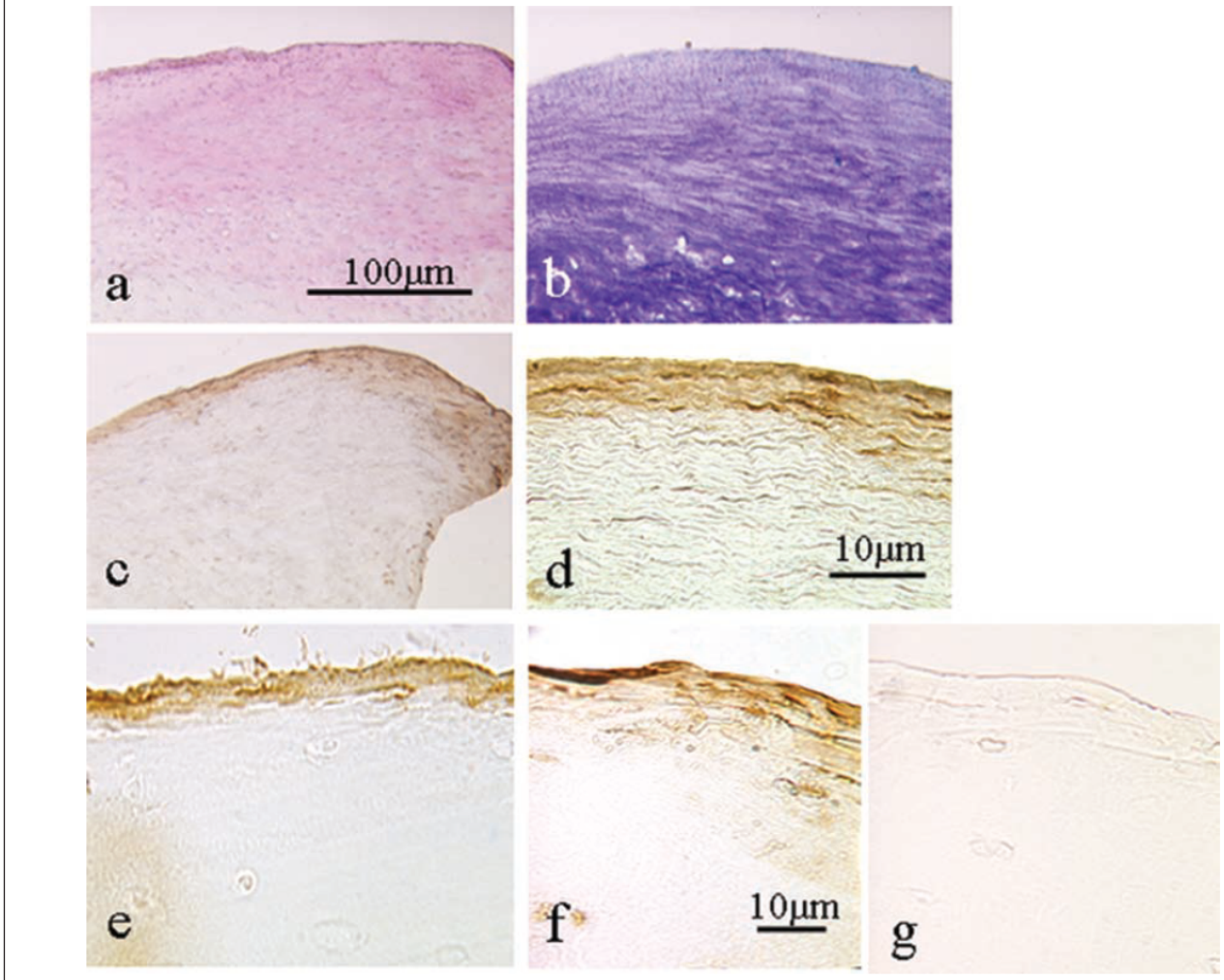

Figure 3. Repair tissue formed 13 months following autologous chondrocyte implantation in (**a-d**) of a 37-year-old man treated with a periosteal flap; sections stained with (**a**) hematoxylin and eosin, (**b**) toluidine blue, and (**c, d**) immunostained for lubricin. (**a-c**) Lower magnification and (**d**) higher magnification as shown by bar. Normal cartilage immunostained for lubricin from a 30-year-old (**e**) and a 40-year-old (**f**). (**g**) Adjacent control section labeled with rabbit IgG.

Roberts S et al. Cartilage 2010

Osteoarthritis and Cartilage 18 (2010) 956–963

Osteoarthritis and Cartilage

OARSI OSTEOARTHRITIS RESEARCH SOCIETY INTERNATIONAL

Atomic force microscope investigation of the boundary-lubricant layer in articular cartilage

S.M.T. Chan †*, C.P. Neu †‡, G. DuRaine †, K. Komvopoulos §, A.H. Reddi †

† *Center for Tissue Regeneration and Repair, Department of Orthopaedic Surgery, University of California, Davis, Medical Center, Sacramento, CA 95817, USA*
‡ *Weldon School of Biomedical Engineering, Purdue University, West Lafayette, IN 47907, USA*
§ *Department of Mechanical Engineering, University of California, Berkeley, CA 94720, USA*

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Friction coefficient
Lubricin
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SUMMARY

Objective: To determine the roles of superficial zone protein (SZP), hyaluronan (HA), and surface-active phospholipids (SAPL) in boundary lubrication of articular cartilage through systematic enzyme digestion using trypsin, hyaluronidase, and phospolipase-C (PLC) surface treatments.
Methods: The friction coefficient of articular cartilage surfaces was measured with an atomic force microscope (AFM) before and after enzyme digestion. Surface roughness, adhesion, and stiffness of the articular surface were also measured to determine the mechanism of friction in the boundary lubrication regime. Histology and transmission electron microscopy were used to visualize the surface changes of treatment groups that showed significant friction changes after enzyme digestion.
Results: A significant increase in the friction coefficient of both load-bearing and non load-bearing regions of the joint was observed after proteolysis by trypsin. Treatment with trypsin, hyaluronidase, or PLC did not affect the surface roughness. However, trypsin treatment decreased the adhesion significantly. Results indicate that the protein component at the articular cartilage surface is the main boundary lubricant, with SZP being a primary candidate. The prevailing nanoscale deformation processes are likely plastic and/or viscoelastic in nature, suggesting that plowing is the dominant friction mechanism.
Conclusions: The findings of this study indicate that SZP plays an intrinsic and critical role in boundary lubrication at the articular surface of cartilage, whereas the effects of HA and SAPL on the tribological behavior are marginal.

Is Lamina Splendens Important?

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Stem Cells and Cartilage Development: Complexities of a Simple Tissue

ANTHONY P. HOLLANDER, SALLY C. DICKINSON, WAEL KAFIENAH

Department of Cellular & Molecular Medicine, University of Bristol, Bristol, United Kingdom

Key Words. Chondrogenesis • Mesenchymal stem cells • Tissue regeneration • Adult stem cells

ABSTRACT

Cartilage is considered to be a simple tissue that should be easy to engineer because it is avascular and contains just one cell type, the chondrocyte. Despite this apparent simplicity, regenerating cartilage in a form that can function effectively after implantation in the joint has proven difficult. This may be because we have not fully appreciated the importance of different structural regions of articular cartilage or of understanding the origins of chondrocytes and how this cell population is maintained in the normal tissue. This review considers what is known about different regions of cartilage and the types of stem cells in articulating joints and emphasizes the potential importance of regeneration of the lamina splendens at the joint surface and calcified cartilage at the junction with bone for long-term survival of regenerated tissue in vivo. STEM CELLS *2010;28:1992–1996*

Is Lamina Splendens Important?

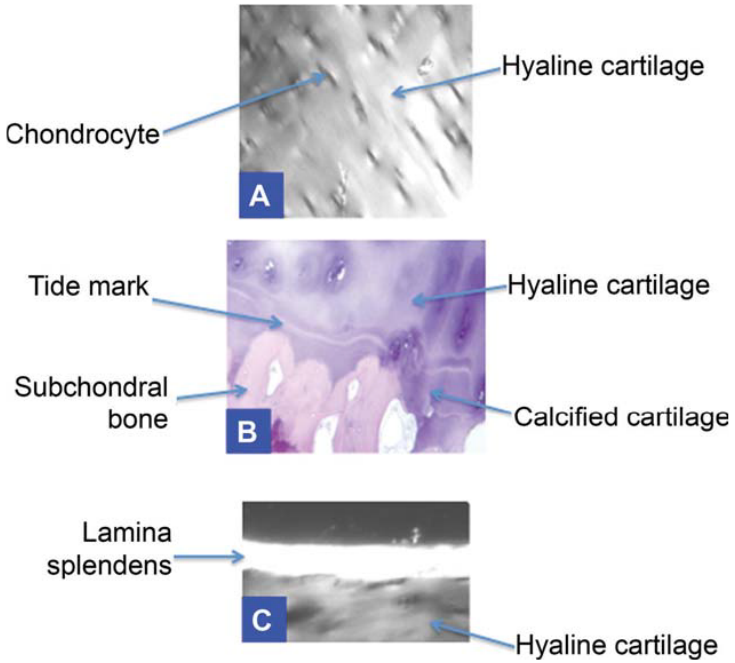

Figure 1. Histological appearance of different zones of articular cartilage. **(A):** The typical glassy appearance of hyaline cartilage under polarized light microscopy. **(B):** The calcified cartilage zone and tide mark at the cartilage–bone junction in hematoxylin and eosin stained sections. **(C):** The lamina splendens at the surface of articular cartilage under polarized light microscopy. All panels were viewed at ×10 magnification.

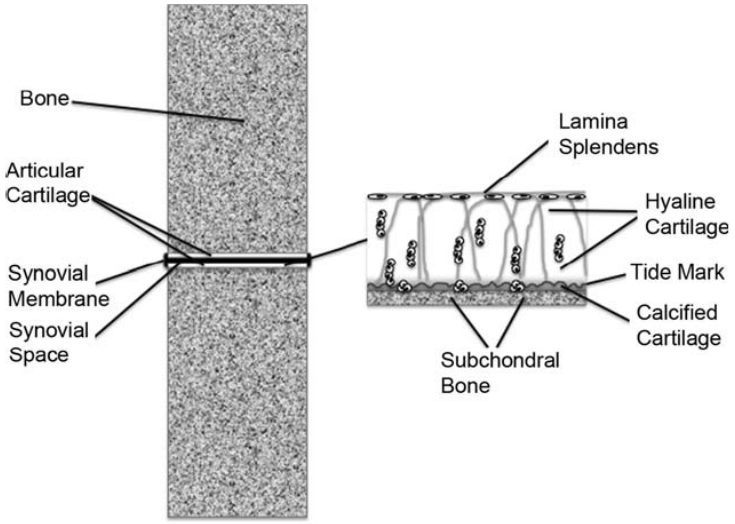

Figure 2. Diagram of the microstructure of articular cartilage found in the joints.

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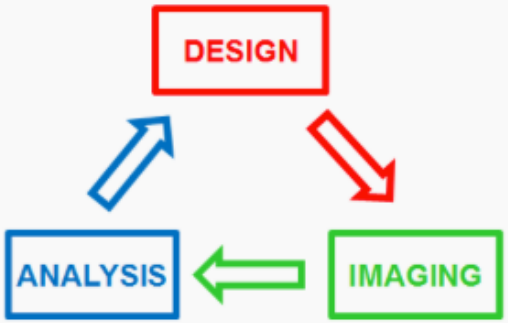
LIVERPOOL CCI
The Centre for Cell Imaging at the University of Liverpool

The Centre for Cell Imaging

At the CCI, we specialise in live-cell imaging, and support our users through the entire process, from experimental design, through image acquisition to post-acquisition data analysis.



Among our areas of expertise are:

- Epifluorescent Microscopy
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- Lifetime Imaging (FLIm)
- Fluorescence Recovery After Photobleaching Analysis
- Forster Resonance Energy Transfer Imaging, including FLIm/FRET
- Single Particle / Single Molecule Imaging and Analysis
- Super-Resolution Imaging
- Photothermal imaging for visualisation of nanoparticles

Light-sheet fluorescence microscopy

Light Sheet Microscopy is one of the greatest recent breakthrough technologies

Main advantages: light-sheet microscopy is faster and less phototoxic than other fluorescence microscopy techniques, making it ideal for studying living organisms and the biological processes that take place within them.

Method of the Year 2014

Light-sheet fluorescence microscopy can image living samples in three dimensions with relatively low phototoxicity and at high speed.

Just about everyone who has examined fluorescent samples under the microscope is aware of the constant struggle to have enough signal to see the labeled structures while also avoiding fluorophore bleaching. What may be less apparent, at least to those who image bright, robust or fixed samples, is how stressful and potentially toxic to living cells and tissues it is to illuminate them with high-intensity light. We have discussed this issue in a previous editorial (*Nat. Methods* **10**, 1135, 2013).

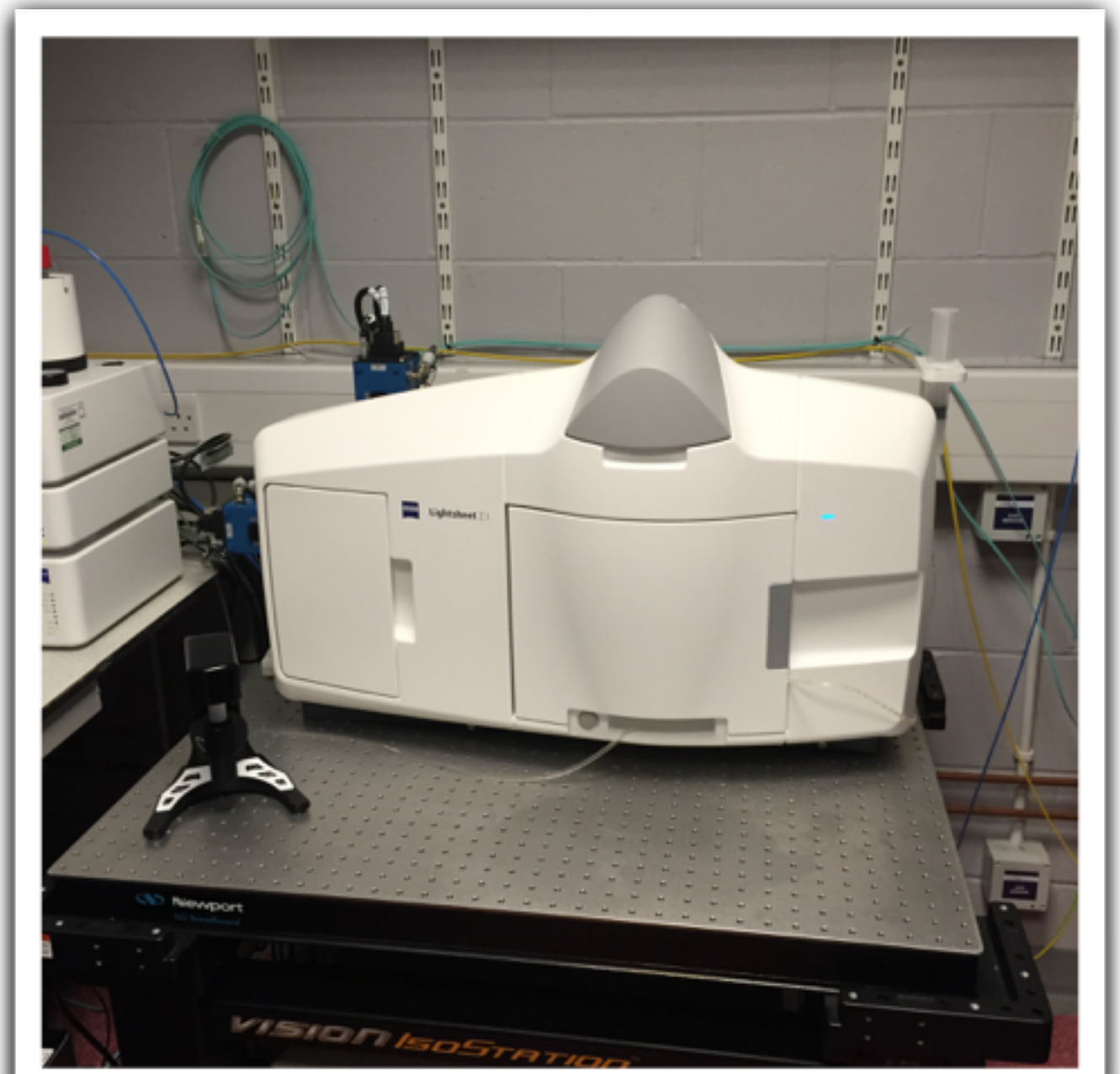
Light-sheet fluorescence microscopy enables relatively gentle imaging of biological samples with high resolution in three dimensions (3D) and over long periods of time. Especially when combined with high-speed cameras, it is fast enough to capture cellular or subcellular dynamics. For its potential for fast, relatively gentle, volumetric imaging of biological samples, we have chosen light-sheet fluorescence microscopy as Method of the Year 2014.

The fundamental idea behind the technique is beautifully simple. Instead of illuminating or scanning the whole sample through the imaging objective, as in wide-field or confocal microscopy, one illuminates the sample from the side with a thin (practically 2D)

Heidelberg, were surrounded by developmental biology laboratories generating and studying such fluorescent transgenics. The light-sheet renaissance thus required collaboration between the disciplines.

For the technology to be used to its fullest, this collaboration must continue. It is not trivial for biologists to implement light-sheet microscopy, as discussed in a Commentary by Pavel Tomancak and colleagues (p30); it requires creativity and interdisciplinary research teams. But with the release of commercial instruments, and efforts by the academic light-sheet development community to make the technology more accessible to users, imaging with light sheets is poised to give us new vistas into biological systems in ways we may not have thought possible.

Indeed, light-sheet fluorescence microscopy has recently been used to image living hearts and functioning brains and to track moving cells within developing embryos. It has been extended to multiview configurations and has been combined with super-resolution imaging, two-photon excitation and structured illumination. It can be used to powerful effect for fast 3D imaging in living cells and can be applied to optically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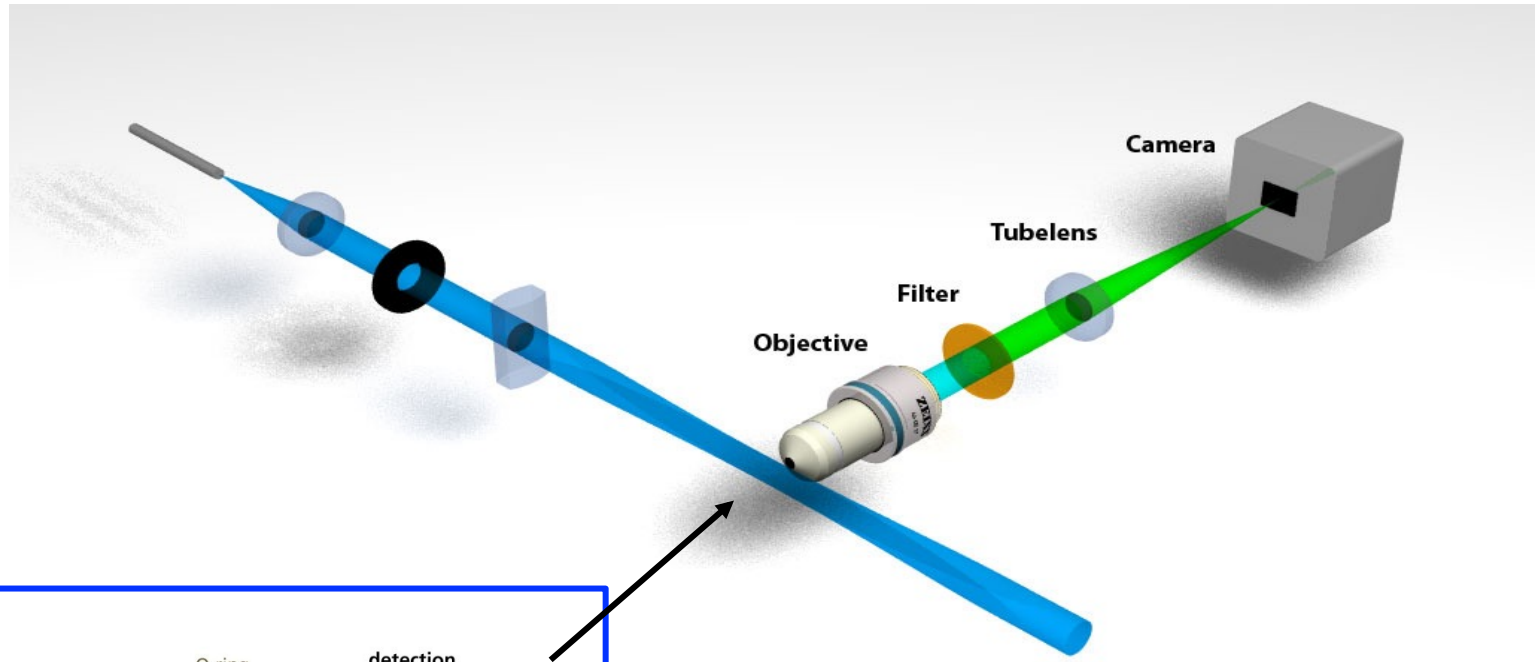
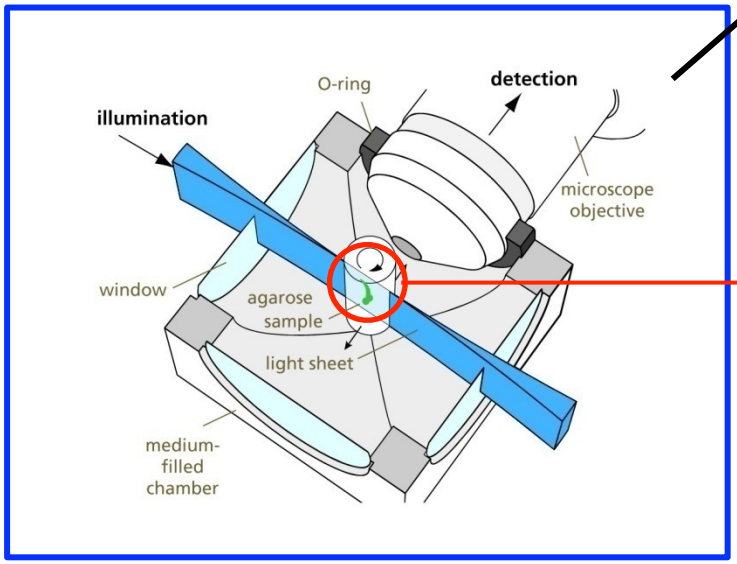
Lamina Splendens mounted on a Light-sheet setup





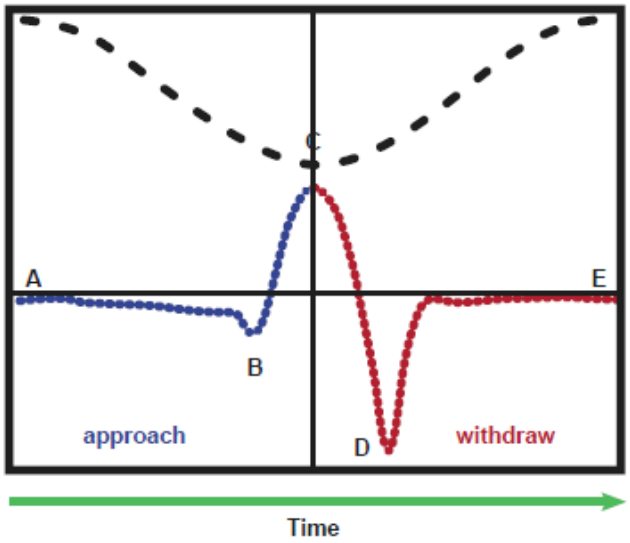
Lamina Splendens embedded in a cylinder of agarose

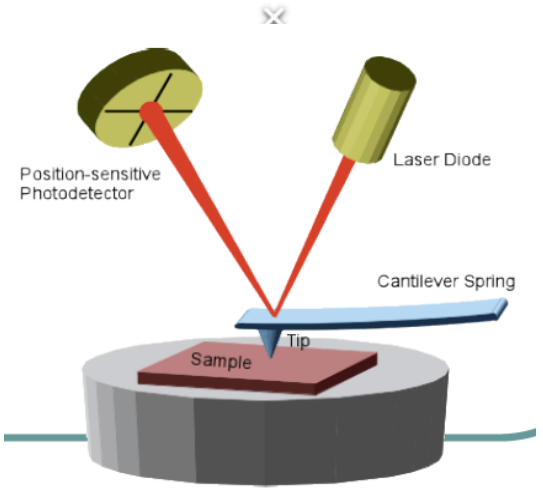
Source: Marco Marcello, Liverpool IIB/CCI

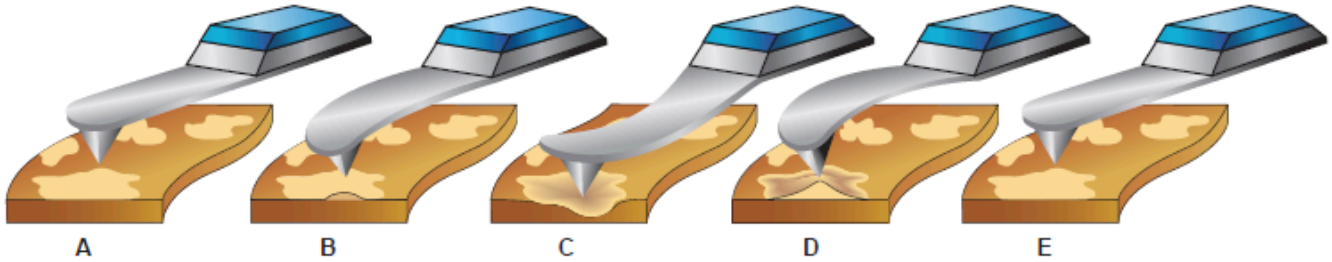
Atomic Force Microscope

Comparison between AFM and Electronic Microscopes

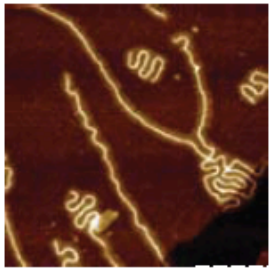
- Optical and electron microscopes can easily generate two dimensional images of a sample surface, with a magnification as large as 1000X for an optical microscope, and a few hundreds thousands ~100,000X for an electron microscope.
- However, these microscopes cannot measure the vertical dimension (z-direction) of the sample, the height (e.g. particles) or depth (e.g. holes, pits) of the surface features.
- AFM, which uses a sharp tip to probe the surface features by raster scanning, can image the surface topography with extremely high magnifications, up to 1,000,000X, comparable or even better than electronic microscopes.
- The measurement of an AFM is made in three dimensions, the horizontal X-Y plane and the vertical Z dimension. Resolution (magnification) at Z-direction is normally higher than X-Y.



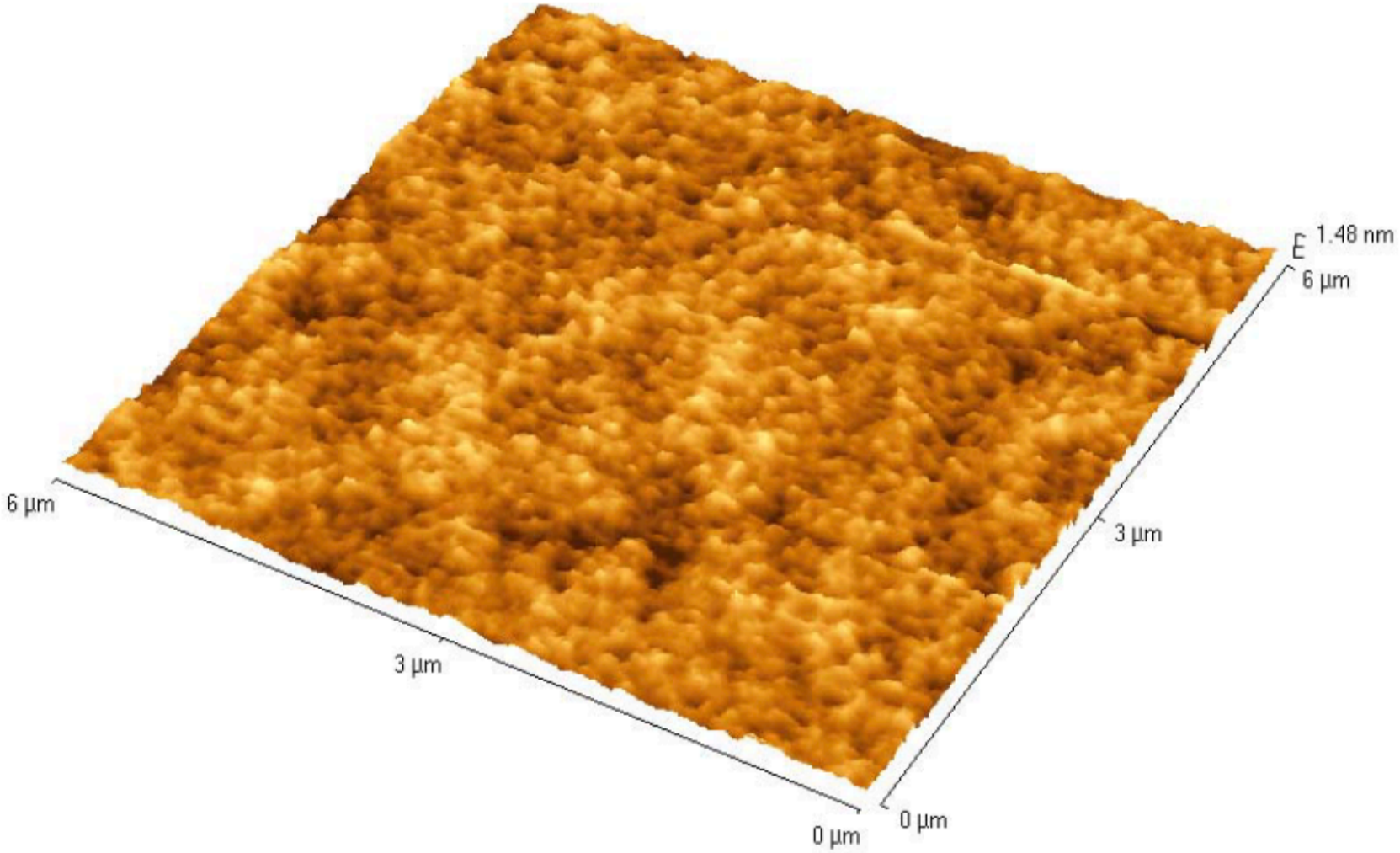




Polymer brush sample imaged on a MultiMode® 8 using ScanAsyst. Sample courtesy of S. Sheiko, University of North Carolina, Chapel Hill.



Clean glass surface: roughness ~ 0.8 nm



What is Lamina Splendens and What Does it Do?

- **The surface zone of articular cartilage is a critical component** of the mature tissue **because its collagen fibrils are oriented parallel to the plane of the tissue surface and so endow it with resistance to shear forces in the joint**.

- It is **also a critical component of the immature tissue because it drives appositional growth and may allow spontaneous healing when there is fibrillation at the surface**.

- It follows that **tissue-engineered cartilage implants that do not have a lamina splendens will not function mechanically in the same way as the natural tissue because they will lack resistance to shear forces**.

- Loss of the surface zone early in OA may be devastating because it will remove the main driver of the appositional growth of cartilage.

- Failure of repair of the lamina splendens may reflect a failure of this niche to function normally in the injured adult joint, leading ultimately to cartilage erosion and loss of joint function.

- Enriching the surface of engineered implants with mesenchymal cells derived from the synovial membrane may be a way of reconstructing the lamina splendens.

Hollander A, at al. Stem Cells and Cartilage Development: Complexities of a Simple Tissue. STEM CELLS 2010;28:1992–1996

Tissue Engineering of Gliding Zone and Lamina Splendens?

Tissue Eng Part A. 2010 Jan;16(1):317-25. doi: 10.1089/ten.TEA.2009.0104.

Mesenchymal progenitor cells derived from synovium and infrapatellar fat pad as a source for superficial zone cartilage tissue engineering: analysis of superficial zone protein/lubricin expression.

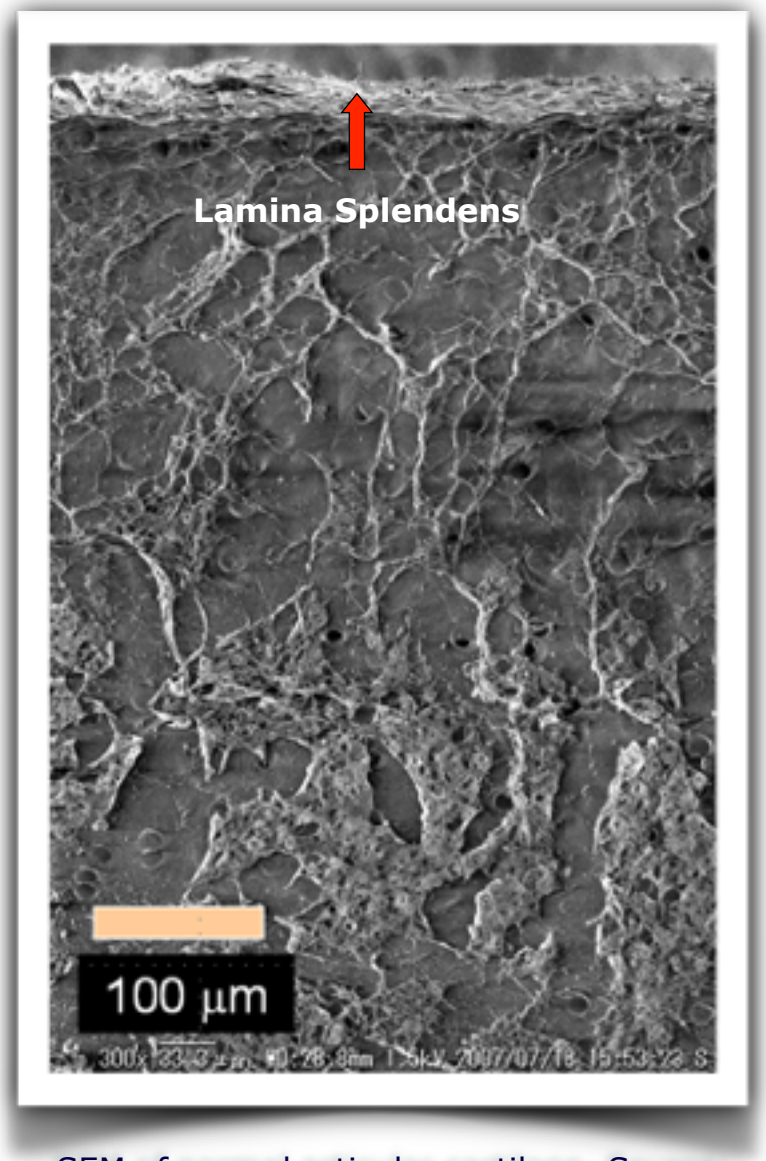
Lee SY[1], Nakagawa T, Reddi AH.

Author information

Abstract

Superficial zone protein (SZP) is a boundary lubricant of articular cartilage in joints. As SZP at the surface of articular cartilage plays an important role in the normal function of synovial joints, the localization of SZP-secreting cells at the surface of tissue-engineered cartilage is prerequisite. The aim of this study was to identify suitable progenitor cell sources for tissue engineering of superficial zone cartilage. We investigated whether mesenchymal progenitor cells (MPCs) from synovium and infrapatellar fat pad (IFP) have the potential for secretion of SZP after chondrogenic differentiation in an aggregate pellet culture system. SZP was immunolocalized in pellets from synovium-MPCs and IFP-MPCs. The enzyme-linked immunosorbent assay analysis of SZP demonstrated that chondrogenically differentiated synovium-MPC and IFP-MPC pellets secreted SZP into media. Real-time polymerase chain reaction analysis showed significant upregulation of SZP mRNA in synovium-MPC and IFP-MPC pellets after chondrogenic differentiation. The synovium-MPCs demonstrated the higher colony-forming, proliferative, and chondrogenic potential, and exhibited greater SZP secretion after chondrogenic induction compared with IFP-MPCs. In conclusion, both synovium and IFP are promising cell sources for tissue engineering of superficial zone cartilage.

In conclusion, both synovium and infra patellar fat pad are promising cell sources for tissue engineering of superficial cartilage zone



SEM of normal articular cartilage. Source: Norimasa Nakamura, Osaka, Japan

Summary

- Lamina splendens definitely exists as a separate layer and has a huge mechanical (tribological) role,
- SZP (Lubricin) plays an intrinsic and critical tribological role in boundary lubrication at the articular surface of cartilage,
- Interwoven collagen bundles in the lamina splendens integrate the obliquely oriented collagen fibres and those in the deeper region to form a 3D collagen scaffold, which anchors to the subchondral bone
- Provides resistance to shear forces
- Provides low-friction surface
- Drives appositional growth

Linkedin Lamina Splendens Interest Group
(dormant since 2011, until a few weeks ago)

From: LinkedIn <customer_service@linkedin.com>
Date: 23 April 2011 08:28:05 GMT+01:00
To: Vladimir Bobic <vbobic@kneeclinic.info>
Subject: **Congratulations on creating your new LinkedIn Group!**

LinkedIn

Hi Vladimir,

Congratulations on creating your new LinkedIn group!

Lamina Splendens Interest Group
http://www.linkedin.com/e/sryqga-gmu894yn-z/vgh/3883357/

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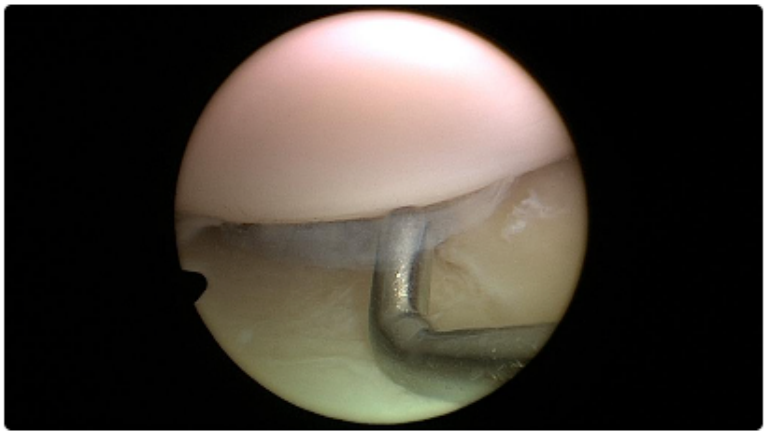
CKC #Arthroscopy: Lamina Splendens #LaminaSplendens



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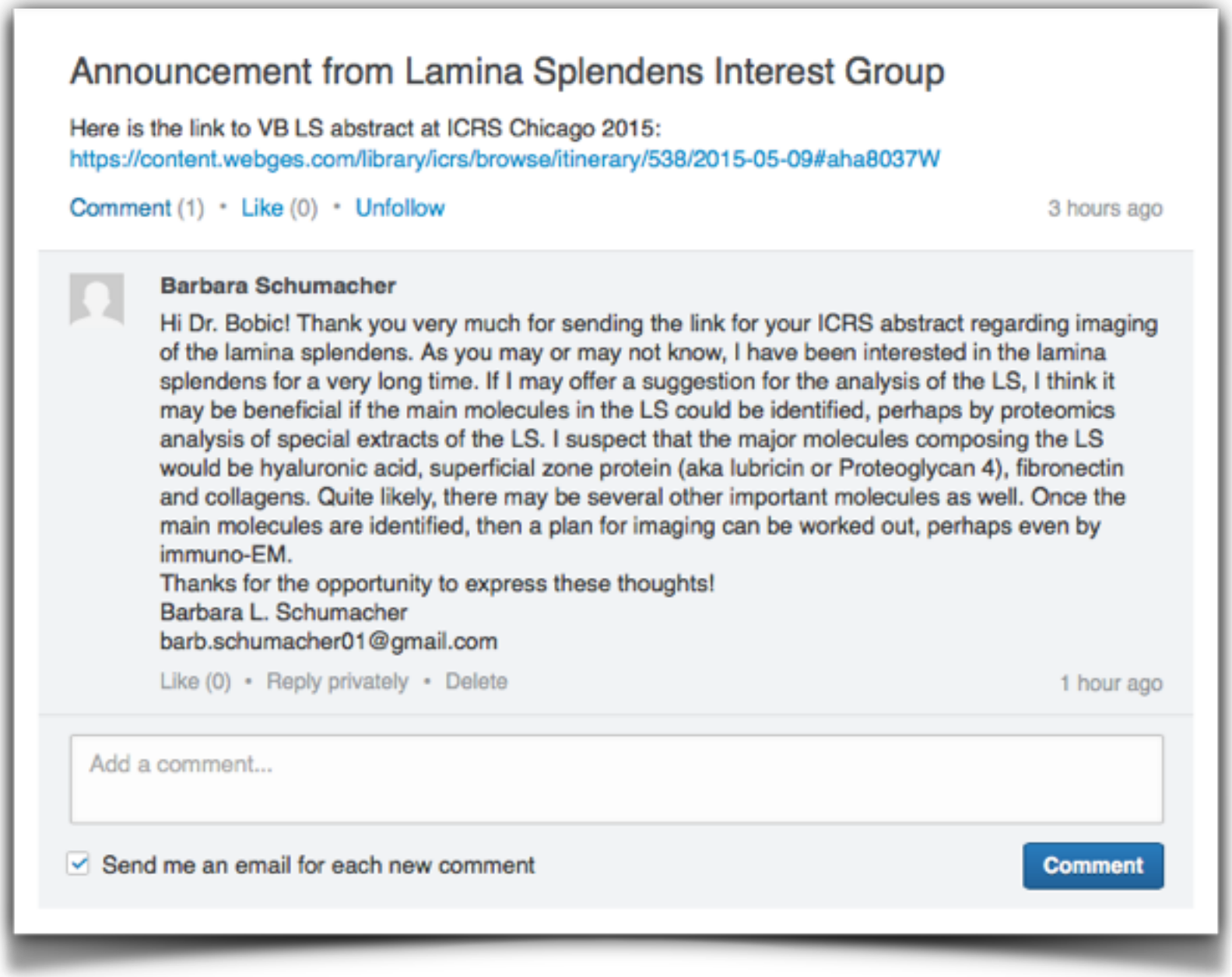

Announcement from Lamina Splendens Interest Group

Here is the link to VB LS abstract at ICRS Chicago 2015:
https://content.webges.com/library/icrs/browse/itinerary/538/2015-05-09#aha8037W

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Barbara Schumacher

Hi Dr. Bobic! Thank you very much for sending the link for your ICRS abstract regarding imaging of the lamina splendens. As you may or may not know, I have been interested in the lamina splendens for a very long time. If I may offer a suggestion for the analysis of the LS, I think it may be beneficial if the main molecules in the LS could be identified, perhaps by proteomics analysis of special extracts of the LS. I suspect that the major molecules composing the LS would be hyaluronic acid, superficial zone protein (aka lubricin or Proteoglycan 4), fibronectin and collagens. Quite likely, there may be several other important molecules as well. Once the main molecules are identified, then a plan for imaging can be worked out, perhaps even by immuno-EM.
Thanks for the opportunity to express these thoughts!
Barbara L. Schumacher
barb.schumacher01@gmail.com

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Stem Cells and Cloning: Advances and Applications

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REVIEW

Current perspectives in stem cell research for knee cartilage repair

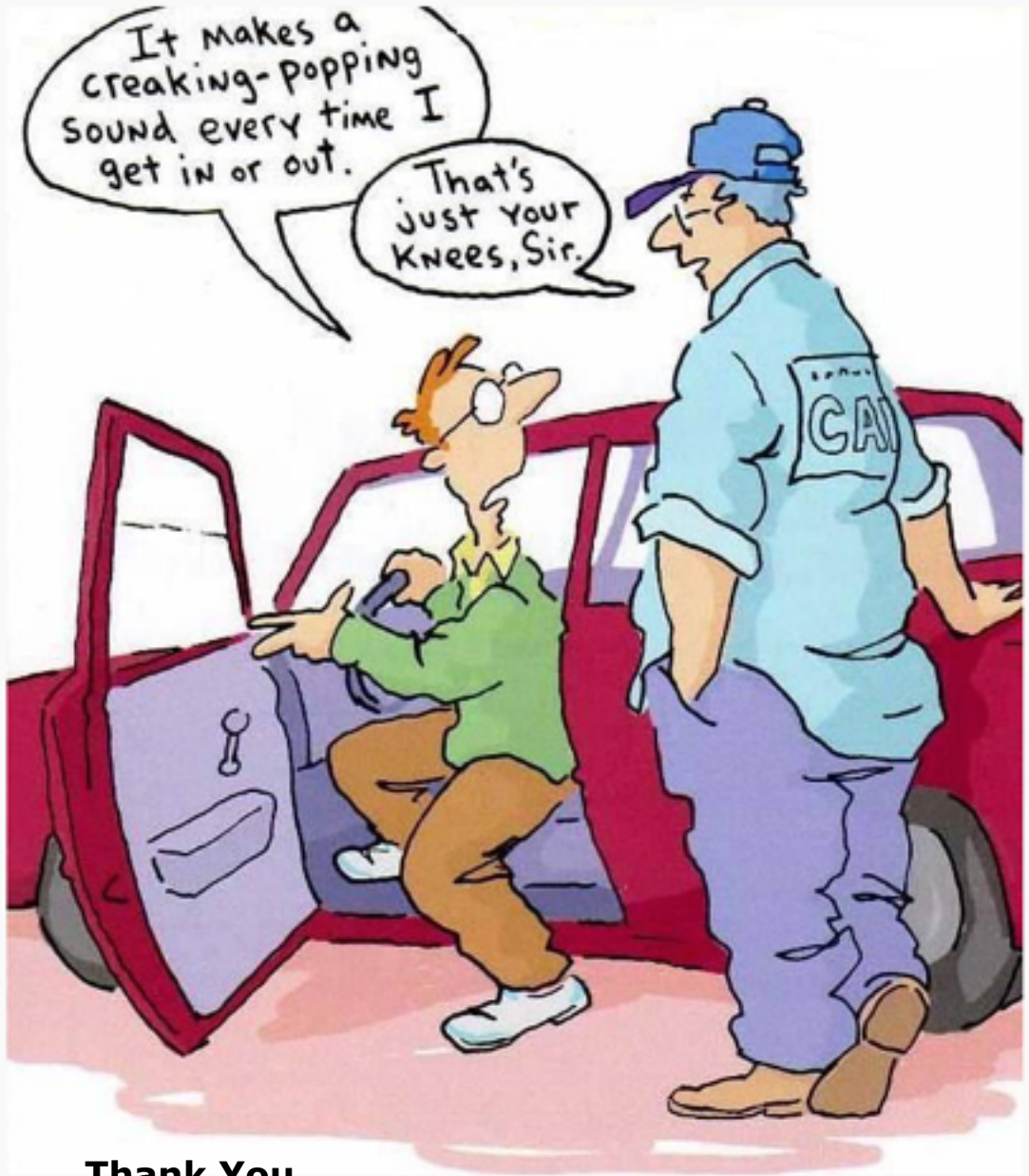
This article was published in the following Dove Press journal:
Stem Cells and Cloning: Advances and Applications
16 January 2014
Number of times this article has been viewed

Patrick Orth[1]
Ana Rey-Rico[2]
Jagadeesh K Venkatesan[2]
Henning Madry[1,2]
Magali Cucchiarini[2]

[1]Department of Orthopaedic Surgery, [2]Center of Experimental Orthopaedics, Saarland University Medical Center, Homburg, Germany

Abstract: Protocols based on the delivery of stem cells are currently applied in patients, showing encouraging results for the treatment of articular cartilage lesions (focal defects, osteoarthritis). Yet, restoration of a fully functional cartilage surface (native structural organization and mechanical functions) especially in the knee joint has not been reported to date, showing the need for improved designs of clinical trials. Various sources of progenitor cells are now available, originating from adult tissues but also from embryonic or reprogrammed tissues, most of which have already been evaluated for their chondrogenic potential in culture and for their reparative properties in vivo upon implantation in relevant animal models of cartilage lesions. Nevertheless, particular attention will be needed regarding their safe clinical use and their potential to form a cartilaginous repair tissue of proper quality and functionality in the patient. Possible improvements may reside in the use of biological supplements in accordance with regulations, while some challenges remain in establishing standardized, effective procedures in the clinics.

Keywords: cartilage repair, knee, focal defects, osteoarthritis, stem cells, clinical trials


It makes a creaking-popping sound every time I get in or out.
That's just your knees, Sir.
CAT

Thank You