Biomechanical and Biochemical Properties of Tissue Engineered Neocartilage Before and After Implantation

by

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ABSTRACT

A novel serum free culture system has been developed in an attempt to generate 3D hyaline like neocartilage independent of polymer scaffolds. This neocartilage is being investigated as a possible implant material for cartilage repair. Biomechanical and biochemical data was acquired for neocartilage grown from donors of a variety of ages and cultured for different durations. Grafts which had been implanted in sheep, as well as surrounding cartilage sites, were also biomechanically analyzed.

Neocartilage from younger ovine donors was stiffer than that from more mature ovine donors. Longer culture times also yielded stiffer ovine and human constructs. The use of tissue transglutaminase in fixing the graft to the defect site may have aided healing, although the mechanism is unclear. Graft stiffness was not found to significantly increase with healing time; however, more samples are needed to confirm this trend. Cartilage surrounding the graft site and from the contralateral joint was found to be significantly affected; eight weeks post-operation, mechanical compressive stiffness dropped and shear stiffness rose. Twenty-six weeks post-operation, the stiffness returned to levels found in control sheep.

Thesis Supervisor: Alan J. Grodzinsky
Title: Professor of Electrical, Mechanical, and Biological Engineering

Acknowledgements

First and foremost, I want to thank my advisor, Professor Alan Grodzinsky, for being a wonderful teacher and mentor these past two years. Many thanks also to Eliot Frank and Han Hwa Hung for all their help in the laboratory. I would also like to acknowledge my collaborators from Isto Technologies; without Joseph Feder, Bob Spiro, Davis Adkisson, Neil Kizer, and Jena Strauss-Schoenberger, this study would not have been possible. Finally, I would like to thank Robin Friedman, Parth Patwari, Nora Szaz, Stephanie Lin, Laurel Ng, Delphine Dean, and everyone else from the Continuum Electromechanics Lab for their time and support.

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Chapter 1 - INTRODUCTION

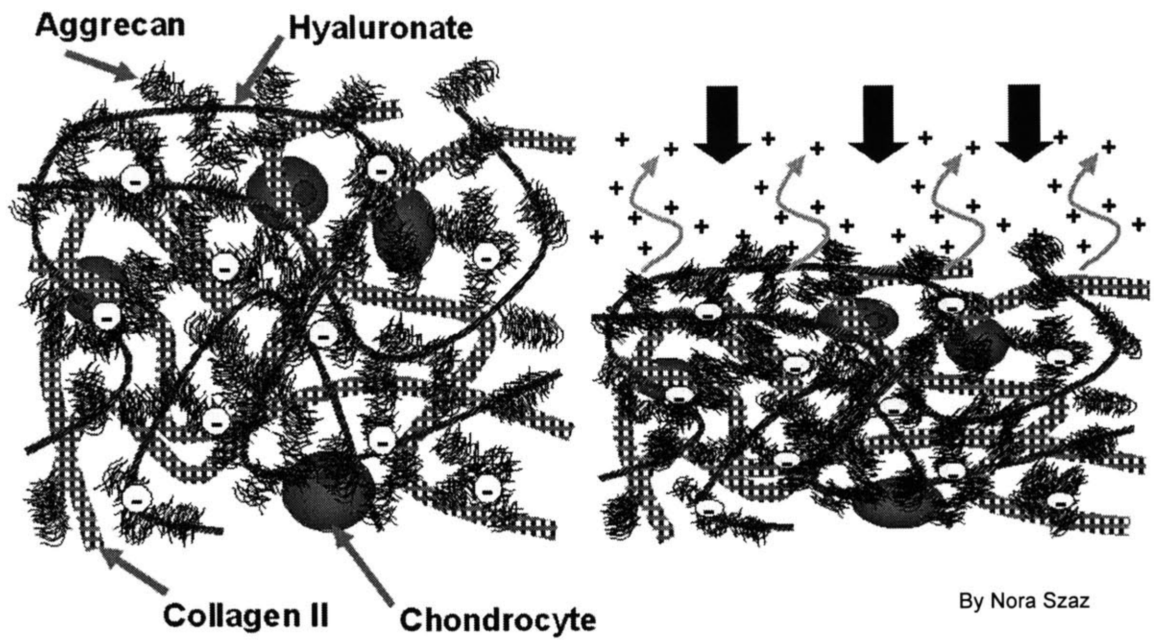
Background

Articular cartilage is the dense connective tissue that covers certain areas of bone. It serves as a shock absorber, softening the impact during loading. Cartilage consists of chondrocytes embedded in an extracellular matrix (ECM) of type II collagen, aggrecan, and highly charged proteoglycans. The components of the ECM are key to cartilage withstanding the complex compressive, tensile, and shear forces encountered in joints.

Aggrecan is a large aggregating chondroitin sulfate proteoglycan. A monomer of aggrecan consists of a protein backbone, on which 100 – 150 chondroitin sulfate glycosaminoglycan (cs-GAG) chains and 30-60 keratin sulfate chains are attached. Up to 100 individual aggrecan monomers bind via a link protein to hyaluranon to form a large aggregate that has a molecular size up to 800 MDa. These aggregates make up approximately 10% of the wet weight of cartilage.

Glycosaminoglycan (GAG) chains, a major component of aggrecan, are linear polymers of repeating disaccharides with hexosamine, carboxylate, and/or sulfate ester functionalities. In cartilage, these functionalities cause aggrecan to have a high anionic charge density, such that when compressed, they exert a high swelling pressure on the collagen fibrillar network.

Mechanical Properties of Articular Cartilage



Cartilage is a negatively charged, viscoelastic material in which the proteoglycans are fixed negative charges. Compression of cartilage results in deformation of chondrocytes and the extracellular matrix. Repulsion between charged proteoglycans contributes to stiffness, and resulting fluid flow induces streaming potentials and currents. Tensile strength is a function of the collagen fibrillar network.

The mechanical properties of cartilage can change with time. It has been observed that chondrocytes can respond to various physical stimuli by altering the ECM. Static mechanical compression of cartilage explants in vitro decreases proteoglycan and protein synthesis [1-5] and delays the high affinity binding of newly synthesized aggrecan to hyaluranon [6]. Dynamic compression can increase biosynthesis [7], and large amplitude dynamic compression can induce degradation and loss of matrix [8].

These in vitro data sets indicate that cartilage is in fact a complex feedback system wherein chondrocytes respond to loading by altering the ECM. This in turn alters the mechanical properties, which changes the loading on the cells… and the cycle continues.

Natural Healing of Cartilage Injury

Cartilage is avascular, alymphatic, and has low cell density. Chondrocytes do not easily proliferate, therefore cartilage injuries generally do not heal well. Further complications are caused by complex mechanical loading of joints; a change in the surface of the cartilage also causes a change in the loading profile, possibly affecting the remaining chondrocytes.

Once chondrocytes are damaged or lost, the surrounding matrix gradually degenerates. Without help, the body is not able to repair these defects. For this reason, the area of tissue engineered cartilage is of great interest to medicine.

The Challenges of Cartilage Engineering

Tissue engineering uses a combination of cells, scaffolds, DNA, and/or protein to restore injured or diseased tissues and organs. Because of the complex nature of cartilage, the quest to create cartilage implants is not straightforward. How can we create a construct that not only biologically heals into the wound, but also integrates and responds to loading like the surrounding cartilage? To answer this, many factors must be taken into account. What cell source is best? Should the cells be seeded in a scaffold or not? How can mechanical and biochemical viability be ensured? There exists a wealth of research aimed at answering these questions.

Cells impart regenerative properties to a cartilage construct; extracellular matrix that is secreted is not only important for the development of the original construct, but for long term maintenance after implantation. There are a number of cell sources: autologous (from patient's own cells), allogeneic (from another human's cells), or xenogeneic (from another species' cells). Ideally, autologous cells would be used to prevent immunological rejection. However, due to high donor site morbidity, generally only a small amount of chondrocytes can be harvested. Expansion of the cells in vitro is therefore an important but difficult step; chondrocytes have a tendency to dedifferentiate upon repeated passaging. [9]

The scaffold both provides short term mechanical stability and serves as a template for the organization of the developing construct. Important criteria for a cell scaffold include: an environment conducive to cell adhesion and growth; non-toxicity in vivo of the scaffold or its degradation products; at least 90% porosity, providing maximum surface area for cell-scaffold interactions, maximum space for ECM regeneration, and minimal diffusion constraints during culture; the tendency to degrade and resorb after sufficient tissue regeneration; and an adjustable degradation rate to match tissue regeneration. Most importantly, in cartilage tissue engineering, the scaffold provides a 3D environment which helps maintain the chondrocytes' phenotype.

Considerable research has been done to characterize the ability of agarose, alginate, collagen I and II, polylactic acid (PLA), polyglycolic acid (PGA), and fibrin scaffolds to maintain chondrocyte phenotype and ECM biosynthesis. Several of these studies have focused on both mechanical and biochemical properties of different cell-seeded scaffolds.

One of the earliest examples of cell seeded scaffolds used polyglycolic acid (PGA) mesh with chondrocytes. [10] PGA scaffolds have since been seeded with both bovine and human articular chondrocytes, and successfully grown into cartilaginous implants in vivo and in vitro [11]. Unfortunately, PGA scaffolds are capable of only a small range of mechanical properties, and degrade quickly upon exposure to aqueous media. A potential solution is coating fibrous PGA meshes with polylactic acid (PLA), adding considerable mechanical stability. However, this also results in decreased cell adhesion and lower rates of proliferation after cell seeding [12]. There is also literature indicating that PGA and PLA degradation results in considerable release of acidic by-products, resulting in inflammatory reactions [13-16]. These results seems to suggest that cartilage constructs may require other stiffer scaffolds.

The behavior of chondrocytes seeded in agarose gels has been studied extensively. Young bovine chondrocytes retain their phenotype very well in agarose, and can create enough ECM in about a month to steadily increase equilibrium modulus and dynamic stiffness over five times to about 25% of that seen in native cartilage. Biosynthetic rates are initially high, and, after a month, settle down to levels similar to those found in native cartilage [17]. It has also been found that applying an "exercise regimen" of dynamic loading to agarose constructs can cause a long term increase in both stiffness and biosynthesis, while applying static compression can cause long term decrease in stiffness and biosynthesis. [18,19] However, not much work has been done in vivo; agarose has mainly been used as a model in which chondrocytes phenotype is maintained for in vitro studies.

Alginate has also been used as a model for maintaining chondrocytes phenotype in vitro [20]. There has been extensive study of alginate as a scaffold for cartilage implants. Injection molded cell-seeded alginate constructs have been grown in-vivo for as long as 30 weeks; proteoglycan synthesis increased to about 60% and equilibrium modulus increased to about 15% of native cartilage values [21]. Alginate gels and sponges have also been successfully modified with high density of adhesive ligand (arganine-lycine-aspartic acid, RGD) and sodium hyaluronate to yield cell seeded constructs with highly cellular cartilaginous matrix [22, 23]. However, alginate has poor biocompatibility, and a lack of biodegradability, both of which can cause potential problems. To circumvent this issue, several recent studies have looked at using alginate as a temporary scaffold in which to foster chondrocyte proliferation and ECM synthesis. After a period of in vitro culture, the alginate is dissolved, and the cells along with their cell associated matrix are either seeded on a second scaffold (fibrin, PGA/PLA) or cultured on a tissue culture insert [24, 25, 26].

Because collagen is an integral part of normal articular cartilage, there has been much work using various collagen I and II gels or sponges as cell scaffolds. Chondrocytes have been shown to retain their phenotype and secrete ECM when cultured in collagen I gels [27, 28], and have also been used to repair cartilage defects in small animals [29, 30, 31]. However, collagen I is usually only found in diseased or damaged articular cartilage. Additionally, it is common laboratory practice to inject collagen I into joints to trigger osteoarthritis. On the other hand, collagen II is a predominant component of healthy articular cartilage. In vitro studies comparing collagen I and collagen II scaffolds concluded that cells in type II scaffolds secreted more ECM and had higher proliferation rates [32]. Collagen II constructs have been shown to greatly aid articular cartilage defect healing in canines; however, 15 weeks after implantation, the compressive stiffness of the repair tissue was 20-fold lower than that of native cartilage [31].

Self-assembling peptide gel scaffolds are another new approach to scaffolds for cartilage tissue engineering. KLD-12 peptide hydrogels have recently been explored as a potential scaffold. Upon casting, the compressive stiffness was 100-1000 times lower than native cartilage. These hydrogels, when cultured for a month, increased in equilibrium modulus and dynamic stiffness to 10%-33% that seen in native tissue and exhibited biosynthesis rates similar to those in agarose [33].

Implantation of the scaffolds previously discussed involves shaping the construct and somehow fastening them into the cartilage defect. The constructs can be delicate, making implantation difficult. Injectable constructs eliminate these complications. For instance, chondrocytes can be suspended in fibrinogen, and then injected into a defect while polymerizing with thrombin, such that the construct solidifies into the shape of the defect.[34]. A potential problem with this method is that it requires a sufficient number of chondrocytes, necessitating either large amounts of donor tissue, or in vitro multiplication of chondrocytes.

Regarding cell preparation, it is hard to passage chondrocytes in vitro from small samples. Studies have shown that chondrocytes, when grown in monolayer, tend to flatten and dedifferentiate [9]. Traditional cell culture techniques involve using serum-supplemented media, which may somehow be involved this dedifferentiation. Serum provides growth factors, hormones, transferin, selenium, and other factors conducive to cell growth and proliferation. However, there are severe limitations with animal sera. Because it is so complex, there is considerable lot-to-lot variation. Serum can cause immunological rejection after implantation, and in some cases can be toxic to cells. Ideally, one could use autogenous tissue that is grown in the patient's own sera to avoid some of these issues, but this is a potentially complicated solution. Therefore, culturing chondrocytes in serum-free media is preferable. Several studies have shown that chondrocytes cultured in various supplemented serum-free media can proliferate at rates at least as high as in media containing serum while retaining their phenotype [35, 36, 37]. The optimal combination and concentration of growth factors remains to be found.

Depending on the cell source and scaffold, the culture conditions (media type, compression duties) and culture lengths required to attain certain mechanical/ biochemical conditions will vary. Finally, at what point mechanically or biochemically is the construct ready to be implanted? How long till implant will heal? Under what loading conditions should the implant be subject to for maximum healing? Clearly, these are questions which must be looked into before the products of cartilage engineering are successfully used in humans.

A New Method

A novel serum free culture system has been developed in an attempt to generate 3D hyaline like neocartilage independent of polymer scaffolds [38]. This neocartilage is being investigated as a possible implant material for cartilage repair. Previous studies have shown that chondrocytes derived from juvenile human cartilage can be grown into neocartilage that has biochemical and morphologic properties reflective of juvenile cartilage-like tissue [38].

As discussed previously, it is advantageous that the implants have sufficiently robust mechanical properties to enable manipulation at the time of implantation, and to allow development of mechanical and biochemical properties relevant to hyaline-like cartilage for use in repair of articular cartilage defects. Factors which may affect biological, biochemical, and mechanical properties include the source and age of cells used in the construct, and the duration of neocartilage culture prior to implantation.

Objectives and Hypotheses

Our first objective was to characterize the biomechanical properties of neocartilage constructs from human/ovine donors of different ages, cultured over a range of times, and to compare these biomechanical properties to biochemical composition. Our hypothesis was that cells from young human or animal donors cultured for sufficient time periods would lead to mechanically stiffer constructs than those cultured from older sources.

Our second objective was to characterize the biomechanical properties of fetal lamb neocartilage constructs implanted into sheep. Two studies were performed at ISTO facilities in Wisconsin. They tested the ability of tissue transglutaminase (tTG) to aid in fixation of a neocartilage implant to a defect site over time in a sheep and conducted a long term study of the healing of neocartilage in sheep after weight bearing conditions. Our hypothesis was that grafts treated with tTG would be stiffer than untreated grafts and that long term healing would lead to mechanically stiffer grafts.

Chapter 2 – METHODS

Neocartilage Biomechanics

Materials

Three types of neocartilages were grown [38]: those seeded with 2nd or 3rd tri-mester **fetal lamb chondrocytes (FLC)** (4x10^6 cells/well), 1 week **lamb chondrocytes (LC)** (4x10^6 cells/well), and **human chondrocytes (HC)** (6x10^6 cells/well). (Table 1)

sample	day	N	m	n
LC15	117	3	12	6
LC 14	158	4	13	8
LC 8	208	1	3	0
FLC E1-2	82	2	12	4
FLC B1-3	89	1	3	2
FLC E	120	3	19	5
FLC B1-3	131	1	4	2
FLC D1-2	131	2	12	4
FLC A2-3	133	2	8	4
FLC A1	133	2	7	4
FLC D	207	3	18	6
FLC B1-3	311	2	10	4
HC 3 week	61	3	18	6
HC 3 week	96	3	19	6
HC 3 week	120	3	18	6
HC (1) 3 month	95	3	20	6
HC (1) 3 month	121	3	18	6
HC (2) 3 month	146	2	10	4
HC (1) 3 month	156	3	18	6

Table 1: Neocartilage Samples.
N = number of disks
m = number of compression cores
n = number of tension strips

Hyaline cartilage was dissected from the proximal tibia and distal femur bones of donors. Chondrocytes were isolated as previously described [38], and plated in 1 mL of Dulbecco's Modified Eagle's Medium with 10% fetal bovine serum. Cultures were then maintained with HL-1 Complete™ serum free medium to stimulate extracellular matrix synthesis.

FLC and LC disks were cultured from different animals for various durations; 3 week infant HC constructs from the same donor, 3 month infant HC constructs from 2 donors (Table 1), and HC disks from a series of 37 week gestation to 8 year donors. Construct disk thickness ranged from 150-600 um.

The approximately 1" diameter constructs were sent overnight from ISTO facilities in St. Louis, MO to MIT labs in Cambridge, MA. The material was immersed in 25 mL tubes filled with HL-1™ Complete serum free media, which in turn was kept cold with ice packs. Contents of HL-1™ Complete include: a modified Dulbecco's Modified Eagle's Medium/F12 base, Hepes buffer, known amounts of insulin, transferring, testosterone, sodium selenite, ethanolamine, various saturated and unsaturated fatty acids, proprietary stabilizing proteins, and β-glycerol phosphate; but do not include bovine serum albumin or other undefined protein mixtures [38].

All constructs were tested between 1 and 3 days of being removed from culture at ISTO facilities. Upon arrival, constructs were either immediately prepared for mechanical testing, or replaced in culture for no longer than 2 days until testing could be done. These constructs were cultured at 37° C, 5% CO_2, in serum free media, also provided by ISTO, which was supplemented with vitamin C (50ug/mL).

Preparation of Disks and Strips for Compression and Tension Tests

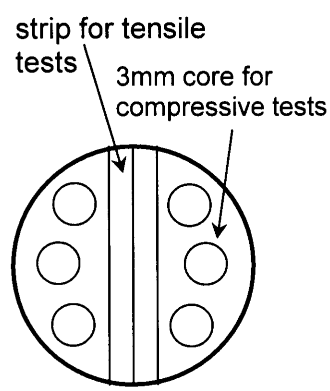


Figure 1. construct disk

Just prior to testing, constructs were placed in a bath of phosphate buffer solution (PBS) with EDTA and 1 ug/mL pepstatin to prevent degradation of the construct. About six circular cores (3mm) and two rectangular strips were removed from each 1" diameter construct with a 3mm dermal punch and straight razor, as pictured in Fig 1. Each core or strip thickness was assessed with a current sensing micrometer.

Mechanical Testing in Confined Compression and Tension Testing

Each 3mm core was statically compressed in two 5% strain steps and two 2.5% strain steps consecutively using a Dynastat Mechanical Spectrometer via methods previously described [39]. The linear component of the equilibrium stress-strain curve was used to determine the equilibrium confined compression aggregate modulus (H_A). At the final 15% static offset strain, the samples were dynamically compressed at 1% sinusoidal strain amplitude at frequencies in the 0.01 to 1 Hz range to determine the dynamic confined compressive stiffness.

Each strip was tested under tension, again by using a Dynastat Mechanical Spectrometer. One end of the specimen was clamped to a load cell; the other end was clamped to the displacement control. Two steps in strain of 5% were applied consecutively, followed by 2.5% strain increments up to 22.5% strain. The Young's modulus in tension (E_t) was determined for each specimen from the linear component of the equilibrium tensile stress-strain curve,

All tests were performed with the specimen immersed in PBS at room temperature, with EDTA and 1 ug/mL pepstatin added to inhibit degradation of the construct. The constructs were then frozen at -80° C and sent overnight back to ISTO facilities in St. Louis, MO for biochemical composition analysis.

Sheep Cartilage and Graft Biomechanics

Materials

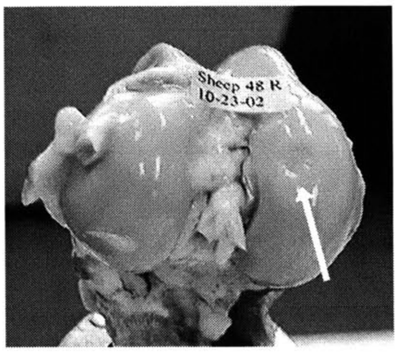


Figure 2A. Condyle with graft site

17 sheep were used in two studies. In all cases, an articular cartilage defect was created in a medial condyle of each sheep, into which neocartilage was implanted. Fig. 2A shows a condyle with an implant site, Fig. 2B shows a control condyle with no implant.

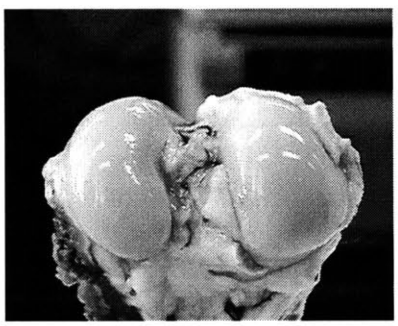


Figure 2B. Control Condyle

In the first study, the neocartilage was affixed to the defect using nylon absorbable suture and tissue transglutaminase (tTG) as a biological glue to aid in implant fixation [41] for 5 sheep. Only sutures were used for another 5 sheep. All animals were allowed to heal for approximately eight weeks in non-weight bearing condition; the operated leg was kept in a sling. Two animals from each group were then sacrificed for analysis, while three animals from each group were allowed to walk on the leg for approximately three weeks (weight bearing condition) before sacrifice (Table 2A).

In the second study, 7 sheep were implanted with neocartilage and allowed to heal for approximately eight weeks in non-weight bearing conditions. This was followed by eighteen weeks in weight bearing conditions (Table 2B).

sheep ID	weight bearing?	healing time (days)	Age (years)	Weight (kg)	tTG?
20	n	62	3	42	n
21	n	62	4	43	n
18	y	81	2	45	n
1	y	81	3.5	46	n
14	y	82	2	45	n
16	n	70	4	43	y
9	n	70	3	39	y
4	y	82	4	48	y
11	y	82	3.5	46	y
13	y	82	4	43	y

Table 2A. Sheep, study 1.

sheep ID	weight bearing?	healing time (days)	Age (years)	Weight (kg)	tTG?
			Not Available		
26	y	182			n
48	y	182			n
29	y	182			n
33	y	182			n
45	y	182			n
35	y	182			n
44	y	182			n

Table 2B. Sheep, study 2.

Upon sacrifice at the veterinary lab in Wisconsin, the femur from both the operated knee and the non-operated control knee were removed and sent overnight to MIT labs in Cambridge, MA. The knees were wrapped in gauze soaked in media, and kept cold with ice packs.

All cartilage samples were tested between 1 and 3 days after sacrifice. Upon arrival, constructs were either immediately prepared for mechanical testing, placed in PBS with EDTA and 1 ug/mL pepstatin (to inhibit degradation of the construct) for no longer than two days at 4°C until testing.

Preparation of Cartilage for Compression and Shear tests

A drill press and hack saw were used to remove 0.25" diameter cores from each condyle. Four cores were taken from both the operated and control knees: two from the medial condyle, and two from the lateral condyle. Therefore, eight cores were taken from each sheep: left medial a (LMa), left medial b (LMb), left lateral a (LLa), left lateral b (LLb), right medial a (RMa), right medial b (RMb), right lateral a (RLa), and right lateral b (RLb).

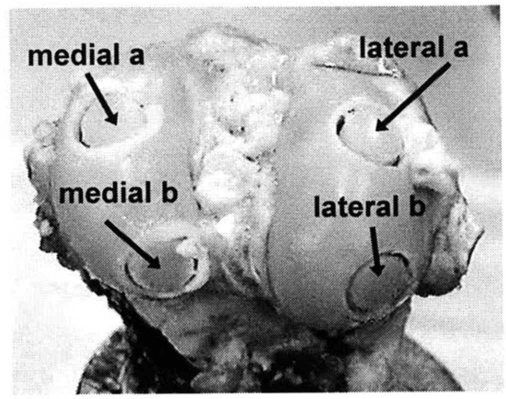


Figure 3. Sheep knee with cores

The top layer of articular cartilage was removed from each core with a sledge microtome. These slices (~480 um thick) were placed in a bath of phosphate buffer solution (PBS) with EDTA and 1 ug/mL pepstatin to prevent degradation of the construct. After shear testing, a 3mm dermal punch was used to create samples for compression testing.

Mechanical Testing in Confined Compression and Torsional Shear

The thickness of each 0.25" diameter slice was measured with a current sensing micrometer, and then placed in a custom built incudyne for shear testing [40]. The sample was first statically compressed to 15% strain and allowed to relax for a minute before undergoing dynamic shear at 1% sinusoidal strain amplitude at frequencies in the 0.1 to 1 Hz range to determine the dynamic shear modulus.

After dynamic shear testing, a 3mm core was removed from each slice. After determining the thickness with a current sensing micrometer, each 3mm core was statically compressed in two 5% strain steps and two 2.5% strain steps consecutively using a Dynastat Mechanical Spectrometer via methods previously described [40]. The linear component of the equilibrium stress-strain curve was used to determine the equilibrium confined compression aggregate modulus (H_A). At the final 15% static offset strain, the samples were dynamically compressed at 1% sinusoidal strain amplitude at frequencies in the 0.01 to 1 Hz range to determine the dynamic confined compressive stiffness.

All tests were performed with the specimen immersed in PBS at room temperature with EDTA and 1 ug/mL pepstatin to inhibit degradation of the construct. The samples were then frozen at -80° C and sent overnight back to ISTO facilities in St. Louis MO, for biochemical composition analysis.

Biochemistry

Colorimetric (DMMB binding) measurement of glycosaminoglycan (GAG) and hydroxyproline (hyPro) content were determined as previously described [38], after digestion of samples in papain buffer. Finally, these data sets were normalized to DNA content (Hoechst dye) [38].

Statistical Analyses

All statistical analysis was performed with SYSTAT v9.0 software. Multifactorial analyses of variance (ANOVA) were performed to examine the effects of independent variables of interest; Tukey / Bonferroni post-hoc and Student T-tests were used to compare data sets.

Chapter 3 - RESULTS

Neocartilage Constructs

Construct disk thickness ranged from 150-600 um, and was measured for each specimen (see Appendix A for details). FLC constructs were generally thicker than LC constructs. Neocartilage seeded with adult HC resulted in a cell monolayer that lacked sufficient matrix to be mechanically tested (data not shown).

The majority of the constructs received had largely smooth surfaces, as shown in Fig. 4A. However, constructs cultured from the 3 week human infant donor exhibited increasing amounts of "bubbling" or corrugation over time. As can be seen in Fig. 4B, at 120 days of culture, the corrugation had spread through the entire construct. Each individual bubble contained liquid media, such that 3 mm punches were flat, but bilayered.

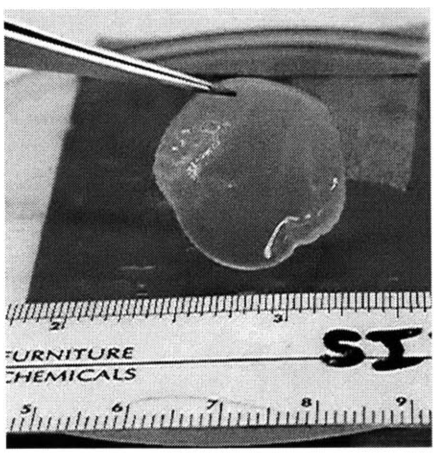


Figure 4A: Smooth construct

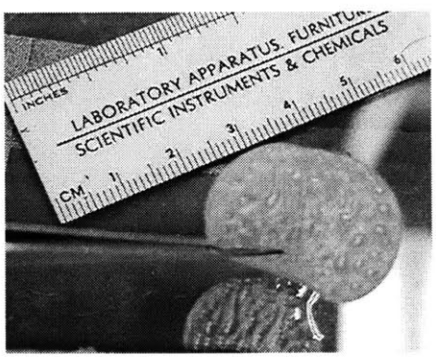


Figure 4B: "Bubbly" construct

Compressive Equilibrium Modulus (H_A)

In constructs cultured for 117-158 days, FLC neocartilage had higher H_A than LC neocartilage (Fig. 5A: $p<0.001$). The H_A of FLC neocartilage was significantly higher at 311 days than all other FLC neocartilage tested (Fig. 5B: ANOVA, Tukey post hoc, $p<0.001$). The H_A of 3 month HC construct did not change significantly over time, although construct H_A at day 156 was significantly higher than at day 95 (Fig. 5C: ANOVA, Tukey post hoc, $p<0.05$). The H_A of 3 week HC construct decreased significantly over time, and was much higher at day 61 than at days 96 and 120 (Fig. 5C: ANOVA, Tukey post hoc $p<0.001$).

The dynamic compressive stiffness of all constructs tested increased with increasing compression frequency, and the values at 1 Hz were about one order of magnitude higher than H_A (data not shown). These trends are consistent with known relative values of static and dynamic compressive mechanical properties of native cartilage explants [39].

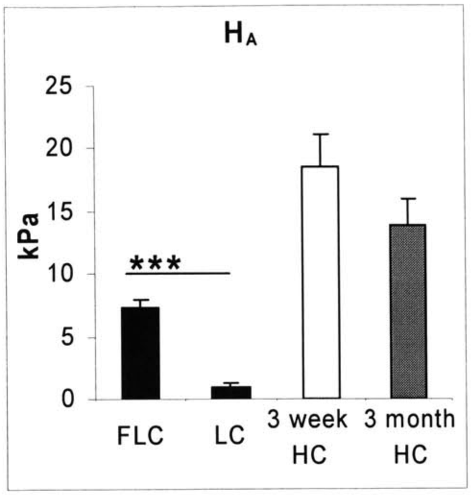


Figure 5A: Equilibrium modulus of constructs cultured for 117-158 days.

*** = p<0.001

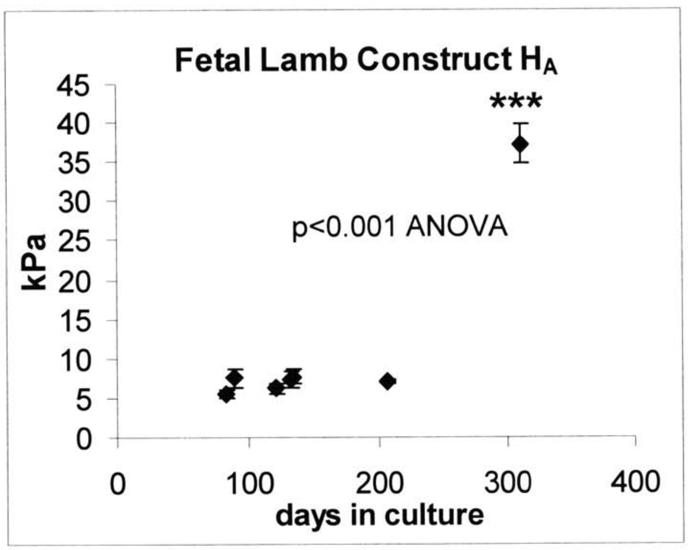


Figure 5B: Equilibrium modulus of FLC neocartilage over time.

*** = p<0.001

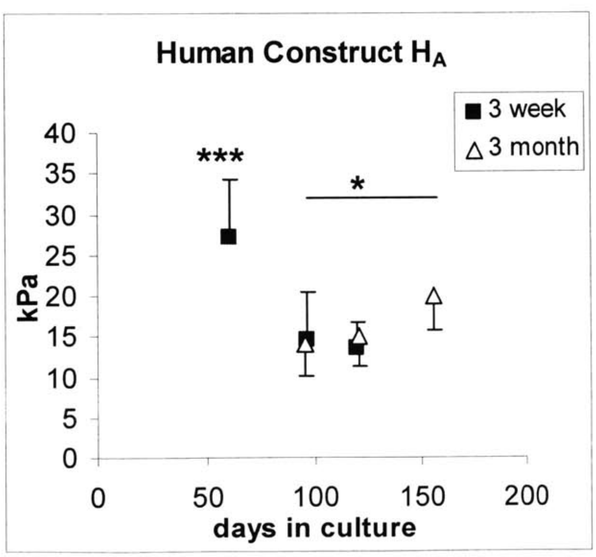


Figure 5C: Equilibrium modulus of HC neocartilage over time

*** = p<0.001

* = p<0.05

Dynamic Compressive Stiffness

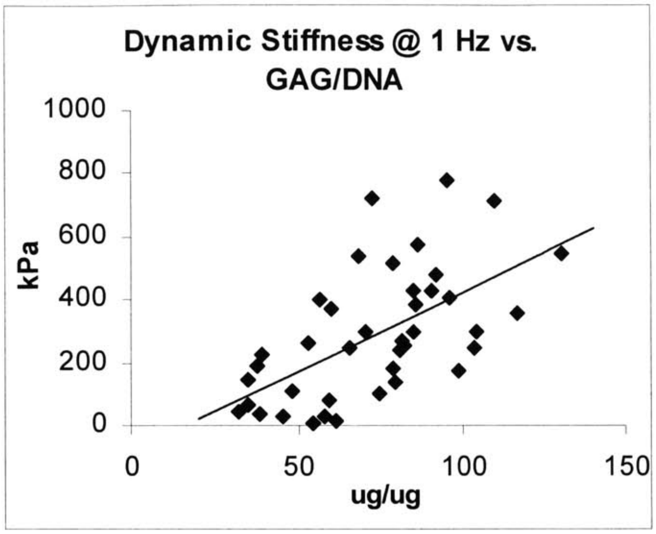


Figure 6: Dynamic stiffness of HC vs. GAG/DNA

Dynamic stiffness of the fetal-8-year series of HC specimens increased significantly with GAG/DNA concentration (Fig. 6: slope = 5.03 kPa, Rval = 0.592, $F_{val} = 20.8 > 4.08 = F_{crit}$)

Tensile Equilibrium Modulus

The E_t of FLC neocartilage was greater than that of LC neocartilage (Fig. 7A: $p<0.001$). E_t of HC neocartilage (3 month and 3 week pooled) was significantly lower than both FLC and LC neocartilage (Fig. 7A: $p<0.001$). The E_t of FLC neocartilage increased significantly with time in culture (Fig. 7B: ANOVA, $p<0.05$). The E_t of 3 week HC neocartilage increased significantly with time in culture (Fig. 7C: ANOVA, $p<0.05$). The E_t of 3 month HC constructs did not change significantly with time in culture (Fig 7C).

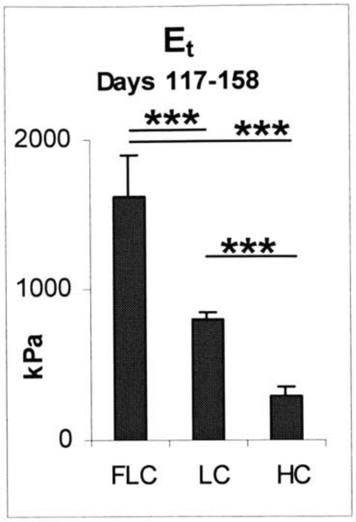


Figure 7A: Tensile modulus of neocartilage cultured for 117-158 days.
*** = $p<0.001$

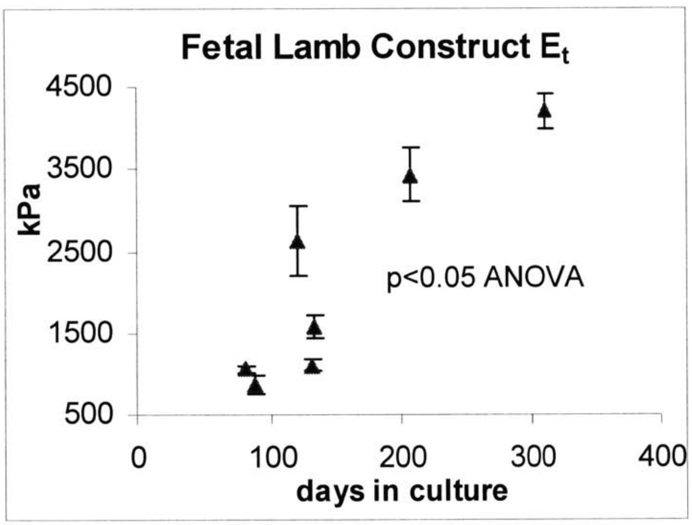
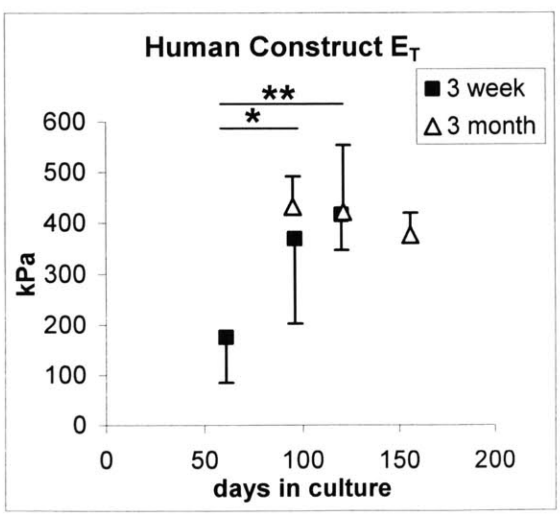


Figure 7B: Tensile modulus of FLC neocartilage over time.



p<0.05 ANOVA

Figure 7C: Tensile modulus of HC neocartilage over time.
** = $p<0.01$
* = $p<0.05$

GAG and Collagen Content: Donor Species and Age

In constructs cultured for 117-158 days, FLC constructs had significantly higher Hypro/DNA concentration than 3 month HC and LC (Fig. 8B, p<0.01, p<0.001). Both 3 week and 3 month HC constructs had significantly higher GAG/DNA content than both LC and HC (Fig. 8A: p<0.001).

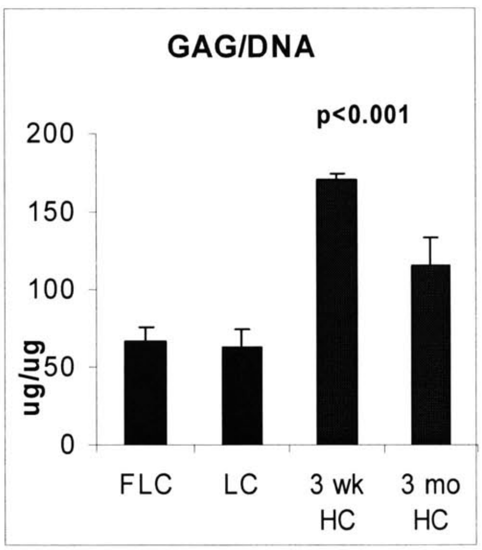


Figure 8A: GAG/DNA of 117-158 day constructs

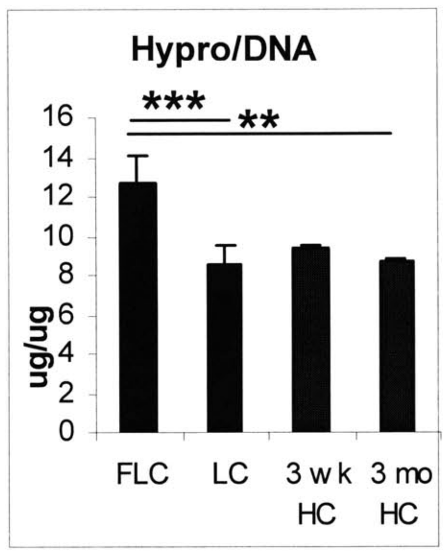


Figure 8B: Hypro/DNA of 117-158 day constructs
** = p<0.01
*** = p<0.001

Ovine GAG and Collagen Content: Timecourse

GAG/DNA in FLC and LC constructs tended to increase with time in culture (Fig. 9A: ANOVA, $p<0.001$). GAG/DNA for FLC constructs peaked significantly at 311 days (Fig. 9A: $p<0.01$). GAG/DNA in day 208 LC neocartilage was significantly higher than in day 158 LC samples (Fig. 9A: $p<0.05$). Hypro/DNA for FLC constructs increased with time (Fig. 9B: ANOVA, $p<0.01$) and peaked significantly at 311 days (Fig. 9B: $p<0.05$). Hypro/DNA for LC constructs did not significantly change with time (Fig 9B).

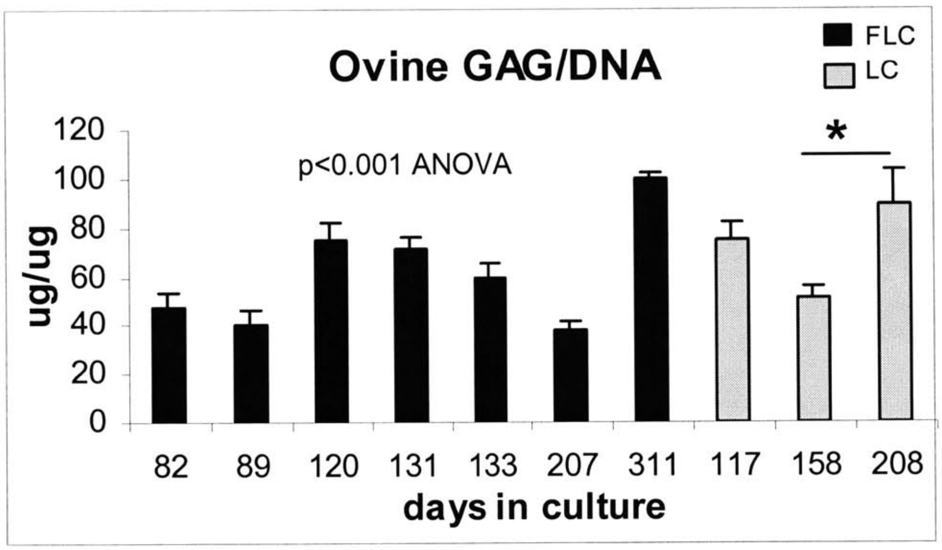


Figure 9A: GAG/DNA of ovine constructs over time. * = $p<0.05$

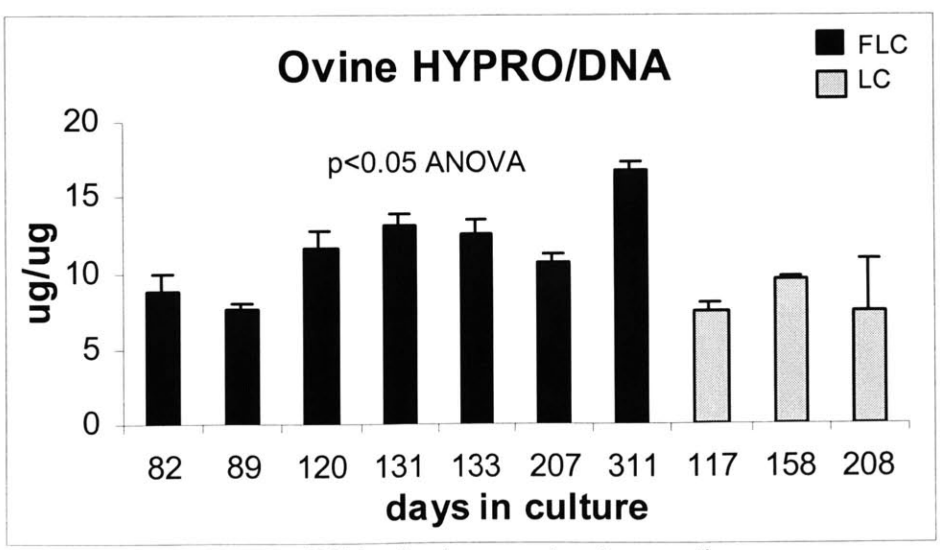


Figure 9B: Hypro/DNA of ovine constructs over time

Human GAG and Collagen Content: Timecourse

GAG/DNA in 3 week HC neocartilage increased significantly with time in culture (Fig.10A: p<0.001). GAG/DNA in 3 month HC construct also increased with time (Fig. 10A: p<0.05), especially from day 121 to day 146 (Fig. 10A: p< 0.05) but was consistently less than 3 week HC constructs of the similar culture duration (Fig. 10A: p<0.01). Hypro/DNA in 3 week HC neocartilage increased significantly with time in culture (Fig. 10B: p<0.001), especially from days 61 and 96 to 120 (Fig. 10B: p<0.01, p<0.001). Hypro/DNA in 3 month HC constructs did not change significantly with time (Fig. 10B).

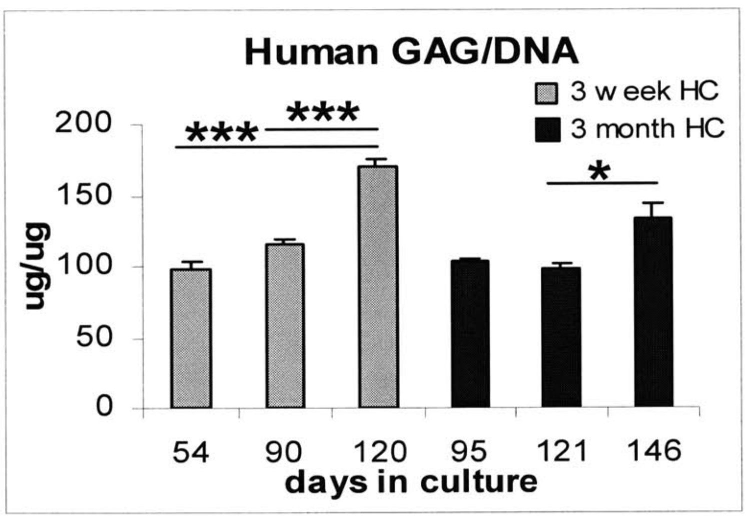


Figure 10A: GAG/DNA of HC neocartilage over time
* = p<0.05
*** = p<0.001

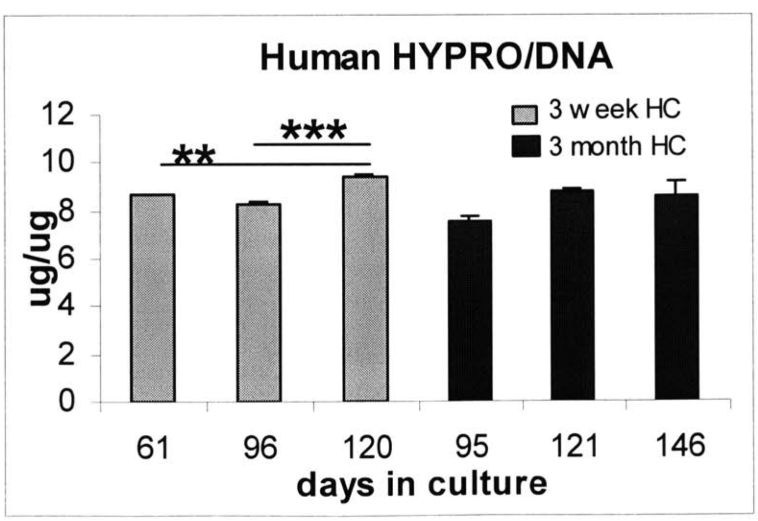


Figure 10B: Hypro/DNA of HC neocartilage over time
** = p<0.01
*** = p<0.001

Biomechanical/Biochemical Correlations

We attempted to correlate biomechanical data to biochemical data, by plotting H_A vs. GAG/DNA; dynamic stiffness vs. GAG/DNA; E_T vs. Hypro/DNA; H_A, dynamic stiffness, and E_T vs. dry weight; H_A, dynamic stiffness, and E_T vs. DNA. Some trends were apparent; for instance, increasing H_A and dynamic stiffness at 1 HZ seems to correlate with increasing GAG/DNA for FLC and 3 month HC neocartilage. However, there were not enough data points to make a truly meaningful regression. (see Appendix D)

Ovine Implants

Study 1

Both tissue transglutaminase (tTG) treated and untreated graft sites were visually different from the surrounding cartilage; the area was slightly depressed, with rough texture and soft consistency (Fig. 11). Great care was needed when removing the top layer of cartilage from the graft site.

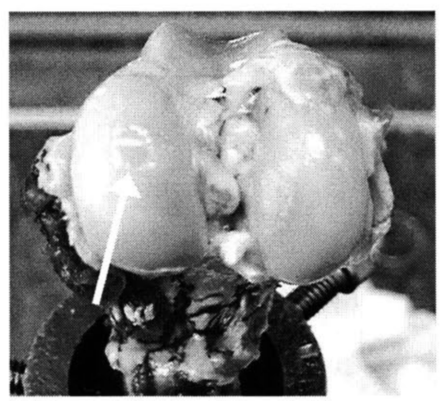


Figure 11: Condyle with graft. Also note the rough surface on the lateral condyle, which occasionally appeared on

Stiffness of Ovine Tissue From Different Sites: Both Studies

The equilibrium modulus, dynamic stiffness, and shear stiffness of cartilage taken from areas near the graft site and from the contralateral control sites did not vary significantly from each other in study 1 (ANOVA, Fig. 12A – Fig. 12C). The stiffness of cartilage sites from each sheep was pooled, and compared to the graft site. The graft site equilibrium modulus and dynamic stiffness were not significantly different from the the rest of the cartilage; however, the average shear stiffness of the graft sites was significantly lower than the surrounding cartilage (Fig. 12B: $p<0.05$).

In study 2, equilibrium modulus, shear stiffness, dynamic stiffness of surrounding cartilage also didn't vary from site to site (ANOVA, Fig. 12A – Fig. 12C). The stiffness of cartilage from each sheep was pooled, and compared to the graft site. On average, the graft site of study 2 animals was significantly softer in equilibrium modulus and dynamic stiffness (Fig. 12A, Fig 12C: $p<0.001$). Interestingly, the average shear stiffness for the graft sites in study 2 tends to be higher than other sites (Fig. 12B: $p<0.01$).

In general, cartilage from animals in study 2 had higher equilibrium modulus and dynamic stiffness than animals in study 1 (Fig. 12A, Fig. 12B: $p<0.01$) This trend appeared to be reversed in shear stiffness: at 1 Hz, study 1 cartilage was stiffer in shear, than study 2 cartilage (Fig. 12B: $p<0.05$). However, the graft sites were significantly stiffer in shear in study 2 than in study 1 (Fig. 12B: $p<0.05$)

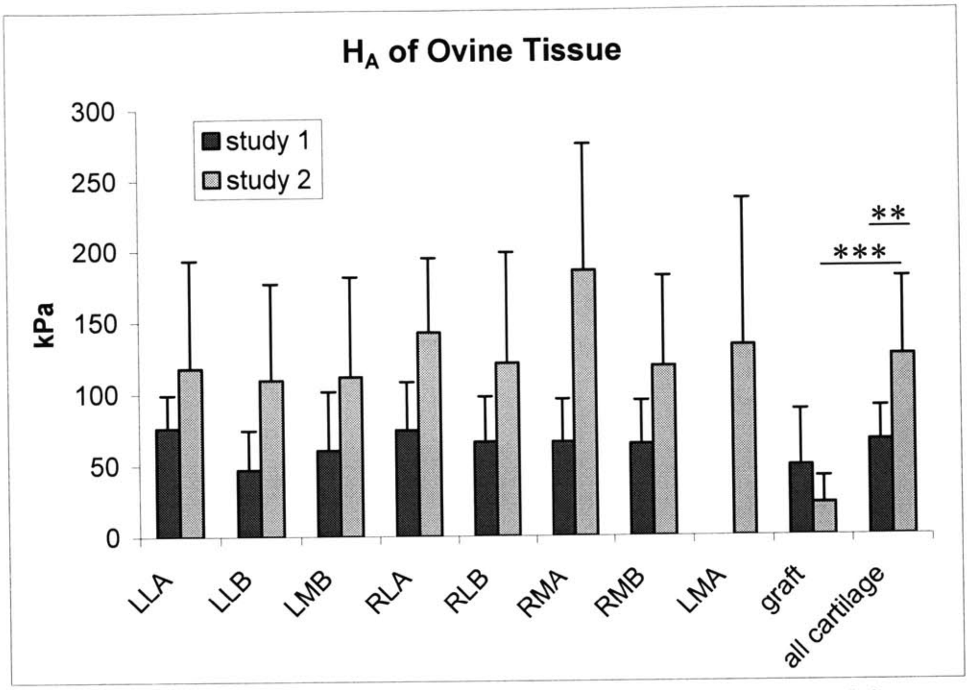


Figure 12A: Equilibrium modulus of ovine cartilage sites. (graft is usually LMA site, except for two sheep in which the graft was at RMA. RMA and LMA in graph are cartilage explants, not graft site)

*** = p<0.001; ** = p<0.01

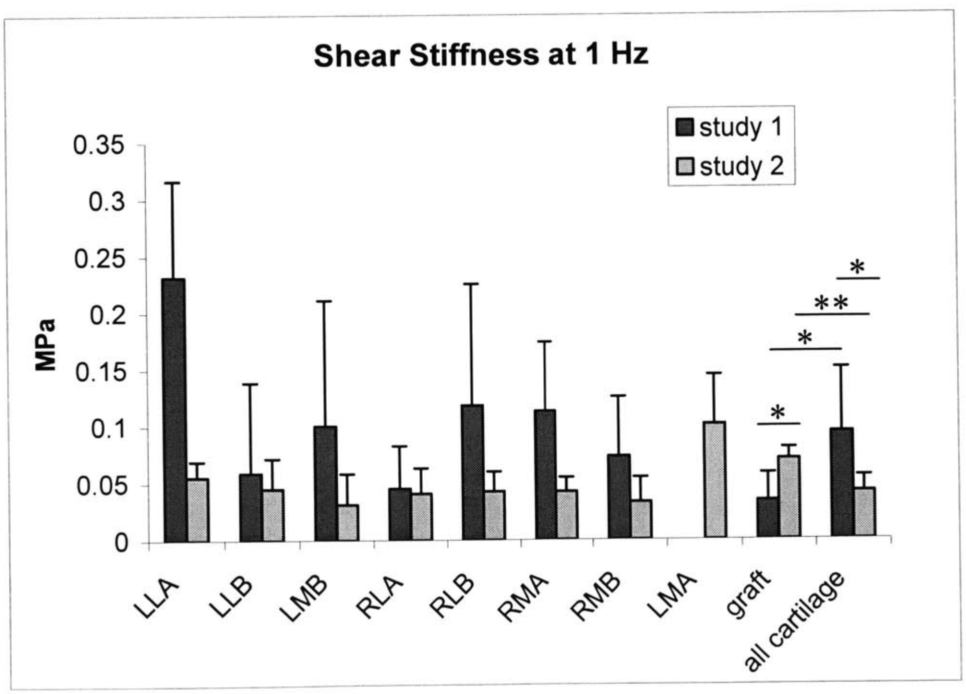


Figure 12B: Shear Stiffness of ovine cartilage sites. (graft is usually LMA site, except for two sheep in which the graft was at RMA. RMA and LMA in graph are cartilage explants, not graft site)

* = p<0.05; ** = p<0.01

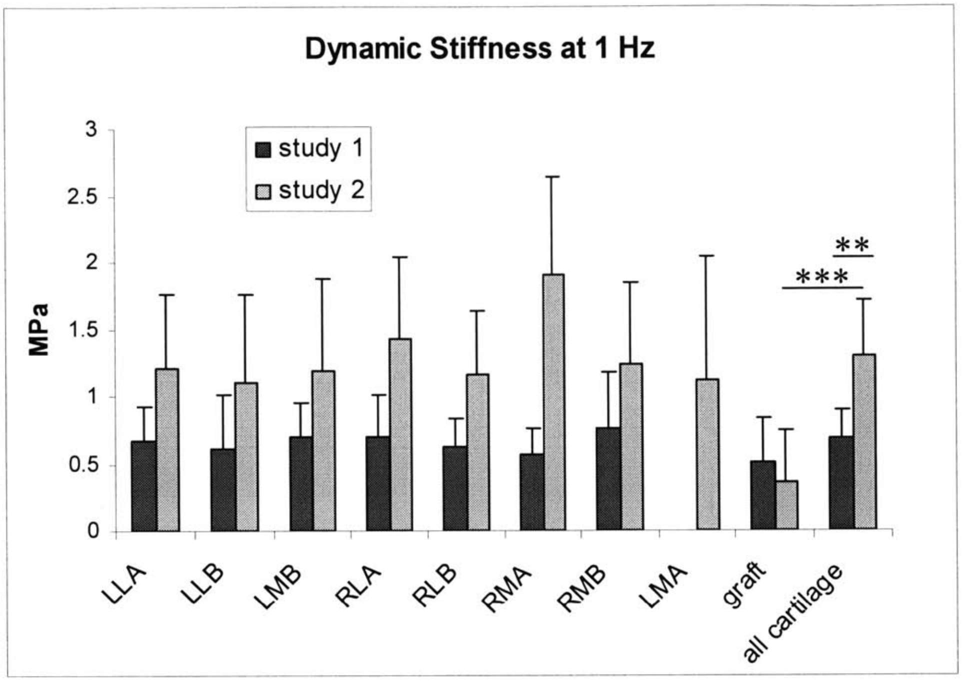


Figure 12C: Dynamic Stiffness of ovine cartilage sites. (graft is usually LMA site, except for two sheep in which the graft was at RMA. RMA and LMA in graph are cartilage explants, not graft site)
*** = $p<0.001$; ** = $p<0.01$

Stiffness of Ovine Tissue Sites in Study 1

For both tTG treated sheep and non tTG treated sheep, there were no significant differences in stiffness between any non-graft cartilage site. Therefore, cartilage stiffnesses were pooled for each sheep. For the pooled cartilage, there was no significant differences between tTG treated sheep and non tTG treated sheep. Grafts treated with tTG were also not significantly different from non tTG treated grafts (Fig. 13A, Fig. 13B, Fig. 13C).

Scatter plots of the normalized equilibrium modulus, dynamic stiffness at 1 Hz, and shear stiffness show that the graft tends to increase in stiffness with weight bearing and tTG treatment, although these trends could not be confirmed statistically (Fig. 14A – Fig. 14F)

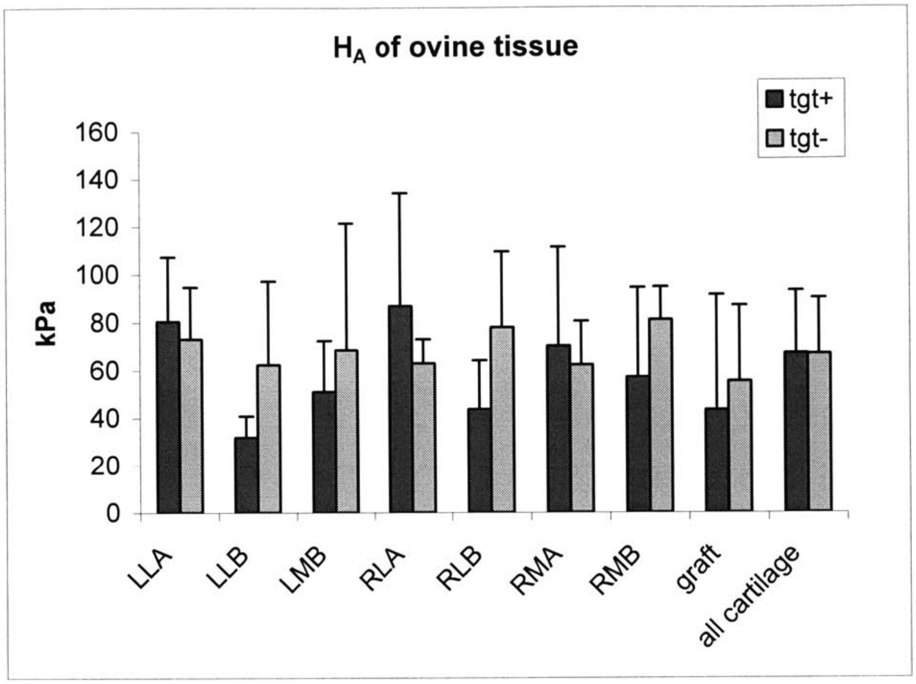


Figure 13A: Equilibrium modulus of study 1 ovine tissue.

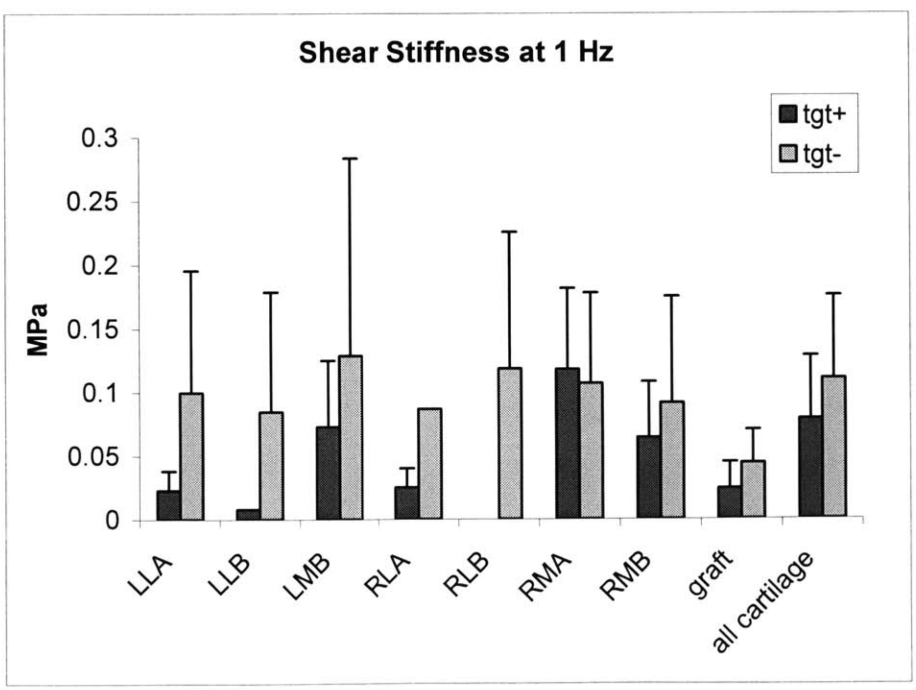


Figure 13B: Shear Stiffness of study 1 ovine tissue.

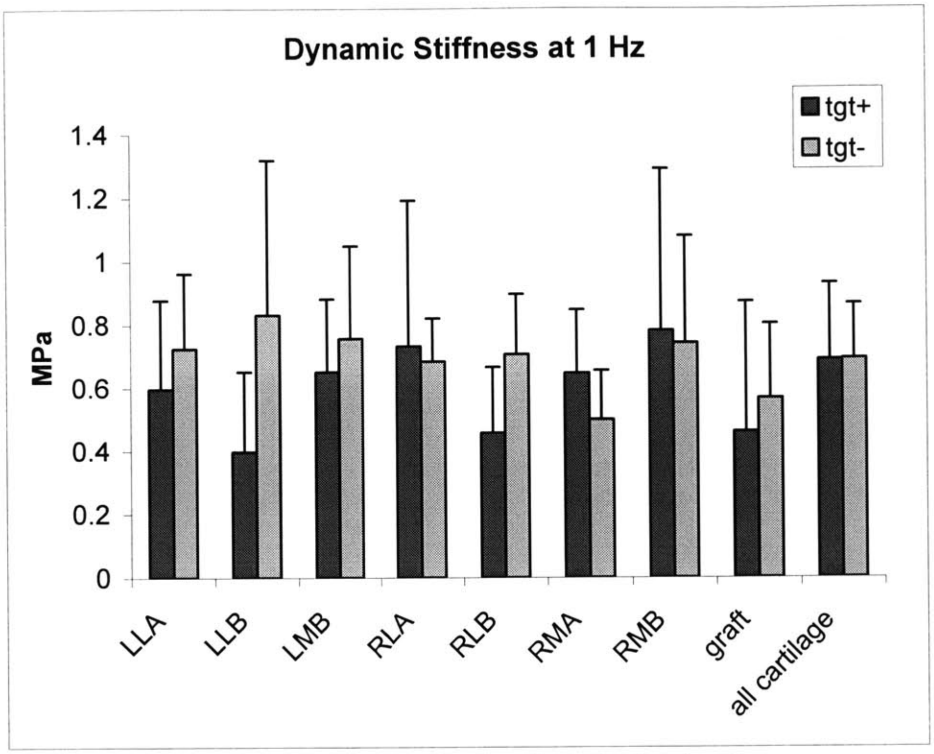


Figure 13C: Dynamic Stiffness of study 1 ovine tissue.

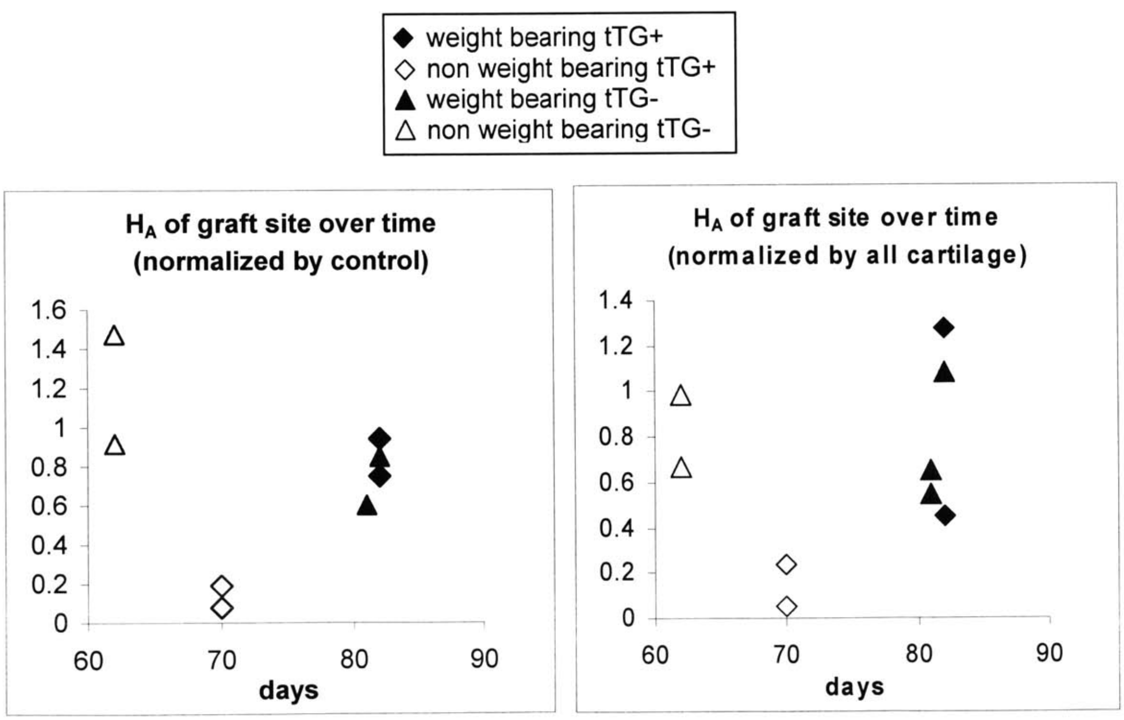
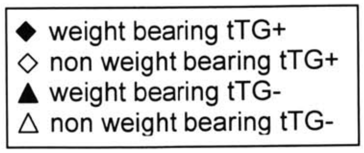


Figure 14A: Equilibrium modulus (normalized by control site) of graft site over time. Note increase of modulus with weight bearing for tTG+ grafts.

Figure 14B: Equilibrium modulus (normalized by all cartilage) of graft site over time. Note increase of modulus with weight bearing for tTG+ grafts.



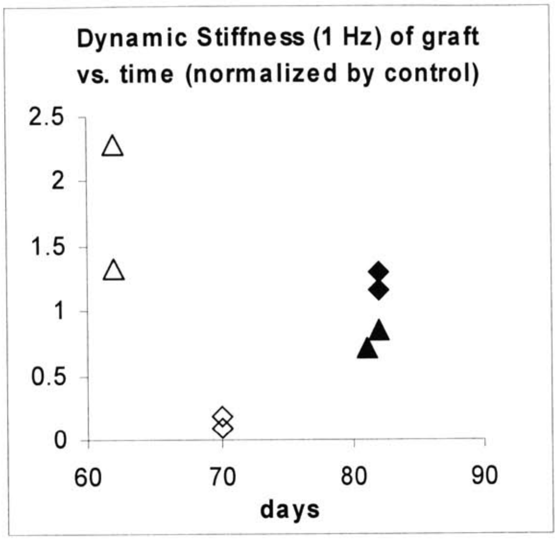


Figure 14C: Dynamic stiffness at 1 Hz (normalized by control site) of graft site over time. Note increase of stiffness with weight bearing for tTG+ grafts.

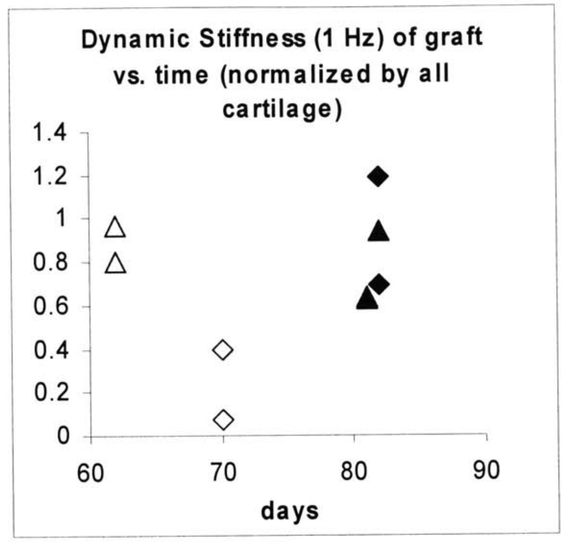
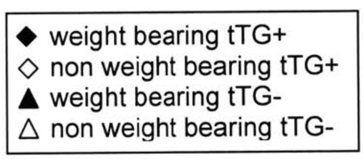


Figure 14D: Dynamic stiffness at 1 Hz (normalized by all cartilage) of graft site over time. Note increase of modulus with weight bearing for tTG+ grafts.



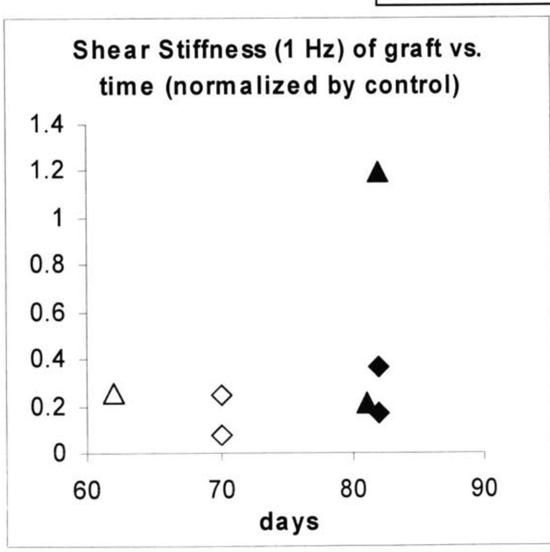


Figure 14E: Shear stiffness at 1 Hz (normalized by control site) of graft site over time.

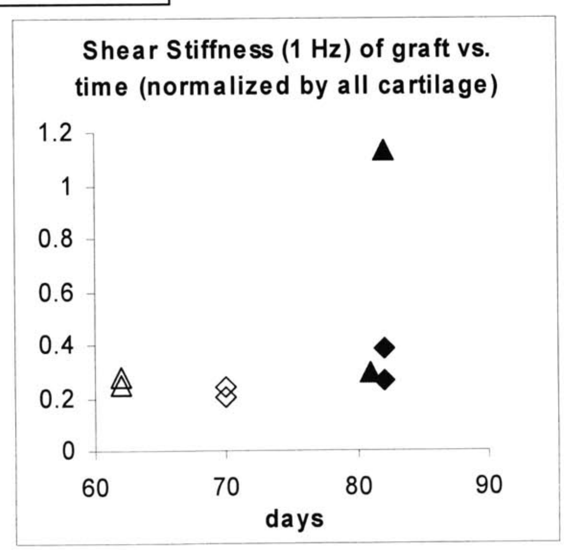


Figure 14F: Shear stiffness at 1 Hz (normalized by all cartilage) of graft site over time.

Effect of Tissue Transglutaminase and Weight Bearing Condition

For non-weight bearing samples, graft site stiffness normalized by stiffness of contralateral control sites (ie. if graft site was left medial a site, contralateral control was right medial a site), as well as by the average of the stiffness of all other cartilage samples taken from that particular sheep seemed to decrease with use of tTG, although there were no statistical significances for any of these trends. (Fig. 15A – Fig. 15C) Dynamic stiffness normalized by control site was significantly higher for weight bearing samples treated with tTG (Fig. 156: $p<0.05$). However, all n's were around 2 or 3, making this analysis somewhat inconclusive.

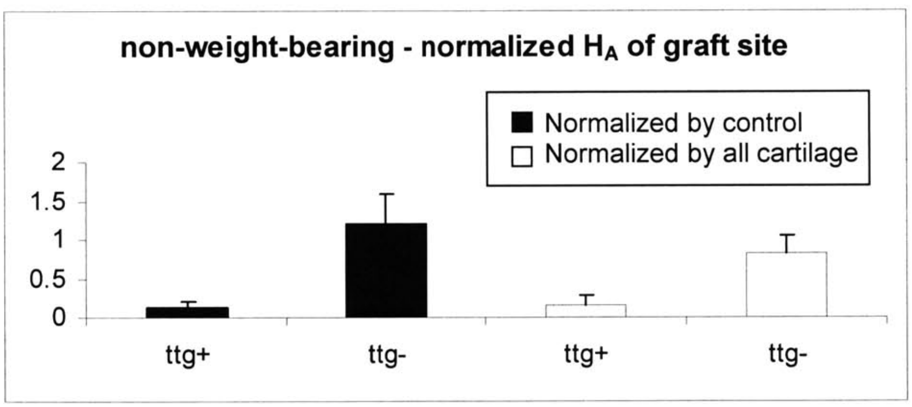


Figure 15A: Normalized Equilibrium Modulus of graft site from non weight bearing sheep

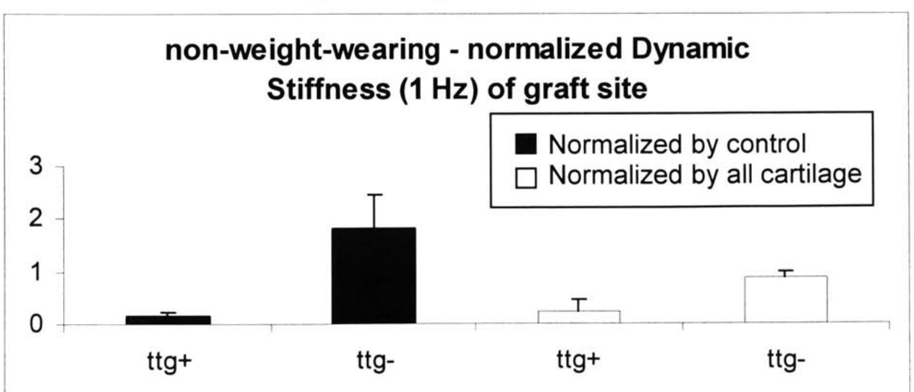


Figure 15B: Normalized Dynamic Stiffness at 1 Hz of graft site from non weight bearing sheep

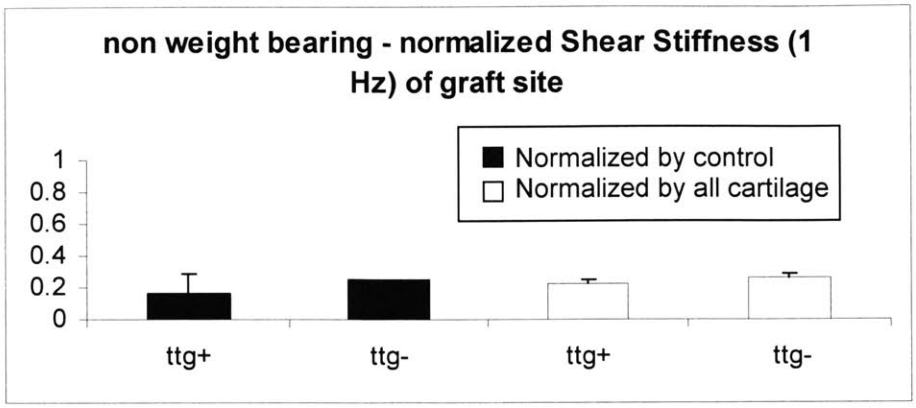


Figure 15C: Normalized Shear Stiffness at 1 Hz of graft site from non weight bearing sheep

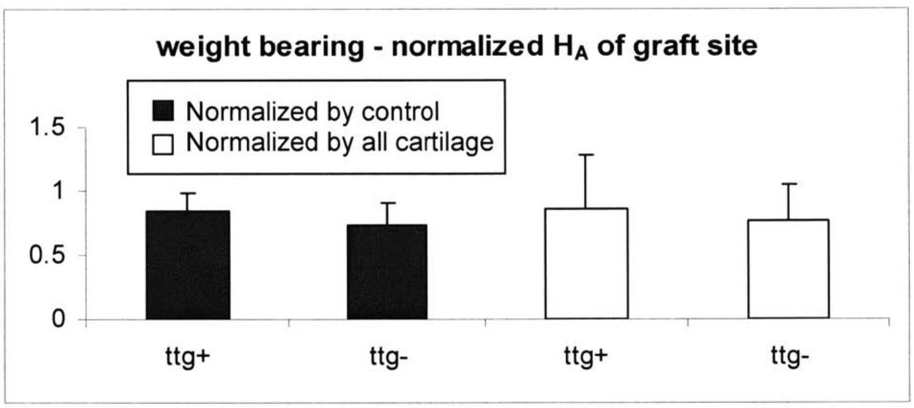


Figure 16A: Normalized Equilibrium Modulus of graft site from weight bearing sheep

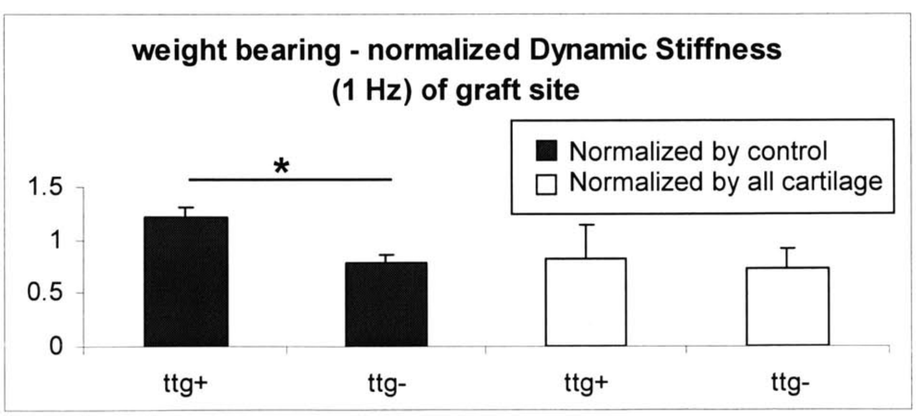


Figure 16B: Normalized Dynamic Stiffness at 1 Hz of graft site from weight bearing sheep. * = $p < 0.05$

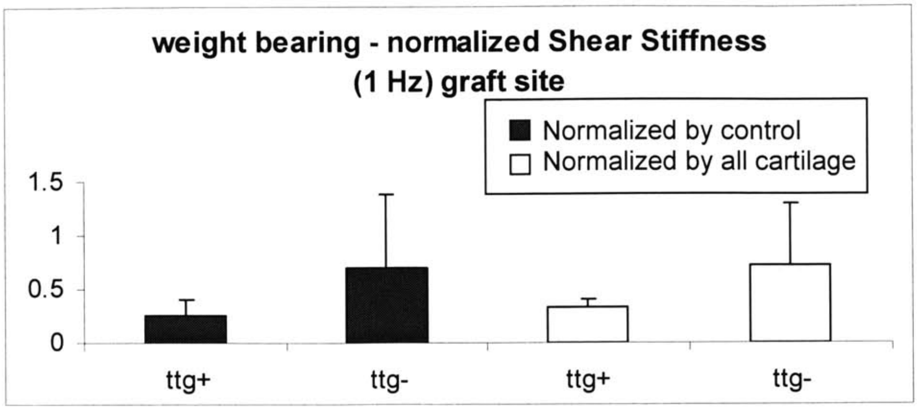


Figure 16C: Normalized Shear Stiffness at 1 Hz of graft site from weight bearing sheep

Stiffness of Ovine Tissue Over Time: Both Studies

Stiffness of graft sites from all samples not treated with transglutaminase from both studies 1 and 2 were normalized by stiffness of contralateral control sites (ie. if graft site was left medial a site, contralateral control was right medial a site), as well as by the average of the stiffness of all other cartilage samples taken from that particular sheep. Both the H_A normalized by control site and H_A normalized by all cartilage and decreased with time (Fig. 17A: ANOVA $p<0.001$, $p<0.01$) Dynamic stiffness normalized by control site and by all cartilage also decreased with time (Fig. 17B: ANOVA $p<0.01$, $p<0.05$). However, shear stiffness normalized by all cartilage increased with time (Fig. 17C: ANOVA $p<0.05$).

Un-normalized equilibrium modulus, dynamic stiffness, and shear stiffness of the graft site did not change with time (Fig. 18A – Fig. 18C). However, dynamic stiffness of all cartilage did increase with time (Fig. 18B, ANOVA $p<0.05$), while shear stiffness of control sites and all cartilage decreased with time (Fig. 18C: ANOVA $p<0.05$, $p<0.001$).

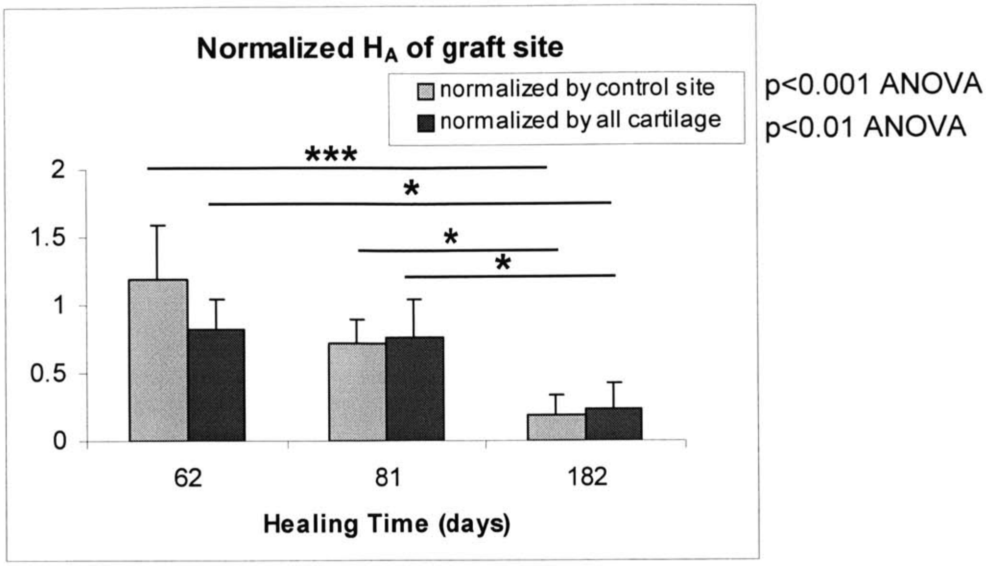


Figure 17A: Normalized Equilibrium Modulus of graft sites not treated with transglutaminase. Grafts that healed for 62 and 81 days are from study 1, while grafts that healed for 182 days are from study 2.

*** = $p < 0.001$, * = $p < 0.05$

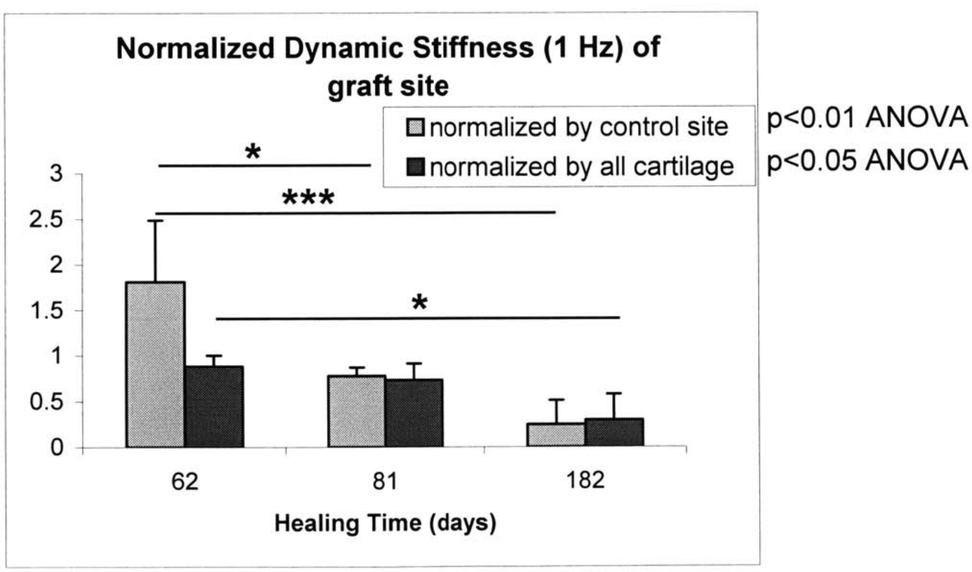
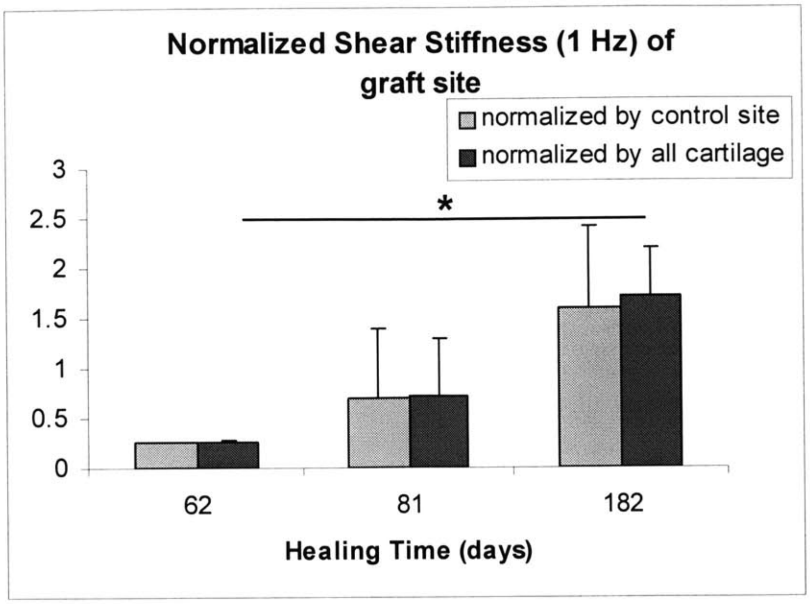


Figure 17B: Normalized Dynamic Stiffness at 1 Hz of graft sites not treated with transglutaminase. Grafts that healed for 62 and 81 days are from study 1, while grafts that healed for 182 days are from study 2.

*** = $p < 0.001$, * = $p < 0.05$



p<0.05 ANOVA

Figure 17C: Normalized Shear Stiffness at 1 Hz of graft sites not treated with transglutaminase. Grafts that healed for 62 and 81 days are from study 1, while grafts that healed for 182 days are from study 2.

* = $p < 0.05$

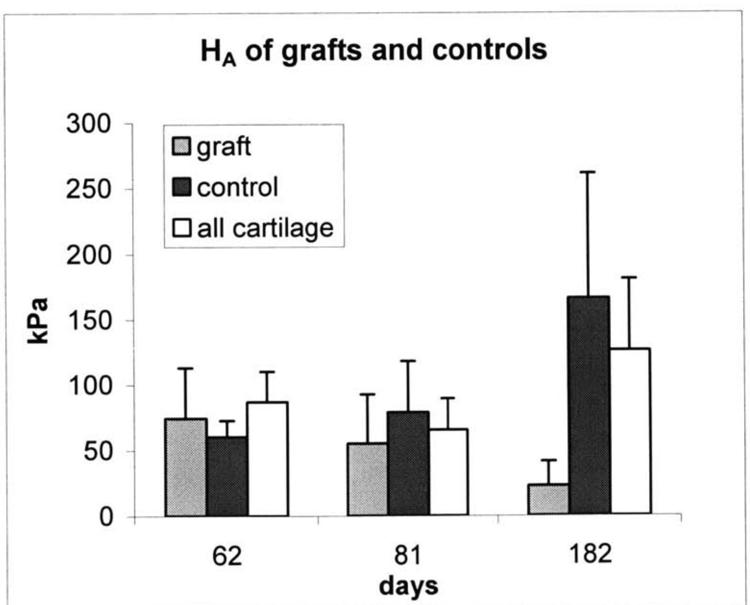


Figure 18A: Equilibrium modulus of graft, control site, and all cartilage. Day 62 and 81 samples are tTG-sheep from study 1, day 182 samples are from study 2

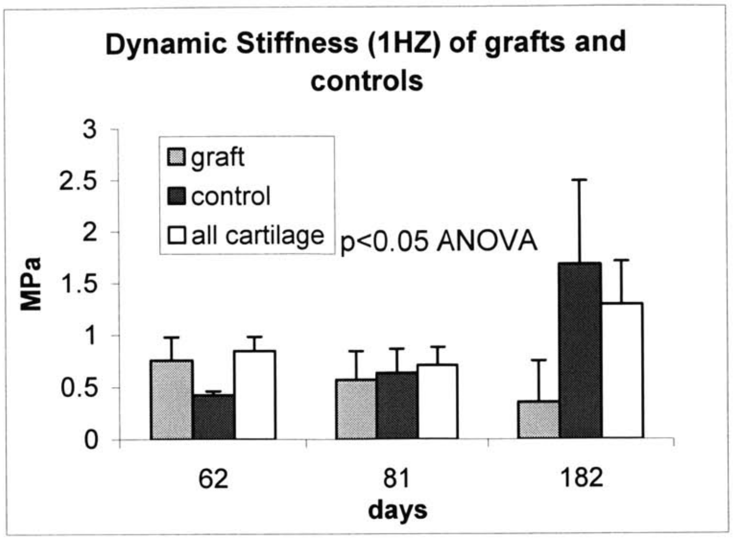


Figure 18B: Dynamic Stiffness at 1 Hz of graft, control site, and all cartilage. Day 62 and 81 samples are tTG- sheep from study 1, day 182 samples are from study 2

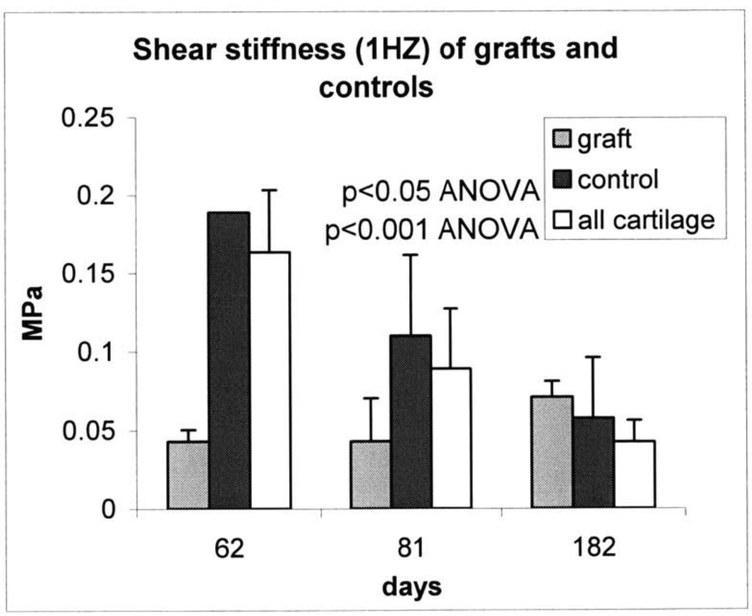


Figure 18C: Shear Stiffness at 1 Hz of graft, control site, and all cartilage. Day 62 and 81 samples are tTG- sheep from study 1, day 182 samples are from study 2

Chapter 4 - Discussion

Neocartilage – Effect of Donor Age

FLC neocartilage was almost always stiffer than LC: H_A and E_t were significantly higher in FLC than LC (Fig. 5A, Fig. 7A). Hypro/DNA was correspondingly higher in FLC than in LC (Fig. 8B). GAG/DNA was significantly higher in 3 week infant HC neocartilage than in 3 month infant HC neocartilage (Fig. 8A). As the weight of DNA can be used as a measure of cell count, this seems to suggest that the younger the donor, the stiffer the resulting construct. Because of the "bubbly" quality of the 3 week infant HC neocartilage, further studies are needed to characterize the biomechanical properties of 3 week HC and confirm this trend.

Neocartilage – Effect of Culture Duration

Data from ovine and 3 month HC constructs suggests that longer culture times result in stiffer constructs. FLC constructs exhibited increasing biomechanical (H_A, E_t; Fig. 5B, Fig.7B) and biochemical (GAG/DNA, Hypro/DNA; Fig.9A, Fig. 9B) properties with time in culture. E_t and Hypro/DNA also increased in 3-week HC neocartilage with time in culture (Fig. 7C, Fig. 10B). Dynamic stiffness of the fetal-8-year series of HC specimens increased significantly with GAG/DNA (Fig. 6). This is consistent with literature which states that E_t changes with Hypro content, and H_A/dynamic stiffness changes with GAG content. Ongoing studies are aimed at verifying the statistical significance of these observed trends.

Ovine Cartilage and Grafts

Study 1 – Effect of Tissue Transglutaminase and Weight Bearing Condition

There was little difference in stiffness between graft site and surrounding cartilage for both tTG treated and non treated sheep joints in study 1; only RMA was significantly higher than the graft site in tTG treated joints (Fig.13B). However, scatter plots of stiffness vs. time indicate that tTG treated grafts tended to become more stiff in compression (H_A and dynamic stiffness) over time / weight bearing period (Fig. 14A – Fig. 14D). Grafts treated with tTG had higher dynamic stiffness than those not treated (Fig. 16B). Additionally, non tTG treated grafts tended to become stiffer in shear with time/weight bearing period (Fig 14E, Fig.14F). It is difficult to draw a definitive conclusion from these results. If tTG treatment did in fact aid in fixing the graft to the defect, then perhaps the graft integrated to the cartilage better, and increased GAG synthesis, which in turn increased compressive stiffness. The fact that shear stiffness increased in non tTG treated grafts is suggestive of a more developed collagen network; however, it is not clear how this may be related to the treatment (no tTG)

Healing Duration – Effect on Graft and Surrounding Cartilage

The equilibrium modulus and 1 Hz dynamic stiffness of the graft site, when normalized by either contralateral control stiffness or stiffness of all cartilage, both decreased significantly with time (Fig. 17A, Fig. 17B), while shear stiffness at 1 Hz increased with time (Fig. 17C). However, it does not appear that non-normalized graft H_A and dynamic stiffness dramatically decreased with time or that shear stiffness increased with time. Rather, graft H_A and dynamic stiffness tended to stay the same or decrease slightly with time. In contrast, the surrounding cartilage H_A and dynamic stiffness increased, the graft shear stiffness tended to increase slightly, and the surrounding cartilage shear modulus decreased (Fig. 18A – Fig. 18C). These slight trends became statistically significant when the graft stifnesses were normalized to the time dependent stiffness of all surrounding normal cartilage.

In fact, when looking at the two studies separately, it appears that non-grafted cartilage from study 2 (in which the sheep healed for 182 days) had a higher H_A and dynamic stiffness than cartilage from study 1 (in which the sheep healed for 62-82 days) (Fig. 12A, Fig. 12C). In study 1, H_A of cartilage ranged from 50 to 75 kPa and dynamic stiffness ranged from 0.6-0.7 MPa; in study 2, H_A of cartilage ranged from 110-190 kPa and dynamic stiffness at 1 Hz ranged from 1.0 – 1.9 MPa. Cartilage from a control sheep of the same age had H_A ~ 200 kPa, and dynamic stiffness at 1 Hz ~ 2.4 MPa. Perhaps the defect creation and resulting damage affected both joints and adjacent cartilage surfaces, not just the defect site. It is possible that biomechanical and/or biochemical stimuli may have caused a drop in GAG synthesis in the surrounding cartilage areas, which was reflected in a drop of H_A and dynamic stiffness from normal levels in cartilage from study 1 animals. Over time, GAG synthesis may have recovered, which was reflected in the higher compressive stiffness in cartilage from study 2 animals.

In contrast, 1 Hz shear stiffness of the normal surrounding cartilage tended to be higher in study 1 than in study 2, significantly so for RMA (Fig. 12B). In cartilage from study 1, shear stiffness at 1 Hz ranged from 0.05 – 0.23 MPa, while in cartilage from study 2, shear stiffness at 1 Hz ranged from 0.03 – 0.07 MPa. Cartilage from a control sheep of the same age had shear stiffness at 1 Hz ~0.07 MPa. Given that shear stiffness reflects the integrity of the collagen network in addition to proteoglycan – GAG content, it is possible that after the operation, the defect and resulting damage may have caused an increase in collagen synthesis and remodeling, resulting in an increase in shear stiffness over normal levels in cartilage from study 1 animals. Over time, collagen synthesis may have dropped back down to normal levels, resulting in closer to normal shear stiffness in cartilage from study 2 animals.

Graft H_A and dynamic stiffness did not differ significantly between the two studies. However, graft shear stiffness at 1 Hz was significantly higher in study 2 than in study 1, even though the surrounding cartilage was stiffer in shear in study 1. In fact, in study 2, the normal cartilage sites were significantly softer in shear than the graft (Fig 12B). It should be noted that for two animals in study two, it was observed at sacrifice that the graft tissue may have fallen out; the tissue in the defect was visibly of poor quality. However, this tissue was included in the biomechanical study and analysis. It is possible that this tissue was more fibrous than the grafts, resulting in a higher average shear stiffness for the graft sites.

Conclusions and Next Steps

Neocartilage

This pilot study seems to confirm our hypothesis that younger donor chondrocytes and longer culture durations result in mechanically stiffer and biochemically more viable constructs. Further research is needed to confirm these results for human donors, and to confirm correlations between compressive stiffness and GAG content, tensile modulus and collagen content.

These results also raise the interesting question of whether the neocartilage technique used here cannot be utilized for autologous transplant, as patients are most often mature adults. Even if neocartilage can be grown with chondrocytes from mature donors, growth of neocartilage requires a large number of cells, which is not easily obtainable through a biopsy. Therefore, the use of serum free media to passage chondrocytes and maintain their phenotype is a subject of importance, which should be studied further.

In general, from the biomechanical perspective, this method of creating scaffold free neocartilage seems to be promising. The neocartilage grafts in sheep healed and increased in compressive stiffness to 10-20% of the stiffness of the native adult ovine cartilage.

Ovine Implants

Study 1 data indicates that the ovine neocartilage graft heals to the defect site, tentatively confirming our hypothesis that the graft better integrates with the cartilage with use of tissue transglutaminase as a biological glue. This mechanical data needs to be confirmed with a larger study using more sheep.

We could not confirm our hypothesis that longer healing time leads to mechanically stiffer grafts. This may be in part due to the two grafts in study 2 which may have fallen out of the defect site. Upon confirming that tTG does aid in implant fixation and integration, long term study of grafts implanted in sheep would be necessary to understand the effects of longer healing times. Long term studies are also needed to look at the effects of weight bearing, as study 2 did not include non weight bearing controls.

Our data strongly indicate that the knee operation, creation of defect and insertion of graft, and eight weeks spent with the leg in a sling may significantly affect the mechanical properties of the cartilage surrounding the defect site, as well as of the cartilage in the contralateral knee. Further studies of graft over time should also look at the surrounding cartilage to confirm this observation.

At the time of writing this document, data on biochemistry of ovine cartilage and grafts from studies 1 and 2 were not available. This data is important for verifying that the cartilage and grafts are biochemically similar to healthy, normal ovine cartilage. We hope to obtain this data in the near future, and correlate it with the biomechanical data.

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Appendix A – Construct Biomechanics

Legend for Construct Biomechanics Data

Donor Abbreviations:
LC = Lamb Chondrocyte
FLC = Fetal Lamb Chondrocyte
HC = Human Chondrocyte

Core/Strip Abbreviations:
c = core
s = strip
(see Figure 1 for core, strip definitions)

Other Definitions

Eqmod = Equilibrium Compression Modulus (H_A)
Dyn = dynamic compressive stiffness
tension = tensile modulus (E_T).

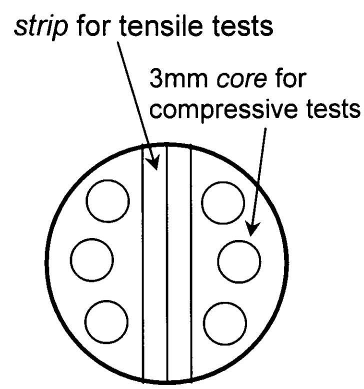


Figure 1. construct *disk*
N = number of disks
m = number of cores
n = number of strips

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	Eq mod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05 Hz	dyn 0.03 Hz	dyn 0.02 Hz	dyn 0.01 Hz	tension
12/11/02	LC	lamb 8	208	1	d	1	74.29	0.465	0.462	0.449	0.430	0.412	0.378	0.342	0.315	0.294	0.261	.
12/11/02	LC	lamb 8	208	1	d	2	68.74	0.466	0.460	0.448	0.431	0.417	0.384	0.351	0.322	0.301	0.267	.
12/11/02	LC	lamb 8	208	1	d	3	37.69	0.278	0.275	0.267	0.257	0.248	0.231	0.213	0.204	0.192	0.171	.
3/6/02	FLC	B1-3	89	1	d	1	9.93	0.110	0.105	0.096	0.085	0.077	0.065	0.055	0.048	0.043	.	.
3/6/02	FLC	B1-3	89	1	d	2	6.29	0.089	0.085	0.078	0.069	0.062	0.050	0.042	0.037	0.034	0.029	.
3/6/02	FLC	B1-3	89	1	d	3	6.49	0.093	0.089	0.082	0.074	0.069	0.061	0.055	0.052	0.050	0.047	.
3/6/02	FLC	B1-3	89	1	s	1	.	.	.	.	.	.	.	.	.	.	.	971.71
3/6/02	FLC	B1-3	89	1	s	2	.	.	.	.	.	.	.	.	.	.	.	756.93
3/28/02	FLC	A2+A3	133	1	d	1	5.53	0.058	0.055	0.047	0.040	0.035	0.028	0.023	0.020	0.018	0.015	.
3/28/02	FLC	A2+A3	133	1	d	2	5.53	0.063	0.059	0.050	0.042	0.037	0.030	0.025	0.023	0.021	0.019	.
3/28/02	FLC	A2+A3	133	1	d	3	8.11	0.088	0.083	0.072	0.061	0.054	0.044	0.037	0.034	0.031	0.028	.
3/28/02	FLC	A2+A3	133	1	d	4	10.97	.	.	.	.	.	.	.	.	.	.	.
3/28/02	FLC	A2+A3	133	2	d	1	5.38	0.043	0.040	0.035	0.031	0.027	0.021	0.018	0.016	0.015	.	.
3/28/02	FLC	A2+A3	133	2	d	2	6.38	0.093	0.089	0.082	0.074	0.068	0.058	0.050	0.044	0.040	0.034	.
3/28/02	FLC	A2+A3	133	2	d	3	7.42	0.165	0.156	0.136	0.117	0.104	0.083	0.066	0.057	0.050	0.040	.
3/28/02	FLC	A2+A3	133	2	d	4	6.38	0.039	0.037	0.033	0.028	0.025	0.021	0.018	0.016	0.014	0.012	.
3/28/02	FLC	A2+A3	133	1	s	1	.	.	.	.	.	.	.	.	.	.	.	1204.25
3/28/02	FLC	A2+A3	133	1	s	2	.	.	.	.	.	.	.	.	.	.	.	1481.99
3/28/02	FLC	A2+A3	133	2	s	1	.	.	.	.	.	.	.	.	.	.	.	1385.42
3/28/02	FLC	A2+A3	133	2	s	2	.	.	.	.	.	.	.	.	.	.	.	1220.26
3/28/02	FLC	A1	133	1	d	1	5.39	0.031	0.029	0.025	0.021	0.019	0.016	0.014	0.012	0.011	0.010	.
3/28/02	FLC	A1	133	1	d	2	19.75	.	.	.	.	.	.	.	.	.	.	.
3/28/02	FLC	A1	133	1	d	3	6.38	0.042	0.040	0.035	0.031	0.027	0.024	0.021	0.019	0.018	0.015	.
3/28/02	FLC	A1	133	1	d	4	6.90	0.116	0.109	0.095	0.083	0.075	0.063	0.053	0.047	0.043	0.035	.
3/28/02	FLC	A1	133	2	d	1	6.51	0.166	0.157	0.141	0.124	0.110	0.092	0.075	0.064	0.055	0.044	.
3/28/02	FLC	A1	133	2	d	2	6.38	0.069	0.063	0.055	0.047	0.042	0.034	0.029	0.026	0.024	0.021	.
3/28/02	FLC	A1	133	2	d	3	8.08	0.187	0.178	0.159	0.138	0.122	0.098	0.077	0.064	0.057	0.045	.
3/28/02	FLC	A1	133	2	d	4	.	0.021	0.020	0.018	0.016	0.015	0.013	0.011	0.011	0.010	0.009	.
3/28/02	FLC	A1	133	1	s	1	.	.	.	.	.	.	.	.	.	.	.	1478.77
3/28/02	FLC	A1	133	1	s	2	.	.	.	.	.	.	.	.	.	.	.	2091.69
3/28/02	FLC	A1	133	2	s	1	.	.	.	.	.	.	.	.	.	.	.	2277.14
3/28/02	FLC	A1	133	2	s	2	.	.	.	.	.	.	.	.	.	.	.	1408.45

date of test	donor	ID	day	disk #	core/strip	core/strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
4/10/02	LC	lamb 14	158	1	d	1	0.11	0.0022	0.0021	0.0019	0.0018	0.0016	0.0014	0.0012	0.0011	0.0011	0.0010	.
4/10/02	LC	lamb 14	158	1	d	2	0.04	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	.
4/10/02	LC	lamb 14	158	1	d	4	1.65	0.0182	0.0178	0.0166	0.0151	0.0140	0.0119	0.0099	0.0088	0.0081	0.0073	.
4/10/02	LC	lamb 14	158	2	d	1	0.20	0.0022	0.0021	0.0020	0.0019	0.0018	0.0017	0.0016	0.0015	0.0014	0.0014	.
4/10/02	LC	lamb 14	158	2	d	2	0.10	0.0009	0.0008	0.0007	0.0007	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	.
4/10/02	LC	lamb 14	158	2	d	4	0.22	0.0010	0.0010	0.0009	0.0008	0.0008	0.0007	0.0006	0.0006	0.0006	0.0005	.
4/10/02	LC	lamb 14	158	3	d	1	0.17	0.0011	0.0011	0.0010	0.0009	0.0009	0.0008	0.0008	0.0007	0.0007	0.0007	.
4/10/02	LC	lamb 14	158	3	d	4	0.14	0.0013	0.0012	0.0011	0.0009	0.0008	0.0007	0.0006	0.0006	0.0006	0.0005	.
4/10/02	LC	lamb 14	158	4	d	1	0.10	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	.
4/10/02	LC	lamb 14	158	4	d	2	0.20	0.0016	0.0015	0.0014	0.0013	0.0012	0.0011	0.0010	0.0009	0.0009	0.0008	.
4/10/02	LC	lamb 14	158	4	d	4	0.28	0.0044	0.0041	0.0037	0.0032	0.0028	0.0023	0.0018	0.0015	0.0014	0.0012	.
4/10/02	LC	lamb 14	158	4	d	5	0.50	0.0071	0.0067	0.0060	0.0053	0.0047	0.0038	0.0032	0.0029	0.0026	0.0024	.
4/10/02	LC	lamb 14	158	4	d	6	0.10	0.0013	0.0013	0.0011	0.0009	0.0008	0.0007	0.0006	0.0006	0.0006	0.0005	.
4/10/02	LC	lamb 14	158	1	s	1	.	.	.	.	.	.	.	.	.	.	.	621.91
4/10/02	LC	lamb 14	158	1	s	2	.	.	.	.	.	.	.	.	.	.	.	767.49
4/10/02	LC	lamb 14	158	2	s	1	.	.	.	.	.	.	.	.	.	.	.	883.80
4/10/02	LC	lamb 14	158	2	s	2	.	.	.	.	.	.	.	.	.	.	.	917.02
4/10/02	LC	lamb 14	158	3	s	1	.	.	.	.	.	.	.	.	.	.	.	40.59
4/10/02	LC	lamb 14	158	3	s	2	.	.	.	.	.	.	.	.	.	.	.	41.02
4/10/02	LC	lamb 14	158	4	s	1	.	.	.	.	.	.	.	.	.	.	.	1552.92
4/10/02	LC	lamb 14	158	4	s	2	.	.	.	.	.	.	.	.	.	.	.	1154.71
4/18/02	FLC	B1-3	131	1	d	1	10.68	0.1283	0.1226	0.1156	0.1079	0.1004	0.0914	0.0824	0.0770	0.0732	0.0687	.
4/18/02	FLC	B1-3	131	1	d	2	18.95	0.1660	0.1591	0.1490	0.1378	0.1305	0.1185	0.1093	0.1039	0.1001	0.0939	.
4/18/02	FLC	B1-3	131	1	d	4	10.82	0.1763	0.1714	0.1591	0.1456	0.1344	0.1151	0.0980	0.0860	0.0773	0.0669	.
4/18/02	FLC	B1-3	131	1	d	5	10.38	0.1579	0.1507	0.1392	0.1265	0.1163	0.0981	0.0813	0.0687	0.0603	0.0475	.
4/18/02	FLC	B1-3	131	1	s	1	.	.	.	.	.	.	.	.	.	.	.	1220.69
4/18/02	FLC	B1-3	131	1	s	2	.	.	.	.	.	.	.	.	.	.	.	1361.74

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
4/23/03	LC	lamb 15	117	1	d	1	1.15	0.0060	0.0055	0.0048	0.0042	0.0039	0.0036	0.0034	0.0033	0.0035	0.0033	.
4/23/03	LC	lamb 15	117	1	d	2	1.27	0.0147	0.0136	0.0118	0.0101	0.0090	0.0075	0.0065	0.0058	0.0056	0.0051	.
4/23/03	LC	lamb 15	117	1	d	3	0.93	0.0080	0.0073	0.0065	0.0056	0.0052	0.0045	0.0042	0.0039	0.0038	0.0035	.
4/23/03	LC	lamb 15	117	1	d	4	2.09	0.0069	0.0064	0.0056	0.0048	0.0044	0.0040	0.0037	0.0036	0.0034	0.0032	.
4/23/03	LC	lamb 15	117	2	d	1	0.99	0.0069	0.0064	0.0055	0.0049	0.0044	0.0039	0.0036	0.0035	0.0034	0.0031	.
4/23/03	LC	lamb 15	117	2	d	2	0.88	0.0118	0.0108	0.0091	0.0077	0.0068	0.0057	0.0049	0.0047	0.0045	0.0043	.
4/23/03	LC	lamb 15	117	2	d	3	5.02	0.0376	0.0346	0.0292	0.0248	0.0217	0.0182	0.0158	0.0148	0.0142	0.0142	.
4/23/03	LC	lamb 15	117	2	d	4	1.86	0.0202	0.0196	0.0182	0.0174	0.0167	0.0154	0.0144	0.0133	0.0125	0.0114	.
4/23/03	LC	lamb 15	117	2	d	5	.	0.0152	0.0148	0.0130	0.0110	0.0097	0.0085	0.0069	0.0064	0.0053	0.0051	.
4/23/03	LC	lamb 15	117	3	d	1	0.88	0.0076	0.0069	0.0058	0.0049	0.0044	0.0040	0.0035	0.0032	0.0031	0.0029	.
4/23/03	LC	lamb 15	117	3	d	2	1.23	0.0084	0.0079	0.0070	0.0061	0.0055	0.0049	0.0044	0.0041	0.0041	0.0042	.
4/23/03	LC	lamb 15	117	3	d	3	2.22	0.0314	0.0304	0.0246	0.0208	0.0180	0.0143	0.0118	0.0105	0.0113	0.0093	.
4/23/03	LC	lamb 15	117	3	d	4	0.75	0.0142	0.0130	0.0110	0.0094	0.0085	0.0071	0.0062	0.0058	0.0055	0.0045	.
4/23/03	LC	lamb 15	117	3	d	5	.	0.0109	0.0098	0.0086	0.0077	0.0071	0.0063	0.0056	0.0052	0.0050	0.0050	.
4/23/03	LC	lamb 15	117	4	d	1	1.61	0.0201	0.0185	0.0154	0.0130	0.0112	0.0093	0.0080	0.0075	0.0069	0.0065	.
4/23/03	LC	lamb 15	117	4	d	2	3.67	0.0407	0.0375	0.0317	0.0261	0.0222	0.0172	0.0141	0.0123	0.0117	0.0105	.
4/23/03	LC	lamb 15	117	4	d	3	2.07	0.0229	0.0211	0.0179	0.0151	0.0131	0.0113	0.0097	0.0087	0.0087	0.0083	.
4/23/03	LC	lamb 15	117	4	d	4	0.88	0.0063	0.0058	0.0051	0.0045	0.0040	0.0037	0.0034	0.0032	0.0031	0.0030	.
4/23/03	LC	lamb 15	117	4	d	5	1.08	0.0122	0.0114	0.0104	0.0094	0.0088	0.0079	0.0071	0.0063	0.0063	0.0059	.
4/23/03	LC	lamb 15	117	1	s	1	.	.	.	.	.	.	.	.	.	.	.	718.83
4/23/03	LC	lamb 15	117	1	s	2	.	.	.	.	.	.	.	.	.	.	.	624.16
4/23/03	LC	lamb 15	117	2	s	1	.	.	.	.	.	.	.	.	.	.	.	725.84
4/23/03	LC	lamb 15	117	2	s	2	.	.	.	.	.	.	.	.	.	.	.	813.68
4/23/03	LC	lamb 15	117	3	s	1	.	.	.	.	.	.	.	.	.	.	.	892.36
4/23/03	LC	lamb 15	117	3	s	2	.	.	.	.	.	.	.	.	.	.	.	1071.96
4/23/03	LC	lamb 15	117	4	s	1	.	.	.	.	.	.	.	.	.	.	.	1047.51
4/23/03	LC	lamb 15	117	4	s	2	.	.	.	.	.	.	.	.	.	.	.	874.22

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
4/30/02	6 week HC	11001735	143	1	d	1	16.578	0.357	0.344	0.315	0.282	0.257	0.215	0.1798	0.1595	0.1505	0.1327	.
4/30/02	6 week HC	11001735	143	1	d	2	15.646	0.273	0.263	0.243	0.22	0.204	0.178	0.1574	0.1432	0.1301	0.1096	.
4/30/02	6 week HC	11001735	143	1	d	3	13	0.237	0.226	0.204	0.181	0.164	0.142	0.1221	0.1097	0.0998	0.083	.
4/30/02	6 week HC	11001735	143	1	d	4	12.315	0.163	0.155	0.138	0.119	0.105	0.083	0.0704	0.064	0.0601	0.0541	.
4/30/02	6 week HC	11001735	143	1	d	5	7.8531	0.126	0.122	0.111	0.1	0.092	0.08	0.0696	0.0622	0.0566	0.0474	.
4/30/02	6 week HC	11001735	143	2	d	1	4.6935	0.065	0.06	0.054	0.047	0.043	0.037	0.0324	0.0299	0.0273	.	.
4/30/02	6 week HC	11001735	143	2	d	2	7.9849	0.096	0.091	0.081	0.071	0.065	0.055	0.0481	0.042	0.041	0.0375	.
4/30/02	6 week HC	11001735	143	2	d	3	7.3388	0.032	0.03	0.027	0.023	0.021	0.018	0.0153	0.0138	0.0132	.	.
4/30/02	6 week HC	11001735	143	2	d	4	5.5519	0.055	0.052	0.046	0.041	0.037	0.032	0.0278	0.026	0.0244	.	.
4/30/02	6 week HC	11001735	143	2	d	5	4.4842	0.047	0.044	0.04	0.035	0.032	0.028	0.0247	0.023	0.0214	0.0186	.
4/30/02	6 week HC	11001735	143	1	s	1	.	.	.	.	.	.	.	.	.	.	.	65.966
4/30/02	6 week HC	11001735	143	2	s	1	.	.	.	.	.	.	.	.	.	.	.	147.985
4/30/02	6 week HC	11001735	143	2	s	2	.	.	.	.	.	.	.	.	.	.	.	121.477
4/30/02	3 month HC	RT01071	146	1	d	1	2.7608	0.044	0.043	0.041	0.04	0.039	0.036	0.0341	0.0325	0.0313	0.0302	.
4/30/02	3 month HC	RT01071	146	1	d	2	2.9049	0.041	0.038	0.034	0.03	0.027	0.023	0.0197	0.0178	0.0166	0.0147	.
4/30/02	3 month HC	RT01071	146	1	d	3	2.1619	0.029	0.027	0.024	0.021	0.019	0.017	0.0146	0.0134	0.0126	0.0116	.
4/30/02	3 month HC	RT01071	146	1	d	4	4.3077	0.073	0.07	0.064	0.057	0.051	0.046	0.0399	0.0364	0.0336	0.029	.
4/30/02	3 month HC	RT01071	146	1	d	5	2.0697	0.04	0.038	0.034	0.03	0.027	0.023	0.0199	0.0181	0.0169	0.0154	.
4/30/02	3 month HC	RT01071	146	2	d	2	1.1151	0.014	0.014	0.012	0.012	0.011	0.01	0.0093	0.0089	0.0087	0.0083	.
4/30/02	3 month HC	RT01071	146	2	d	3	1.7085	0.024	0.023	0.021	0.018	0.017	0.015	0.0133	0.0124	0.012	0.0113	.
4/30/02	3 month HC	RT01071	146	2	d	4	1.0457	0.018	0.017	0.016	0.014	0.012	0.01	0.0087	0.0079	0.0074	0.0068	.
4/30/02	3 month HC	RT01071	146	2	d	5	4.3291	0.053	0.05	0.044	0.038	0.035	0.028	0.0239	0.0214	0.0203	0.0182	.
4/30/02	3 month HC	RT01071	146	2	d	6	2.5418	0.019	0.018	0.016	0.014	0.013	0.012	0.0101	0.0091	0.0084	0.0075	.
4/30/02	3 month HC	RT01071	146	1	s	1	.	.	.	.	.	.	.	.	.	.	.	160.921
4/30/02	3 month HC	RT01071	146	1	s	2	.	.	.	.	.	.	.	.	.	.	.	171.662
4/30/02	3 month HC	RT01071	146	2	s	1	.	.	.	.	.	.	.	.	.	.	.	272.88
4/30/02	3 month HC	RT01071	146	2	s	2	.	.	.	.	.	.	.	.	.	.	.	259.115

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
7/24/02	FLC	E1-2	82	1	d	1	3.2969	0.045	0.044	0.038	0.034	0.03	0.024	0.02	0.0168	0.0145	0.0127	.
7/24/02	FLC	E1-2	82	1	d	2	6.1619	0.081	0.074	0.066	0.054	0.045	0.034	0.0254	0.0197	0.0155	0.0115	.
7/24/02	FLC	E1-2	82	1	d	3	4.8342	0.072	0.07	0.063	0.056	0.051	0.043	0.0357	0.0328	0.0309	0.0278	.
7/24/02	FLC	E1-2	82	1	d	4	7.8299	0.102	0.098	0.092	0.08	0.071	0.058	0.0479	0.0416	0.0378	0.031	.
7/24/02	FLC	E1-2	82	1	d	5	5.3339	0.081	0.075	0.068	0.058	0.051	0.04	0.0318	0.0269	0.024	0.0199	.
7/24/02	FLC	E1-2	82	1	d	6	3.0862	0.037	0.035	0.03	0.025	0.022	0.018	0.0153	0.0141	0.0132	0.0085	.
7/24/02	FLC	E1-2	82	1	s	1	.	.	.	.	.	.	.	.	.	.	.	958.245
7/24/02	FLC	E1-2	82	1	s	2	.	.	.	.	.	.	.	.	.	.	.	1013.46
7/24/02	FLC	E1-2	82	2	d	1	5.1098	0.078	0.076	0.07	0.063	0.058	0.049	0.0418	0.0387	0.0375	0.0326	.
7/24/02	FLC	E1-2	82	2	d	2	6.0541	0.061	0.057	0.049	0.043	0.037	0.03	0.0246	0.0216	0.0194	0.0165	.
7/24/02	FLC	E1-2	82	2	d	3	9.6465	0.154	0.148	0.132	0.11	0.101	0.079	0.0614	0.0517	0.0455	0.0378	.
7/24/02	FLC	E1-2	82	2	d	4	4.1832	0.064	0.062	0.055	0.046	0.041	0.032	0.0264	0.0234	0.0208	0.0181	.
7/24/02	FLC	E1-2	82	2	d	5	5.6328	0.074	0.07	0.063	0.054	0.045	0.036	0.0287	0.0247	0.0241	0.0224	.
7/24/02	FLC	E1-2	82	2	d	6	4.9033	0.068	0.062	0.056	0.045	0.04	0.032	0.0264	0.024	0.0219	0.0199	.
7/24/02	FLC	E1-2	82	2	s	1	.	.	.	.	.	.	.	.	.	.	.	1161.65
7/24/02	FLC	E1-2	82	2	s	2	.	.	.	.	.	.	.	.	.	.	.	1089.13
7/24/02	FLC	D1-2	131	1	d	1	4.9171	0.06	0.058	0.055	0.051	0.048	0.041	0.0359	0.0324	0.0297	0.0255	.
7/24/02	FLC	D1-2	131	1	d	2	3.9175	0.038	0.037	0.034	0.03	0.028	0.024	0.021	0.0192	0.018	0.0157	.
7/24/02	FLC	D1-2	131	1	d	3	7.2543	0.087	0.083	0.073	0.064	0.057	0.048	0.0406	0.0374	0.0353	0.0309	.
7/24/02	FLC	D1-2	131	1	d	4	5.5501	0.077	0.075	0.071	0.062	0.055	0.048	0.0405	0.0356	0.032	0.0232	.
7/24/02	FLC	D1-2	131	1	d	5	4.3373	0.034	0.032	0.027	0.022	0.019	0.015	0.0128	0.0111	0.0099	0.0084	.
7/24/02	FLC	D1-2	131	1	d	6	5.5284	0.064	0.06	0.052	0.044	0.039	0.032	0.027	0.0242	0.024	0.0212	.
7/24/02	FLC	D1-2	131	1	s	1	.	.	.	.	.	.	.	.	.	.	.	1044.67
7/24/02	FLC	D1-2	131	1	s	2	.	.	.	.	.	.	.	.	.	.	.	1037.31
7/24/02	FLC	D1-2	131	2	d	1	5.2977	0.061	0.06	0.053	0.049	0.044	0.037	0.0328	0.0293	0.0279	0.0239	.
7/24/02	FLC	D1-2	131	2	d	2	9.7183	0.103	0.097	0.089	0.077	0.068	0.053	0.0434	0.0379	0.0351	0.0298	.
7/24/02	FLC	D1-2	131	2	d	3	4.6177	0.06	0.057	0.051	0.045	0.04	0.034	0.0296	0.027	0.0248	0.0214	.
7/24/02	FLC	D1-2	131	2	d	4	4.6037	0.06	0.057	0.049	0.04	0.035	0.028	0.0234	0.0213	0.0193	0.0177	.
7/24/02	FLC	D1-2	131	2	d	5	5.6867	0.056	0.054	0.046	0.038	0.034	0.027	0.0222	0.0201	0.0184	0.0164	.
7/24/02	FLC	D1-2	131	2	d	6	5.0159	0.042	0.039	0.034	0.029	0.025	0.022	0.0188	0.0169	0.0152	0.0131	.
7/24/02	FLC	D1-2	131	2	s	1	.	.	.	.	.	.	.	.	.	.	.	1018.6
7/24/02	FLC	D1-2	131	2	s	2	.	.	.	.	.	.	.	.	.	.	.	958.245

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
9/24/02	3 week HC	RT02055	61	1	d	1	16.685	0.167	0.159	0.141	0.121	0.106	0.083	0.0646	0.0559	0.051	0.0448	.
9/24/02	3 week HC	RT02055	61	1	d	2	19.31	0.205	0.195	0.181	0.157	0.137	0.107	0.0831	0.0711	0.0645	0.0553	.
9/24/02	3 week HC	RT02055	61	1	d	3	17.411	0.225	0.216	0.197	0.166	0.145	0.109	0.0815	0.0682	0.0612	0.0522	.
9/24/02	3 week HC	RT02055	61	1	d	4	22.118	0.29	0.275	0.25	0.216	0.19	0.142	0.1039	0.0862	0.0765	0.0684	.
9/24/02	3 week HC	RT02055	61	1	d	5	23.779	0.345	0.326	0.3	0.26	0.227	0.18	0.1447	0.1261	0.1162	0.1033	.
9/24/02	3 week HC	RT02055	61	1	d	6	15.092	0.317	0.3	0.269	0.243	0.217	0.173	0.1384	0.1218	0.1127	0.1037	.
9/24/02	3 week HC	RT02055	61	1	s	1	.	.	.	.	.	.	.	.	.	.	.	114.181
9/24/02	3 week HC	RT02055	61	1	s	2	.	.	.	.	.	.	.	.	.	.	.	137.057
9/24/02	3 week HC	RT02055	61	2	d	1	31.805	0.41	0.389	0.356	0.314	0.276	0.216	0.1608	0.1295	0.1133	0.1004	.
9/24/02	3 week HC	RT02055	61	2	d	2	33.015	0.436	0.413	0.38	0.335	0.305	0.251	0.208	0.1877	0.165	0.1443	.
9/24/02	3 week HC	RT02055	61	2	d	3	38.043	0.531	0.507	0.468	0.422	0.385	0.316	0.2487	0.212	0.1844	0.1596	.
9/24/02	3 week HC	RT02055	61	2	d	4	33.286	0.509	0.489	0.443	0.396	0.356	0.286	0.2217	0.1826	0.1607	0.133	.
9/24/02	3 week HC	RT02055	61	2	d	5	36.049	0.509	0.488	0.444	0.395	0.354	0.28	0.2189	0.1877	0.169	0.146	.
9/24/02	3 week HC	RT02055	61	2	d	6	24.974	0.375	0.36	0.327	0.302	0.268	0.22	0.1715	0.1448	0.1266	0.1036	.
9/24/02	3 week HC	RT02055	61	2	s	1	.	.	.	.	.	.	.	.	.	.	.	314.319
9/24/02	3 week HC	RT02055	61	2	s	2	.	.	.	.	.	.	.	.	.	.	.	258.999
9/24/02	3 week HC	RT02055	61	3	d	1	18.923	0.233	0.209	0.191	0.165	0.143	0.109	0.0839	0.0734	0.0681	0.0606	.
9/24/02	3 week HC	RT02055	61	3	d	2	28.726	0.361	0.348	0.308	0.275	0.24	0.19	0.1543	0.1367	0.1286	0.1155	.
9/24/02	3 week HC	RT02055	61	3	d	3	30.375	0.428	0.409	0.374	0.327	0.29	0.231	0.1857	0.1635	0.1516	0.1371	.
9/24/02	3 week HC	RT02055	61	3	d	4	33.224	0.509	0.49	0.447	0.403	0.365	0.301	0.2492	0.2192	0.1984	0.1679	.
9/24/02	3 week HC	RT02055	61	3	d	5	33.485	0.502	0.477	0.439	0.388	0.344	0.265	0.1999	0.1643	0.1469	0.1255	.
9/24/02	3 week HC	RT02055	61	3	d	6	31.308	0.464	0.446	0.41	0.358	0.317	0.239	0.1782	0.1441	0.1272	0.1082	.
9/24/02	3 week HC	RT02055	61	3	s	1	.	.	.	.	.	.	.	.	.	.	.	83.2638
9/24/02	3 week HC	RT02055	61	3	s	2	.	.	.	.	.	.	.	.	.	.	.	142.628
10/1/02	FLC	fetal E	120	1	d	1	2.7967	0.042	0.039	0.034	0.029	0.024	0.019	0.0153	0.0132	0.0116	0.0097	.
10/1/02	FLC	fetal E	120	1	d	2	2.09	0.02	0.019	0.015	0.013	0.012	0.009	0.0074	0.0067	0.0062	0.0055	.
10/1/02	FLC	fetal E	120	1	d	3	4.1295	0.042	0.039	0.034	0.029	0.025	0.02	0.0166	0.0146	0.0134	0.0121	.
10/1/02	FLC	fetal E	120	1	d	4	12.2	0.123	0.115	0.101	0.088	0.075	0.057	0.0476	0.0418	0.0369	0.0321	.
10/1/02	FLC	fetal E	120	1	d	5	7.9597	0.082	0.078	0.077	0.067	0.062	0.051	0.0408	0.0344	0.031	0.0251	.
10/1/02	FLC	fetal E	120	1	d	6	10.869	0.099	0.094	0.086	0.077	0.07	0.056	0.0451	0.0387	0.0336	0.0287	.

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
10/1/02	FLC	fetal E	120	1	s	1	.	.	.	.	.	.	.	.	.	.	.	1252.93
10/1/02	FLC	fetal E	120	1	s	2	.	.	.	.	.	.	.	.	.	.	.	3544.42
10/1/02	FLC	fetal E	120	2	d	1	6.5075	0.065	0.06	0.054	0.046	0.04	0.034	0.0287	0.0257	0.0236	0.0205	.
10/1/02	FLC	fetal E	120	2	d	2	2.875	0.023	0.022	0.02	0.015	0.015	0.013	0.011	0.0103	0.0097	0.0091	.
10/1/02	FLC	fetal E	120	2	d	3	5.3051	0.039	0.037	0.033	0.029	0.026	0.022	0.0196	0.0173	0.016	0.0153	.
10/1/02	FLC	fetal E	120	2	d	4	6.6758	0.056	0.052	0.044	0.038	0.034	0.028	0.025	0.0226	0.0216	0.0195	.
10/1/02	FLC	fetal E	120	2	d	5	5.6507	0.049	0.044	0.037	0.032	0.028	0.023	0.0207	0.019	0.0172	0.0156	.
10/1/02	FLC	fetal E	120	2	d	6	6.4623	0.057	0.056	0.049	0.041	0.037	0.032	0.0278	0.0255	0.0238	0.0208	.
10/1/02	FLC	fetal E	120	2	d	7	5.4518	0.057	0.055	0.049	0.04	0.035	0.028	0.0232	0.0214	0.0195	0.0177	.
10/1/02	FLC	fetal E	120	2	s	1	.	.	.	.	.	.	.	.	.	.	.	3475.81
10/1/02	FLC	fetal E	120	2	s	2	.	.	.	.	.	.	.	.	.	.	.	.
10/1/02	FLC	fetal E	120	3	d	1	7.8614	0.073	0.069	0.057	0.049	0.042	0.035	0.0309	0.0286	0.026	0.0241	.
10/1/02	FLC	fetal E	120	3	d	2	6.1091	0.058	0.052	0.046	0.038	0.034	0.029	0.0248	0.0225	0.0203	0.0173	.
10/1/02	FLC	fetal E	120	3	d	3	5.1551	0.048	0.046	0.039	0.034	0.029	0.025	0.0214	0.0193	0.0178	0.0158	.
10/1/02	FLC	fetal E	120	3	d	4	7.1899	0.073	0.07	0.06	0.052	0.045	0.039	0.0331	0.0303	0.0284	0.0249	.
10/1/02	FLC	fetal E	120	3	d	5	6.4118	0.072	0.07	0.063	0.053	0.047	0.038	0.0306	0.0262	0.0231	0.0196	.
10/1/02	FLC	fetal E	120	3	d	6	5.613	0.067	0.063	0.054	0.046	0.039	0.032	0.0268	0.0236	0.0226	0.0189	.
10/1/02	FLC	fetal E	120	3	s	1	.	.	.	.	.	.	.	.	.	.	.	2547.88
10/1/02	FLC	fetal E	120	3	s	2	.	.	.	.	.	.	.	.	.	.	.	2294.79
10/9/02	FLC	fetal D	207	1	d	1	7.8857	0.081	0.075	0.07	0.059	0.05	0.042	0.0324	0.0279	0.025	0.0216	.
10/9/02	FLC	fetal D	207	1	d	2	6.7381	0.063	0.059	0.049	0.047	0.04	0.032	0.0262	0.0225	0.0201	0.0166	.
10/9/02	FLC	fetal D	207	1	d	3	6.9782	0.058	0.054	0.048	0.039	0.034	0.027	0.0228	0.02	0.0179	0.0154	.
10/9/02	FLC	fetal D	207	1	d	4	6.6192	0.082	0.077	0.069	0.058	0.052	0.043	0.0353	0.0305	0.0266	0.022	.
10/9/02	FLC	fetal D	207	1	d	5	6.6905	0.064	0.059	0.05	0.041	0.035	0.029	0.0242	0.0225	0.0213	0.0201	.
10/9/02	FLC	fetal D	207	1	d	6	9.6807	0.099	0.095	0.083	0.075	0.067	0.055	0.0452	0.0398	0.0363	0.0307	.
10/9/02	FLC	fetal D	207	1	s	1	.	.	.	.	.	.	.	.	.	.	.	2214.76
10/9/02	FLC	fetal D	207	1	s	2	.	.	.	.	.	.	.	.	.	.	.	2643.81
10/9/02	FLC	fetal D	207	2	d	1	4.4156	0.048	0.045	0.038	0.032	0.028	0.022	0.0184	0.0163	0.0148	0.0134	.
10/9/02	FLC	fetal D	207	2	d	2	6.9439	0.071	0.068	0.058	0.05	0.044	0.036	0.0299	0.0262	0.024	0.0206	.
10/9/02	FLC	fetal D	207	2	d	3	6.8447	0.084	0.082	0.074	0.067	0.059	0.05	0.0408	0.0362	0.0321	0.0269	.
10/9/02	FLC	fetal D	207	2	d	4	7.3317	0.063	0.061	0.055	0.047	0.041	0.034	0.0271	0.0236	0.021	0.0182	.

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
10/9/02	FLC	fetal D	207	2	d	5	8.1205	0.09	0.084	0.07	0.059	0.052	0.041	0.0352	0.0315	0.0293	0.0266	.
10/9/02	FLC	fetal D	207	2	d	6	6.64	0.069	0.067	0.059	0.052	0.046	0.037	0.0304	0.0268	0.0252	0.0219	.
10/9/02	FLC	fetal D	207	2	s	1	.	.	.	.	.	.	.	.	.	.	.	3964.1
10/9/02	FLC	fetal D	207	2	s	2	.	.	.	.	.	.	.	.	.	.	.	3962.02
10/9/02	FLC	fetal D	207	3	d	1	6.6467	0.069	0.067	0.06	0.048	0.044	0.037	0.0312	0.027	0.0242	0.0198	.
10/9/02	FLC	fetal D	207	3	d	2	5.6681	0.055	0.052	0.044	0.036	0.031	0.025	0.021	0.0187	0.0174	0.0151	.
10/9/02	FLC	fetal D	207	3	d	3	6.8397	0.067	0.061	0.054	0.046	0.041	0.033	0.0276	0.0236	0.0213	0.0182	.
10/9/02	FLC	fetal D	207	3	d	4	8.4658	0.094	0.09	0.078	0.072	0.064	0.049	0.0404	0.0355	0.0329	0.0284	.
10/9/02	FLC	fetal D	207	3	d	5	5.9298	0.061	0.054	0.048	0.043	0.037	0.031	0.0267	0.0236	0.0213	0.0187	.
10/9/02	FLC	fetal D	207	3	d	6	8.3645	0.084	0.077	0.067	0.057	0.05	0.042	0.0356	0.0318	0.0295	0.0252	.
10/9/02	FLC	fetal D	207	3	s	1	.	.	.	.	.	.	.	.	.	.	.	3791.71
10/9/02	FLC	fetal D	207	3	s	2	.	.	.	.	.	.	.	.	.	.	.	3998.21
10/15/02	FLC	fetal B	311	1	d	1	25.397	0.335	0.32	0.292	0.26	0.234	0.194	0.1583	0.1323	0.1134	0.086	.
10/15/02	FLC	fetal B	311	1	d	2	43.18	0.352	0.334	0.293	0.25	0.219	0.175	0.1466	0.1308	0.1174	0.1039	.
10/15/02	FLC	fetal B	311	1	d	3	34.74	0.298	0.285	0.258	0.223	0.199	0.158	0.127	0.1078	0.096	0.0797	.
10/15/02	FLC	fetal B	311	1	d	4	37.796	0.382	0.366	0.328	0.286	0.251	0.201	0.1587	0.1337	0.1215	0.1007	.
10/15/02	FLC	fetal B	311	1	d	5	28.458	0.246	0.233	0.208	0.177	0.153	0.121	0.1004	0.0884	0.0796	0.0698	.
10/15/02	FLC	fetal B	311	1	d	6	42.745	0.492	0.475	0.438	0.388	0.345	0.288	0.2379	0.2012	0.1762	0.1385	.
10/15/02	FLC	fetal B	311	1	s	1	.	.	.	.	.	.	.	.	.	.	.	4507.78
10/15/02	FLC	fetal B	311	1	s	2	.	.	.	.	.	.	.	.	.	.	.	4587.78
10/15/02	FLC	fetal B	311	2	d	1	50.525	0.608	0.589	0.545	0.495	0.453	0.384	0.3189	0.2705	0.2358	0.1805	.
10/15/02	FLC	fetal B	311	2	d	2	31.172	0.38	0.362	0.321	0.276	0.239	0.188	0.153	0.1332	0.1182	0.0999	.
10/15/02	FLC	fetal B	311	2	d	4	44.599	0.491	0.479	0.445	0.403	0.368	0.31	0.2553	0.2214	0.1948	0.1546	.
10/15/02	FLC	fetal B	311	2	d	6	33.944	0.529	0.505	0.461	0.413	0.37	0.296	0.2309	0.1959	0.1735	0.139	.
10/15/02	FLC	fetal B	311	2	s	1	.	.	.	.	.	.	.	.	.	.	.	4032.99
10/15/02	FLC	fetal B	311	2	s	2	.	.	.	.	.	.	.	.	.	.	.	3699.57
10/29/02	3 week HC	RT02055	96	1	d	1	5.8675	0.065	0.063	0.056	0.052	0.048	0.041	0.0349	0.0316	0.0298	0.0272	.
10/29/02	3 week HC	RT02055	96	1	d	2	15.998	0.214	0.207	0.188	0.163	0.144	0.111	0.0857	0.0734	0.0662	0.0575	.
10/29/02	3 week HC	RT02055	96	1	d	3	11.43	0.118	0.114	0.101	0.084	0.073	0.054	0.0412	0.0354	0.0321	0.0279	.
10/29/02	3 week HC	RT02055	96	1	d	4	17.747	0.227	0.219	0.196	0.172	0.154	0.123	0.1008	0.0887	0.0795	0.0675	.
10/29/02	3 week HC	RT02055	96	1	d	5	7.6327	0.107	0.101	0.09	0.076	0.067	0.052	0.0416	0.0372	0.0348	0.0314	.
10/29/02	3 week HC	RT02055	96	1	d	6	6.6074	0.141	0.135	0.12	0.108	0.098	0.088	0.0771	0.0718	0.0679	0.061	.

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
10/29/02	3 week HC	RT02055	96	1	s	7	13.793	0.171	0.162	0.15	0.132	0.118	0.099	0.0832	0.0744	0.0685	0.06	.
10/29/02	3 week HC	RT02055	96	1	s	1	.	.	.	.	.	.	.	.	.	.	.	572.154
10/29/02	3 week HC	RT02055	96	1	s	2	.	.	.	.	.	.	.	.	.	.	.	199.434
10/29/02	3 week HC	RT02055	96	2	d	1	16.774	0.261	0.251	0.237	0.217	0.196	0.164	0.1377	0.1229	0.1152	0.105	.
10/29/02	3 week HC	RT02055	96	2	d	2	4.5273	0.096	0.091	0.084	0.075	0.07	0.06	0.0526	0.0479	0.0459	0.0418	.
10/29/02	3 week HC	RT02055	96	2	d	3	14.816	0.168	0.164	0.147	0.128	0.117	0.096	0.0803	0.0714	0.0662	0.0585	.
10/29/02	3 week HC	RT02055	96	2	d	4	16.027	0.295	0.285	0.263	0.237	0.216	0.181	0.1527	0.1381	0.1315	0.1212	.
10/29/02	3 week HC	RT02055	96	2	d	5	8.7388	0.125	0.121	0.113	0.099	0.091	0.074	0.0625	0.0566	0.0533	0.0486	.
10/29/02	3 week HC	RT02055	96	2	d	6	12.239	0.166	0.157	0.143	0.122	0.107	0.082	0.0624	0.0537	0.0492	0.0432	.
10/29/02	3 week HC	RT02055	96	2	s	1	.	.	.	.	.	.	.	.	.	.	.	562.464
10/29/02	3 week HC	RT02055	96	2	s	2	.	.	.	.	.	.	.	.	.	.	.	396.463
10/29/02	3 week HC	RT02055	96	3	d	1	27.902	0.361	0.348	0.322	0.29	0.263	0.22	0.183	0.1667	0.161	0.1506	.
10/29/02	3 week HC	RT02055	96	3	d	2	21.771	0.339	0.324	0.297	0.264	0.236	0.189	0.1527	0.1343	0.1225	0.104	.
10/29/02	3 week HC	RT02055	96	3	d	3	18.924	0.222	0.212	0.19	0.166	0.145	0.113	0.0903	0.08	0.0732	0.0648	.
10/29/02	3 week HC	RT02055	96	3	d	4	17.077	0.237	0.227	0.205	0.18	0.161	0.136	0.1194	0.1111	0.1032	0.09	.
10/29/02	3 week HC	RT02055	96	3	d	5	20.1	0.269	0.26	0.238	0.212	0.19	0.153	0.1235	0.1066	0.0961	0.0806	.
10/29/02	3 week HC	RT02055	96	3	d	6	16.875	0.225	0.219	0.201	0.177	0.16	0.125	0.0971	0.0838	0.0769	0.0664	.
10/29/02	3 week HC	RT02055	96	3	s	1	.	.	.	.	.	.	.	.	.	.	.	240.251
10/29/02	3 week HC	RT02055	96	3	s	2	.	.	.	.	.	.	.	.	.	.	.	246.245
11/7/02	3 month HC	RT02064	95	1	d	1	22.159	0.268	0.259	0.234	0.206	0.182	0.153	0.131	0.1205	0.1136	0.1012	.
11/7/02	3 month HC	RT02064	95	1	d	2	10.239	0.127	0.119	0.107	0.096	0.085	0.068	0.0521	0.0434	0.0381	0.0319	.
11/7/02	3 month HC	RT02064	95	1	d	3	24.473	0.398	0.381	0.343	0.295	0.259	0.202	0.1647	0.149	0.1417	0.132	.
11/7/02	3 month HC	RT02064	95	1	d	4	14.8	0.22	0.209	0.192	0.165	0.144	0.111	0.09	0.0824	0.0784	0.0718	.
11/7/02	3 month HC	RT02064	95	1	d	5	14.327	0.177	0.173	0.158	0.138	0.123	0.097	0.0732	0.0579	0.0489	0.0389	.
11/7/02	3 month HC	RT02064	95	1	d	6	14.554	0.202	0.196	0.178	0.159	0.143	0.114	0.0895	0.0741	0.0646	0.0549	.
11/7/02	3 month HC	RT02064	95	1	s	7	14.752	0.247	0.237	0.22	0.198	0.181	0.15	0.1261	0.1124	0.1026	0.0903	.
11/7/02	3 month HC	RT02064	95	1	s	1	.	.	.	.	.	.	.	.	.	.	.	496.587
11/7/02	3 month HC	RT02064	95	1	s	2	.	.	.	.	.	.	.	.	.	.	.	407.142
11/7/02	3 month HC	RT02064	95	2	d	1	14.881	0.195	0.186	0.171	0.151	0.13	0.103	0.0772	0.0612	0.0522	0.0422	.
11/7/02	3 month HC	RT02064	95	2	d	2	14.507	0.206	0.192	0.174	0.152	0.134	0.109	0.0936	0.0863	0.0836	0.0769	.
11/7/02	3 month HC	RT02064	95	2	d	3	11.978	0.183	0.174	0.157	0.136	0.118	0.097	0.0832	0.0765	0.0732	0.0673	.

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
11/7/02	3 month HC	RT02064	95	2	d	4	17.018	0.333	0.306	0.273	0.237	0.203	0.161	0.1352	0.1251	0.1196	0.1097	.
11/7/02	3 month HC	RT02064	95	2	d	5	9.4308	0.159	0.153	0.144	0.12	0.106	0.081	0.0601	0.0466	0.0395	0.0317	.
11/7/02	3 month HC	RT02064	95	2	d	6	13.771	0.195	0.191	0.172	0.154	0.139	0.111	0.0872	0.0714	0.0614	0.0494	.
11/7/02	3 month HC	RT02064	95	2	s	7	14.782	0.219	0.212	0.197	0.178	0.165	0.136	0.1131	0.0954	0.0829	0.0655	.
11/7/02	3 month HC	RT02064	95	2	s	1	.	.	.	.	.	.	.	.	.	.	.	374.023
11/7/02	3 month HC	RT02064	95	2	s	2	.	.	.	.	.	.	.	.	.	.	.	512.396
11/7/02	3 month HC	RT02064	95	3	d	1	9.5198	0.196	0.189	0.168	0.145	0.127	0.099	0.0724	0.0564	0.0455	0.0339	.
11/7/02	3 month HC	RT02064	95	3	d	2	8.5792	0.172	0.165	0.15	0.13	0.114	0.089	0.0658	0.0528	0.0441	0.0344	.
11/7/02	3 month HC	RT02064	95	3	d	3	11.583	0.163	0.157	0.142	0.124	0.109	0.085	0.0654	0.0534	0.0461	0.0394	.
11/7/02	3 month HC	RT02064	95	3	d	4	15.22	0.266	0.254	0.235	0.21	0.187	0.15	0.1156	0.0937	0.0793	0.064	.
11/7/02	3 month HC	RT02064	95	3	d	5	9.5094	0.135	0.129	0.116	0.101	0.087	0.066	0.0484	0.0384	0.033	0.0274	.
11/7/02	3 month HC	RT02064	95	3	d	6	15.666	0.256	0.243	0.218	0.186	0.165	0.126	0.1011	0.0909	0.0856	0.0803	.
11/7/02	3 month HC	RT02064	95	3	s	1	.	.	.	.	.	.	.	.	.	.	.	372.516
11/7/02	3 month HC	RT02064	95	3	s	2	.	.	.	.	.	.	.	.	.	.	.	427.141
11/22/02	3 week HC	RT02055	120	1	d	1	19.54	0.284	0.272	0.248	0.22	0.202	0.166	0.1359	0.1193	0.1089	0.0961	.
11/22/02	3 week HC	RT02055	120	1	d	2	10.597	0.24	0.227	0.201	0.176	0.159	0.136	0.1175	0.1059	0.0981	0.0875	.
11/22/02	3 week HC	RT02055	120	1	d	3	19.246	0.384	0.365	0.333	0.293	0.26	0.208	0.1708	0.1515	0.1413	0.128	.
11/22/02	3 week HC	RT02055	120	1	d	4	19.042	0.363	0.345	0.315	0.281	0.255	0.211	0.1761	0.1581	0.1461	0.1323	.
11/22/02	3 week HC	RT02055	120	1	d	5	16.307	0.312	0.295	0.265	0.228	0.206	0.172	0.1493	0.1359	0.1268	0.1103	.
11/22/02	3 week HC	RT02055	120	1	d	6	11.85	0.209	0.198	0.178	0.154	0.135	0.105	0.0857	0.0762	0.0699	0.0621	.
11/22/02	3 week HC	RT02055	120	1	s	1	.	.	.	.	.	.	.	.	.	.	.	408.969
11/22/02	3 week HC	RT02055	120	1	s	2	.	.	.	.	.	.	.	.	.	.	.	365.995
11/22/02	3 week HC	RT02055	120	2	d	1	12.937	0.219	0.21	0.194	0.174	0.159	0.134	0.1124	0.0998	0.0902	0.0751	.
11/22/02	3 week HC	RT02055	120	2	d	2	14.263	0.173	0.166	0.15	0.133	0.119	0.094	0.0747	0.0655	0.0599	0.052	.
11/22/02	3 week HC	RT02055	120	2	d	3	10.677	0.2	0.192	0.172	0.154	0.139	0.117	0.0991	0.0884	0.0809	0.0676	.
11/22/02	3 week HC	RT02055	120	2	d	4	14.589	0.266	0.248	0.225	0.201	0.177	0.146	0.1226	0.1107	0.1029	0.0935	.
11/22/02	3 week HC	RT02055	120	2	d	5	13.119	0.239	0.226	0.207	0.183	0.165	0.139	0.1171	0.1059	0.0995	0.0898	.
11/22/02	3 week HC	RT02055	120	2	d	6	13.962	0.281	0.265	0.243	0.216	0.196	0.164	0.1349	0.1203	0.1116	0.0998	.
11/22/02	3 week HC	RT02055	120	2	s	1	.	.	.	.	.	.	.	.	.	.	.	482.498
11/22/02	3 week HC	RT02055	120	2	s	2	.	.	.	.	.	.	.	.	.	.	.	311.167

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
11/22/02	3 week HC	RT02055	120	3	d	1	8.1557	0.133	0.127	0.115	0.104	0.093	0.077	0.0631	0.0556	0.0501	0.042	.
11/22/02	3 week HC	RT02055	120	3	d	2	14.772	0.251	0.235	0.212	0.185	0.166	0.138	0.116	0.1022	0.0918	0.076	.
11/22/02	3 week HC	RT02055	120	3	d	3	10.562	0.256	0.242	0.214	0.188	0.169	0.143	0.1249	0.1138	0.1068	0.0945	.
11/22/02	3 week HC	RT02055	120	3	d	4	10.945	0.243	0.229	0.205	0.178	0.159	0.135	0.117	0.1069	0.1005	0.09	.
11/22/02	3 week HC	RT02055	120	3	d	5	10.581	0.19	0.179	0.16	0.138	0.12	0.097	0.0783	0.0701	0.0658	0.0605	.
11/22/02	3 week HC	RT02055	120	3	d	6	11.523	0.257	0.244	0.22	0.192	0.173	0.148	0.1296	0.1195	0.1126	0.1011	.
11/22/02	3 week HC	RT02055	120	3	s	1	.	.	.	.	.	.	.	.	.	.	.	488.54
11/22/02	3 week HC	RT02055	120	3	s	2	.	.	.	.	.	.	.	.	.	.	.	441.093
12/4/02	3 month HC	RT02064	121	1	d	1	10.883	0.169	0.159	0.141	0.119	0.105	0.079	0.0602	0.0489	0.0423	0.0366	.
12/4/02	3 month HC	RT02064	121	1	d	2	17.377	0.279	0.266	0.24	0.211	0.186	0.146	0.1122	0.0909	0.0781	0.0633	.
12/4/02	3 month HC	RT02064	121	1	d	3	19.123	0.322	0.31	0.285	0.251	0.222	0.176	0.139	0.1245	0.1159	0.1064	.
12/4/02	3 month HC	RT02064	121	1	d	4	16.461	0.294	0.282	0.259	0.233	0.213	0.177	0.1432	0.1202	0.1026	0.0792	.
12/4/02	3 month HC	RT02064	121	1	d	5	20.826	0.336	0.324	0.296	0.264	0.237	0.191	0.1445	0.1164	0.0969	0.0757	.
12/4/02	3 month HC	RT02064	121	1	d	6	17.444	0.251	0.237	0.216	0.192	0.169	0.136	0.1034	0.0832	0.0691	0.0586	.
12/4/02	3 month HC	RT02064	121	1	s	1	.	.	.	.	.	.	.	.	.	.	.	279.221
12/4/02	3 month HC	RT02064	121	1	s	2	.	.	.	.	.	.	.	.	.	.	.	358.48
12/4/02	3 month HC	RT02064	121	2	d	1	15.857	0.246	0.232	0.21	0.185	0.167	0.134	0.1118	0.0998	0.0916	0.0789	.
12/4/02	3 month HC	RT02064	121	2	d	2	22.916	0.38	0.361	0.328	0.284	0.25	0.2	0.1601	0.1412	0.1307	0.117	.
12/4/02	3 month HC	RT02064	121	2	d	3	14.828	0.21	0.199	0.18	0.158	0.14	0.114	0.0945	0.0847	0.0813	0.0728	.
12/4/02	3 month HC	RT02064	121	2	d	4	17.374	0.275	0.263	0.238	0.212	0.187	0.152	0.1235	0.1065	0.0973	0.0839	.
12/4/02	3 month HC	RT02064	121	2	d	5	14.175	0.214	0.205	0.186	0.169	0.153	0.128	0.1023	0.0857	0.0744	0.0601	.
12/4/02	3 month HC	RT02064	121	2	d	6	17.279	0.288	0.274	0.247	0.214	0.188	0.151	0.1219	0.1051	0.0946	0.0821	.
12/4/02	3 month HC	RT02064	121	2	s	1	.	.	.	.	.	.	.	.	.	.	.	440.256
12/4/02	3 month HC	RT02064	121	2	s	2	.	.	.	.	.	.	.	.	.	.	.	615.864
12/4/02	3 month HC	RT02064	121	3	d	1	12.051	0.191	0.183	0.163	0.146	0.13	0.106	0.0851	0.0736	0.0679	0.0591	.
12/4/02	3 month HC	RT02064	121	3	d	2	13.01	0.227	0.215	0.191	0.166	0.147	0.115	0.0879	0.0723	0.0635	0.0529	.
12/4/02	3 month HC	RT02064	121	3	d	3	11.138	0.171	0.165	0.151	0.136	0.127	0.106	0.0884	0.0772	0.0685	0.058	.
12/4/02	3 month HC	RT02064	121	3	d	4	13.008	0.209	0.199	0.179	0.16	0.143	0.113	0.0866	0.0731	0.0619	0.0511	.
12/4/02	3 month HC	RT02064	121	3	d	5	8.4298	0.124	0.116	0.104	0.09	0.079	0.066	0.0576	0.0533	0.0498	0.0471	.
12/4/02	3 month HC	RT02064	121	3	d	6	10.164	0.182	0.176	0.159	0.145	0.135	0.114	0.0952	0.0835	0.0743	0.0631	.

date of test	donor	ID	day	disk #	core/ strip	core/ strip#	eqmod	dyn 1Hz	dyn 0.8Hz	dyn 0.5Hz	dyn 0.3Hz	dyn 0.2Hz	dyn 0.1Hz	dyn 0.05Hz	dyn 0.03Hz	dyn 0.02Hz	dyn 0.01Hz	tension
12/4/02	3 month HC	RT02064	121	3	s	1	.	.	.	.	.	.	.	.	.	.	.	530.062
12/4/02	3 month HC	RT02064	121	3	s	2	.	.	.	.	.	.	.	.	.	.	.	306.815
1/7/03	3 month HC	RT02064	156	1	d	1	19.39	0.2740	0.2613	0.2356	0.2050	0.1811	0.1408	0.1081	0.0870	0.0739	0.0603	.
1/7/03	3 month HC	RT02064	156	1	d	2	13.74	0.1823	0.1754	0.1576	0.1332	0.1166	0.0945	0.0801	0.0725	0.0678	0.0624	.
1/7/03	3 month HC	RT02064	156	1	d	3	13.13	0.1787	0.1720	0.1531	0.1296	0.1101	0.0861	0.0713	0.0639	0.0608	0.0552	.
1/7/03	3 month HC	RT02064	156	1	d	4	16.98	0.2229	0.2118	0.1953	0.1770	0.1611	0.1332	0.1124	0.1006	0.0921	0.0818	.
1/7/03	3 month HC	RT02064	156	1	d	5	19.28	0.2443	0.2380	0.2172	0.1891	0.1676	0.1346	0.1092	0.0976	0.0905	0.0802	.
1/7/03	3 month HC	RT02064	156	1	d	6	20.62	0.3149	0.2970	0.2717	0.2406	0.2150	0.1730	0.1404	0.1252	0.1165	0.1067	.
1/7/03	3 month HC	RT02064	156	1	s	1	.	.	.	.	.	.	.	.	.	.	.	325.37
1/7/03	3 month HC	RT02064	156	1	s	2	.	.	.	.	.	.	.	.	.	.	.	336.61
1/7/03	3 month HC	RT02064	156	2	d	1	21.56	0.2582	0.2487	0.2311	0.2083	0.1895	0.1576	0.1289	0.1112	0.1029	0.0918	.
1/7/03	3 month HC	RT02064	156	2	d	2	25.17	0.2872	0.2749	0.2573	0.2268	0.2045	0.1633	0.1281	0.1082	0.0958	0.0853	.
1/7/03	3 month HC	RT02064	156	2	d	3	25.59	0.3422	0.3204	0.2910	0.2572	0.2267	0.1890	0.1604	0.1468	0.1375	0.1268	.
1/7/03	3 month HC	RT02064	156	2	d	4	15.40	0.2321	0.2237	0.2061	0.1805	0.1615	0.1305	0.1066	0.0956	0.0892	0.0809	.
1/7/03	3 month HC	RT02064	156	2	d	5	22.24	0.3203	0.3065	0.2806	0.2404	0.2151	0.1697	0.1286	0.1064	0.0949	0.0803	.
1/7/03	3 month HC	RT02064	156	2	d	6	24.93	0.3635	0.3466	0.3156	0.2801	0.2537	0.2058	0.1697	0.1527	0.1420	0.1298	.
1/7/03	3 month HC	RT02064	156	2	s	1	.	.	.	.	.	.	.	.	.	.	.	426.73
1/7/03	3 month HC	RT02064	156	2	s	2	.	.	.	.	.	.	.	.	.	.	.	357.37
1/7/03	3 month HC	RT02064	156	3	d	1	13.72	0.2374	0.2245	0.2043	0.1785	0.1567	0.1272	0.1044	0.0921	0.0856	0.0770	.
1/7/03	3 month HC	RT02064	156	3	d	2	20.31	0.2735	0.2652	0.2439	0.2189	0.2005	0.1590	0.1222	0.0990	0.0841	0.0669	.
1/7/03	3 month HC	RT02064	156	3	d	3	22.98	0.2832	0.2718	0.2545	0.2288	0.2089	0.1690	0.1316	0.1047	0.0891	0.0701	.
1/7/03	3 month HC	RT02064	156	3	d	4	25.09	0.3059	0.2938	0.2684	0.2389	0.2189	0.1750	0.1342	0.1104	0.0934	0.0753	.
1/7/03	3 month HC	RT02064	156	3	d	5	16.60	0.2322	0.2187	0.2006	0.1770	0.1540	0.1209	0.0954	0.0827	0.0772	0.0689	.
1/7/03	3 month HC	RT02064	156	3	d	6	25.02	0.2921	0.2821	0.2612	0.2278	0.2064	0.1633	0.1242	0.0997	0.0847	0.0688	.
1/7/03	3 month HC	RT02064	156	3	s	1	.	.	.	.	.	.	.	.	.	.	.	426.30
1/7/03	3 month HC	RT02064	156	3	s	2	.	.	.	.	.	.	.	.	.	.	.	383.96

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
12/11/02	LC	lamb 8	208	1	d	1	330
12/11/02	LC	lamb 8	208	1	d	2	330
12/11/02	LC	lamb 8	208	1	d	3	330
3/6/02	FLC	B1-3	89	1	d	1	209
3/6/02	FLC	B1-3	89	1	d	2	320
3/6/02	FLC	B1-3	89	1	d	3	350
3/6/02	FLC	B1-3	89	1	s	1	345
3/6/02	FLC	B1-3	89	1	s	2	305
3/28/02	FLC	A2+A3	133	1	d	1	180
3/28/02	FLC	A2+A3	133	1	d	2	190
3/28/02	FLC	A2+A3	133	1	d	3	230
3/28/02	FLC	A2+A3	133	1	d	4	310
3/28/02	FLC	A2+A3	133	2	d	1	290
3/28/02	FLC	A2+A3	133	2	d	2	250
3/28/02	FLC	A2+A3	133	2	d	3	280
3/28/02	FLC	A2+A3	133	2	d	4	260
3/28/02	FLC	A2+A3	133	1	s	1	183
3/28/02	FLC	A2+A3	133	1	s	2	170
3/28/02	FLC	A2+A3	133	2	s	1	
3/28/02	FLC	A2+A3	133	2	s	2	
3/28/02	FLC	A1	133	1	d	1	290
3/28/02	FLC	A1	133	1	d	2	210
3/28/02	FLC	A1	133	1	d	3	250
3/28/02	FLC	A1	133	1	d	4	310
3/28/02	FLC	A1	133	2	d	1	220
3/28/02	FLC	A1	133	2	d	2	390
3/28/02	FLC	A1	133	2	d	3	230
3/28/02	FLC	A1	133	2	d	4	210
3/28/02	FLC	A1	133	1	s	1	
3/28/02	FLC	A1	133	1	s	2	
3/28/02	FLC	A1	133	2	s	1	
3/28/02	FLC	A1	133	2	s	2	
4/10/02	LC	lamb 14	158	1	d	1	290
4/10/02	LC	lamb 14	158	1	d	2	250
4/10/02	LC	lamb 14	158	1	d	4	280
4/10/02	LC	lamb 14	158	2	d	1	180
4/10/02	LC	lamb 14	158	2	d	2	200
4/10/02	LC	lamb 14	158	2	d	4	245
4/10/02	LC	lamb 14	158	3	d	1	230
4/10/02	LC	lamb 14	158	3	d	4	175
4/10/02	LC	lamb 14	158	4	d	1	175
4/10/02	LC	lamb 14	158	4	d	2	140
4/10/02	LC	lamb 14	158	4	d	4	115
4/10/02	LC	lamb 14	158	4	d	5	135
4/10/02	LC	lamb 14	158	4	d	6	135

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
4/10/02	LC	lamb 14	158	1	s	1	293
4/10/02	LC	lamb 14	158	1	s	2	100
4/10/02	LC	lamb 14	158	2	s	1	236
4/10/02	LC	lamb 14	158	2	s	2	166
4/10/02	LC	lamb 14	158	3	s	1	175
4/10/02	LC	lamb 14	158	3	s	2	175
4/10/02	LC	lamb 14	158	4	s	1	135
4/10/02	LC	lamb 14	158	4	s	2	120
4/18/02	FLC	B1-3	131	1	d	1	390
4/18/02	FLC	B1-3	131	1	d	2	375
4/18/02	FLC	B1-3	131	1	d	4	205
4/18/02	FLC	B1-3	131	1	d	5	250
4/18/02	FLC	B1-3	131	1	s	1	336
4/18/02	FLC	B1-3	131	1	s	2	310
4/23/03	LC	lamb 15	117	1	d	1	170
4/23/03	LC	lamb 15	117	1	d	2	160
4/23/03	LC	lamb 15	117	1	d	3	160
4/23/03	LC	lamb 15	117	1	d	4	165
4/23/03	LC	lamb 15	117	2	d	1	185
4/23/03	LC	lamb 15	117	2	d	2	138
4/23/03	LC	lamb 15	117	2	d	3	138
4/23/03	LC	lamb 15	117	2	d	4	125
4/23/03	LC	lamb 15	117	2	d	5	120
4/23/03	LC	lamb 15	117	3	d	1	135
4/23/03	LC	lamb 15	117	3	d	2	125
4/23/03	LC	lamb 15	117	3	d	3	128
4/23/03	LC	lamb 15	117	3	d	4	145
4/23/03	LC	lamb 15	117	3	d	5	140
4/23/03	LC	lamb 15	117	4	d	1	165
4/23/03	LC	lamb 15	117	4	d	2	145
4/23/03	LC	lamb 15	117	4	d	3	130
4/23/03	LC	lamb 15	117	4	d	4	160
4/23/03	LC	lamb 15	117	4	d	5	128
4/23/03	LC	lamb 15	117	1	s	1	200
4/23/03	LC	lamb 15	117	1	s	2	200
4/23/03	LC	lamb 15	117	2	s	1	163
4/23/03	LC	lamb 15	117	2	s	2	163
4/23/03	LC	lamb 15	117	3	s	1	143
4/23/03	LC	lamb 15	117	3	s	2	115
4/23/03	LC	lamb 15	117	4	s	1	125
4/23/03	LC	lamb 15	117	4	s	2	185
4/30/02	6 week HC	11001735	143	1	d	1	648
4/30/02	6 week HC	11001735	143	1	d	2	450
4/30/02	6 week HC	11001735	143	1	d	3	465
4/30/02	6 week HC	11001735	143	1	d	4	490
4/30/02	6 week HC	11001735	143	1	d	5	508
4/30/02	6 week HC	11001735	143	2	d	1	480

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
4/30/02	6 week HC	11001735	143	2	d	2	620
4/30/02	6 week HC	11001735	143	2	d	3	658
4/30/02	6 week HC	11001735	143	2	d	4	690
4/30/02	6 week HC	11001735	143	2	d	5	548
4/30/02	6 week HC	11001735	143	1	s	1	623
4/30/02	6 week HC	11001735	143	2	s	1	690
4/30/02	6 week HC	11001735	143	2	s	2	747
4/30/02	3 month HC	RT01071	146	1	d	1	648
4/30/02	3 month HC	RT01071	146	1	d	2	473
4/30/02	3 month HC	RT01071	146	1	d	3	550
4/30/02	3 month HC	RT01071	146	1	d	4	478
4/30/02	3 month HC	RT01071	146	1	d	5	488
4/30/02	3 month HC	RT01071	146	2	d	2	380
4/30/02	3 month HC	RT01071	146	2	d	3	430
4/30/02	3 month HC	RT01071	146	2	d	4	460
4/30/02	3 month HC	RT01071	146	2	d	5	555
4/30/02	3 month HC	RT01071	146	2	d	6	529
4/30/02	3 month HC	RT01071	146	1	s	1	673
4/30/02	3 month HC	RT01071	146	1	s	2	617
4/30/02	3 month HC	RT01071	146	2	s	1	527
4/30/02	3 month HC	RT01071	146	2	s	2	590
7/24/02	FLC	E1-2	82	1	d	1	210
7/24/02	FLC	E1-2	82	1	d	2	110
7/24/02	FLC	E1-2	82	1	d	3	185
7/24/02	FLC	E1-2	82	1	d	4	145
7/24/02	FLC	E1-2	82	1	d	5	140
7/24/02	FLC	E1-2	82	1	d	6	180
7/24/02	FLC	E1-2	82	1	s	1	125
7/24/02	FLC	E1-2	82	1	s	2	127
7/24/02	FLC	E1-2	82	2	d	1	190
7/24/02	FLC	E1-2	82	2	d	2	125
7/24/02	FLC	E1-2	82	2	d	3	175
7/24/02	FLC	E1-2	82	2	d	4	175
7/24/02	FLC	E1-2	82	2	d	5	155
7/24/02	FLC	E1-2	82	2	d	6	145
7/24/02	FLC	E1-2	82	2	s	1	150
7/24/02	FLC	E1-2	82	2	s	2	125
7/24/02	FLC	D1-2	131	1	d	1	
7/24/02	FLC	D1-2	131	1	d	2	
7/24/02	FLC	D1-2	131	1	d	3	
7/24/02	FLC	D1-2	131	1	d	4	
7/24/02	FLC	D1-2	131	1	d	5	
7/24/02	FLC	D1-2	131	1	d	6	
7/24/02	FLC	D1-2	131	1	s	1	
7/24/02	FLC	D1-2	131	1	s	2	

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
7/24/02	FLC	D1-2	131	2	d	1	155
7/24/02	FLC	D1-2	131	2	d	2	155
7/24/02	FLC	D1-2	131	2	d	3	235
7/24/02	FLC	D1-2	131	2	d	4	195
7/24/02	FLC	D1-2	131	2	d	5	180
7/24/02	FLC	D1-2	131	2	d	6	205
7/24/02	FLC	D1-2	131	2	s	1	215
7/24/02	FLC	D1-2	131	2	s	2	205
9/24/02	3 week HC	RT02055	61	1	d	1	366
9/24/02	3 week HC	RT02055	61	1	d	2	370
9/24/02	3 week HC	RT02055	61	1	d	3	250
9/24/02	3 week HC	RT02055	61	1	d	4	255
9/24/02	3 week HC	RT02055	61	1	d	5	290
9/24/02	3 week HC	RT02055	61	1	d	6	450
9/24/02	3 week HC	RT02055	61	1	s	1	300
9/24/02	3 week HC	RT02055	61	1	s	2	286
9/24/02	3 week HC	RT02055	61	2	d	1	265
9/24/02	3 week HC	RT02055	61	2	d	2	385
9/24/02	3 week HC	RT02055	61	2	d	3	390
9/24/02	3 week HC	RT02055	61	2	d	4	365
9/24/02	3 week HC	RT02055	61	2	d	5	400
9/24/02	3 week HC	RT02055	61	2	d	6	310
9/24/02	3 week HC	RT02055	61	2	s	1	243
9/24/02	3 week HC	RT02055	61	2	s	2	260
9/24/02	3 week HC	RT02055	61	3	d	1	200
9/24/02	3 week HC	RT02055	61	3	d	2	235
9/24/02	3 week HC	RT02055	61	3	d	3	285
9/24/02	3 week HC	RT02055	61	3	d	4	370
9/24/02	3 week HC	RT02055	61	3	d	5	230
9/24/02	3 week HC	RT02055	61	3	d	6	165
9/24/02	3 week HC	RT02055	61	3	s	1	343
9/24/02	3 week HC	RT02055	61	3	s	2	260
10/1/02	FLC	fetal E	120	1	d	1	130
10/1/02	FLC	fetal E	120	1	d	2	125
10/1/02	FLC	fetal E	120	1	d	3	150
10/1/02	FLC	fetal E	120	1	d	4	195
10/1/02	FLC	fetal E	120	1	d	5	190
10/1/02	FLC	fetal E	120	1	d	6	165
10/1/02	FLC	fetal E	120	1	s	1	163
10/1/02	FLC	fetal E	120	1	s	2	140
10/1/02	FLC	fetal E	120	2	d	1	185
10/1/02	FLC	fetal E	120	2	d	2	160
10/1/02	FLC	fetal E	120	2	d	3	130
10/1/02	FLC	fetal E	120	2	d	4	145

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
10/1/02	FLC	fetal E	120	2	d	5	120
10/1/02	FLC	fetal E	120	2	d	6	140
10/1/02	FLC	fetal E	120	2	d	7	175
10/1/02	FLC	fetal E	120	2	s	1	110
10/1/02	FLC	fetal E	120	2	s	2	135
10/1/02	FLC	fetal E	120	3	d	1	180
10/1/02	FLC	fetal E	120	3	d	2	160
10/1/02	FLC	fetal E	120	3	d	3	170
10/1/02	FLC	fetal E	120	3	d	4	185
10/1/02	FLC	fetal E	120	3	d	5	185
10/1/02	FLC	fetal E	120	3	d	6	
10/1/02	FLC	fetal E	120	3	s	1	150
10/1/02	FLC	fetal E	120	3	s	2	106
10/9/02	FLC	fetal D	207	1	d	1	210
10/9/02	FLC	fetal D	207	1	d	2	185
10/9/02	FLC	fetal D	207	1	d	3	185
10/9/02	FLC	fetal D	207	1	d	4	175
10/9/02	FLC	fetal D	207	1	d	5	150
10/9/02	FLC	fetal D	207	1	d	6	200
10/9/02	FLC	fetal D	207	1	s	1	175
10/9/02	FLC	fetal D	207	1	s	2	183
10/9/02	FLC	fetal D	207	2	d	1	140
10/9/02	FLC	fetal D	207	2	d	2	150
10/9/02	FLC	fetal D	207	2	d	3	185
10/9/02	FLC	fetal D	207	2	d	4	175
10/9/02	FLC	fetal D	207	2	d	5	175
10/9/02	FLC	fetal D	207	2	d	6	165
10/9/02	FLC	fetal D	207	2	s	1	130
10/9/02	FLC	fetal D	207	2	s	2	163
10/9/02	FLC	fetal D	207	3	d	1	145
10/9/02	FLC	fetal D	207	3	d	2	125
10/9/02	FLC	fetal D	207	3	d	3	130
10/9/02	FLC	fetal D	207	3	d	4	150
10/9/02	FLC	fetal D	207	3	d	5	100
10/9/02	FLC	fetal D	207	3	d	6	115
10/9/02	FLC	fetal D	207	3	s	1	150
10/9/02	FLC	fetal D	207	3	s	2	145
10/15/02	FLC	fetal B	311	1	d	1	240
10/15/02	FLC	fetal B	311	1	d	2	180
10/15/02	FLC	fetal B	311	1	d	3	150
10/15/02	FLC	fetal B	311	1	d	4	190
10/15/02	FLC	fetal B	311	1	d	5	190
10/15/02	FLC	fetal B	311	1	d	6	285
10/15/02	FLC	fetal B	311	1	s	1	166
10/15/02	FLC	fetal B	311	1	s	2	210
10/15/02	FLC	fetal B	311	2	d	1	400
10/15/02	FLC	fetal B	311	2	d	2	185

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
10/15/02	FLC	fetal B	311	2	d	4	205
10/15/02	FLC	fetal B	311	2	d	6	245
10/15/02	FLC	fetal B	311	2	s	1	180
10/15/02	FLC	fetal B	311	2	s	2	
10/29/02	3 week HC	RT02055	96	1	d	1	480
10/29/02	3 week HC	RT02055	96	1	d	2	330
10/29/02	3 week HC	RT02055	96	1	d	3	320
10/29/02	3 week HC	RT02055	96	1	d	4	350
10/29/02	3 week HC	RT02055	96	1	d	5	380
10/29/02	3 week HC	RT02055	96	1	d	6	390
10/29/02	3 week HC	RT02055	96	1	d	7	285
10/29/02	3 week HC	RT02055	96	1	s	1	333
10/29/02	3 week HC	RT02055	96	1	s	2	356
10/29/02	3 week HC	RT02055	96	2	d	1	410
10/29/02	3 week HC	RT02055	96	2	d	2	390
10/29/02	3 week HC	RT02055	96	2	d	3	280
10/29/02	3 week HC	RT02055	96	2	d	4	420
10/29/02	3 week HC	RT02055	96	2	d	5	380
10/29/02	3 week HC	RT02055	96	2	d	6	290
10/29/02	3 week HC	RT02055	96	2	s	1	430
10/29/02	3 week HC	RT02055	96	2	s	2	420
10/29/02	3 week HC	RT02055	96	3	d	1	455
10/29/02	3 week HC	RT02055	96	3	d	2	400
10/29/02	3 week HC	RT02055	96	3	d	3	380
10/29/02	3 week HC	RT02055	96	3	d	4	405
10/29/02	3 week HC	RT02055	96	3	d	5	320
10/29/02	3 week HC	RT02055	96	3	d	6	370
10/29/02	3 week HC	RT02055	96	3	s	1	450
10/29/02	3 week HC	RT02055	96	3	s	2	410
11/7/02	3 month HC	RT02064	95	1	d	1	290
11/7/02	3 month HC	RT02064	95	1	d	2	290
11/7/02	3 month HC	RT02064	95	1	d	3	320
11/7/02	3 month HC	RT02064	95	1	d	4	285
11/7/02	3 month HC	RT02064	95	1	d	5	255
11/7/02	3 month HC	RT02064	95	1	d	6	290
11/7/02	3 month HC	RT02064	95	1	s	1	440
11/7/02	3 month HC	RT02064	95	1	s	2	375
11/7/02	3 month HC	RT02064	95	2	d	1	310
11/7/02	3 month HC	RT02064	95	2	d	2	260
11/7/02	3 month HC	RT02064	95	2	d	3	260
11/7/02	3 month HC	RT02064	95	2	d	4	295
11/7/02	3 month HC	RT02064	95	2	d	5	250
11/7/02	3 month HC	RT02064	95	2	d	6	310
11/7/02	3 month HC	RT02064	95	2	d	7	520
11/7/02	3 month HC	RT02064	95	2	s	1	345
11/7/02	3 month HC	RT02064	95	2	s	2	340
11/7/02	3 month HC	RT02064	95	3	d	1	305

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
11/7/02	3 month HC	RT02064	95	3	d	2	260
11/7/02	3 month HC	RT02064	95	3	d	3	290
11/7/02	3 month HC	RT02064	95	3	d	4	300
11/7/02	3 month HC	RT02064	95	3	d	5	225
11/7/02	3 month HC	RT02064	95	3	d	6	295
11/7/02	3 month HC	RT02064	95	3	s	1	345
11/7/02	3 month HC	RT02064	95	3	s	2	340
11/22/02	3 week HC	RT02055	120	1	d	1	550
11/22/02	3 week HC	RT02055	120	1	d	2	530
11/22/02	3 week HC	RT02055	120	1	d	3	480
11/22/02	3 week HC	RT02055	120	1	d	4	580
11/22/02	3 week HC	RT02055	120	1	d	5	490
11/22/02	3 week HC	RT02055	120	1	d	6	450
11/22/02	3 week HC	RT02055	120	1	s	1	490
11/22/02	3 week HC	RT02055	120	1	s	2	470
11/22/02	3 week HC	RT02055	120	2	d	1	460
11/22/02	3 week HC	RT02055	120	2	d	2	390
11/22/02	3 week HC	RT02055	120	2	d	3	445
11/22/02	3 week HC	RT02055	120	2	d	4	550
11/22/02	3 week HC	RT02055	120	2	d	5	500
11/22/02	3 week HC	RT02055	120	2	d	6	550
11/22/02	3 week HC	RT02055	120	2	s	1	550
11/22/02	3 week HC	RT02055	120	2	s	2	613
11/22/02	3 week HC	RT02055	120	3	d	1	500
11/22/02	3 week HC	RT02055	120	3	d	2	425
11/22/02	3 week HC	RT02055	120	3	d	3	460
11/22/02	3 week HC	RT02055	120	3	d	4	480
11/22/02	3 week HC	RT02055	120	3	d	5	550
11/22/02	3 week HC	RT02055	120	3	d	6	575
11/22/02	3 week HC	RT02055	120	3	s	1	553
11/22/02	3 week HC	RT02055	120	3	s	2	
12/4/02	3 month HC	RT02064	121	1	d	1	320
12/4/02	3 month HC	RT02064	121	1	d	2	340
12/4/02	3 month HC	RT02064	121	1	d	3	330
12/4/02	3 month HC	RT02064	121	1	d	4	380
12/4/02	3 month HC	RT02064	121	1	d	5	320
12/4/02	3 month HC	RT02064	121	1	d	6	330
12/4/02	3 month HC	RT02064	121	1	s	1	333
12/4/02	3 month HC	RT02064	121	1	s	2	340
12/4/02	3 month HC	RT02064	121	2	d	1	425
12/4/02	3 month HC	RT02064	121	2	d	2	325
12/4/02	3 month HC	RT02064	121	2	d	3	315
12/4/02	3 month HC	RT02064	121	2	d	4	410
12/4/02	3 month HC	RT02064	121	2	d	5	390
12/4/02	3 month HC	RT02064	121	2	d	6	380
12/4/02	3 month HC	RT02064	121	2	s	1	333
12/4/02	3 month HC	RT02064	121	2	s	2	340

date of test	donor	ID	day	disk #	core/ strip	core/strip#	thickness (um)
12/4/02	3 month HC	RT02064	121	3	d	1	355
12/4/02	3 month HC	RT02064	121	3	d	2	260
12/4/02	3 month HC	RT02064	121	3	d	3	355
12/4/02	3 month HC	RT02064	121	3	d	4	320
12/4/02	3 month HC	RT02064	121	3	d	5	260
12/4/02	3 month HC	RT02064	121	3	d	6	300
12/4/02	3 month HC	RT02064	121	3	s	1	350
12/4/02	3 month HC	RT02064	121	3	s	2	373
1/7/03	3 month HC	RT02064	156	1	d	1	410
1/7/03	3 month HC	RT02064	156	1	d	2	290
1/7/03	3 month HC	RT02064	156	1	d	3	295
1/7/03	3 month HC	RT02064	156	1	d	4	480
1/7/03	3 month HC	RT02064	156	1	d	5	345
1/7/03	3 month HC	RT02064	156	1	d	6	3258
1/7/03	3 month HC	RT02064	156	1	s	1	403
1/7/03	3 month HC	RT02064	156	1	s	2	336
1/7/03	3 month HC	RT02064	156	2	d	1	375
1/7/03	3 month HC	RT02064	156	2	d	2	355
1/7/03	3 month HC	RT02064	156	2	d	3	365
1/7/03	3 month HC	RT02064	156	2	d	4	385
1/7/03	3 month HC	RT02064	156	2	d	5	360
1/7/03	3 month HC	RT02064	156	2	d	6	345
1/7/03	3 month HC	RT02064	156	2	s	1	403
1/7/03	3 month HC	RT02064	156	2	s	2	387
1/7/03	3 month HC	RT02064	156	3	d	1	370
1/7/03	3 month HC	RT02064	156	3	d	2	360
1/7/03	3 month HC	RT02064	156	3	d	3	360
1/7/03	3 month HC	RT02064	156	3	d	4	450
1/7/03	3 month HC	RT02064	156	3	d	5	335
1/7/03	3 month HC	RT02064	156	3	d	6	410
1/7/03	3 month HC	RT02064	156	3	s	1	370
1/7/03	3 month HC	RT02064	156	3	s	2	410

type	average of each disc sample	day	disc#	EQMOD	m	TENSION	n
LC	lamb 8	208	1	60.24235	3		
FLC	fetal B1-3	89	1	7.5712	3	864.319	2
FLC	A2-3	133	1	7.53186	4	1343.123	2
FLC	A2-3	133	2	6.39036	4	1302.841	2
FLC	A1	133	1	9.60458	4	1785.228	2
FLC	A1	133	2	6.98944	3	1842.793	2
LC	lamb 14	158	1	0.5997	3	694.7027	2
LC	lamb 14	158	2	0.17535	3	900.4093	2
LC	lamb 14	158	3	0.15359	2	40.80525	2
LC	lamb 14	158	4	0.23672	5	1353.812	2
FLC	B1-3	131	1	12.70956	4	1291.214	2
HC (6 weeks)	11001735	143	1	13.07828	5	65.96595	1
HC (6 weeks)	11001735	143	2	6.01064	5	134.7308	2
HC (3 month)	RT01071	146	1	2.841	5	166.2913	2
HC (3 month)	RT01071	146	2	2.14804	5	265.9974	2
FLC	fetal E1-2	82	1	5.09049	6	985.8517	2
FLC	fetal E1-2	82	2	5.92163	6	1125.389	2
FLC	fetal D1-2	131	1	5.25078	6	1040.994	2
FLC	fetal D1-2	131	2	5.82335	6	988.4232	2
HC (3 week)	RT02055	61	1	19.06589	6	125.6186	2
HC (3 week)	RT02055	61	2	32.86189	6	286.659	2
HC (3 week)	RT02055	61	3	29.33994	6	112.9459	2
FLC	fetal E	120	1	6.67408	6	2398.672	2
FLC	fetal E	120	2	5.56116	7	3475.813	1
FLC	fetal E	120	3	6.39004	6	2421.335	2
FLC	fetal D	207	1	7.43207	6	2429.285	2
FLC	fetal D	207	2	6.71606	6	3963.058	2
FLC	fetal D	207	3	6.98577	6	3894.964	2
LC	lamb15	117	1	1.35929	4	671.4965	2
LC	lamb15	117	2	2.1901	4	769.7646	2
LC	lamb15	117	3	1.2711	4	982.1566	2
LC	lamb15	117	4	1.86287	5	960.8639	2
FLC	fetal B1-3	311	1	35.38596	6	4547.778	2
FLC	fetal B1-3	311	2	40.06018	4	3866.279	2
HC (3 week)	RT02055	96	1	11.29632	7	385.7938	2
HC (3 week)	RT02055	96	2	12.18702	6	479.4633	2
HC (3 week)	RT02055	96	3	20.44165	6	243.248	2
HC (3 month)	RT02064	95	1	16.47217	7	451.8642	2
HC (3 month)	RT02064	95	2	13.76703	7	443.2096	2
HC (3 month)	RT02064	95	3	11.67966	6	399.8284	2
HC (3 week)	RT02055	120	1	16.09692	6	387.4818	2
HC (3 week)	RT02055	120	2	13.25768	6	396.8321	2
HC (3 week)	RT02055	120	3	11.08961	6	464.8162	2
HC (3 month)	RT02064	121	1	17.01891	6	318.8506	2

type	average of each disc sample	day	disc#	EQMOD	m	TENSION	n
HC (3 month)	RT02064	121	2	17.07154	6	528.0601	2
HC (3 month)	RT02064	121	3	11.29999	6	418.4387	2
HC (3 month)	RT02064	156	1	17.18914	6	330.9924	2
HC (3 month)	RT02064	156	2	22.48394	6	392.0522	2
HC (3 month)	RT02064	156	3	20.62	6	405.1319	2

Appendix B – Construct Biochemistry

Definitions for Construct Biochemistry Data

<u>Donor Abbreviations:</u>

LC = Lamb Chondrocyte
FLC = Fetal Lamb Chondrocyte
HC = Human Chondrocyte

<u>Source:</u>

p = parallel disk
c = core
s = strip
r = remnant

The majority of the biochemistry data was obtained from *parallel* disks. A group of construct disks is seeded from the same donor chondrocyte population. From this group, a few are packaged and sent for immediate biomechanical characterization. At the same time, a few from the same group are immediately biochemically analyzed.

The rest of the biochemistry data was obtained from either the material that was mechanically tested, or the *remnants* of the disk that was dissected for mechanical testing.

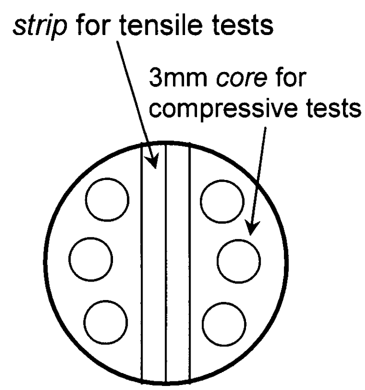


Figure 1. construct *disk*
N = number of disks
m = number of cores
n = number of strips

date of test	type	day	specimen	disc#	source	sgag (ug)	hpro (ug)	dna (ug)	sgag/dna	hpro/ dna	wet weight (mg)	dry weight (mg)
3/28/02	FLC	133	A2-3	1	p	2884.2	503.4	43.8	65.8493	11.4932	81.6	9.2
3/28/02	FLC	133	A2-3	1	p	2656.9	487.5	42.3	62.8109	11.5248	81.6	8.6
3/28/02	FLC	133	A2-3	1	p	2404.5	511.5	46.1	52.1584	11.0954	97.4	10.4
3/28/02	FLC	133	A1	1	p	2234.2	526.2	33.6	66.494	15.6607	82.5	9.4
3/28/02	FLC	133	A1	1	p	2170.9	551.9	41.3	52.5642	13.3632	98.3	9.7
3/28/02	FLC	133	A1	1	p	2209.9	515.3	41	53.9	12.5683	99	8.9
4/18/02	FLC	131	B1-3	1	p	4276.9	756.4	44.1	97	17.1519	.	17.8
4/18/02	FLC	131	B1-3	2	p	4498.3	853.8	51.8	86.8	16.4826	.	18.8
4/18/02	FLC	131	B1-3	3	p	5449.7	943.5	55.4	98.4	17.0307	.	22.3
4/18/02	FLC	131	B1-3	4	p	5326.5	930.6	48.4	110.1	19.2273	.	21
10/15/02	FLC	311	B	1	p	4276.9	756.4	44.1	97	17.1519	.	17.8
10/15/02	FLC	311	B	2	p	4498.3	853.8	51.8	86.8	16.4826	.	18.8
10/15/02	FLC	311	B	3	p	5449.7	943.5	55.4	98.4	17.0307	.	22.3
10/15/02	FLC	311	B	4	p	5326.5	930.6	48.4	110.1	19.2273	.	21
4/23/02	LC	117	lamb15	1	p	1448	150.6	17.2	84.186	8.75581	45.8	3.7
4/23/02	LC	117	lamb15	1	p	1341.9	129.8	18.3	73.3279	7.0929	46.6	3.9
4/23/02	LC	117	lamb15	1	p	1050.2	132.1	19.4	54.134	6.80928	40.6	3.3
4/23/02	LC	117	lamb15	1	p	1442	122.1	16.7	86.3473	7.31138	45.4	3.9
4/10/02	LC	158	lamb14	1	p	1078.5	228.9	23.8	45.3151	9.61765	61.8	5
4/10/02	LC	158	lamb14	1	p	1148.5	208.3	21	54.6905	9.91905	51.8	4.9
4/10/02	LC	158	lamb14	1	p	1026.4	221.7	23.7	43.308	9.35443	55.7	4.8
4/10/02	LC	158	lamb14	1	p	1351.4	204.6	21.9	61.7078	9.34247	47.8	4.5
12/11/01	LC	208	lamb8	1	c	63.7	6	1	63.7	6	.	.
12/11/01	LC	208	lamb8	1	c	55.2	3.6	0.7	78.8571	5.14286	.	.
12/11/01	LC	208	lamb8	1	c	49.7	1	0.6	82.8333	1.66667	.	.
12/11/01	LC	208	lamb8 remnant	1	r	1563.6	204.8	12	130.3	17.0667	.	.
4/30/02	6 week HC	143	11001735	1	s	1629.3	.	14.5	112.4		.	3.9
4/30/02	6 week HC	143	11001735	2	s	1011.7	.	6.9	146.6		.	3.1
4/30/02	6 week HC	143	11001735 rem	1	r	11780	.	75.3	156.4		.	30.6
4/30/02	6 week HC	143	11001735 rem	2	r	11915	.	73.4	162.3		.	29.2

date of test	type	day	specimen	disc#	source	sgag (ug)	hpro (ug)	dna (ug)	sgag/dna	hpro/ dna	wet weight (mg)	dry weight (mg)
9/24/02	3 week HC	61	RT02055	1	p	4108.5	336.7	38.6	106.4	8.7228	106.1	9.4
9/24/02	3 week HC	61	RT02055	2	p	3391	325.4	38.3	88.5	8.49608	102.5	8.8
9/24/02	3 week HC	61	RT02055	3	p	3750.3	323.1	37	101.4	8.73243	100.7	9.5
10/29/02	3 week HC	96	RT02055	1	p	7238	534.3	64.3	112.6	8.30949	159.4	14.7
10/29/02	3 week HC	96	RT02055	2	p	8192	562.2	66.7	122.8	8.42879	158.3	14.5
10/29/02	3 week HC	96	RT02055	3	p	7412.3	531.3	64.9	114.2	8.18644	156.7	15.1
11/22/02	3 week HC	120	RT02055	1	p	12378	693.7	74.9	165.3	9.26168	281	23.4
11/22/02	3 week HC	120	RT02055	2	p	12171	697.4	73	166.7	9.55342	269.2	22.3
11/22/02	3 week HC	120	RT02055	3	p	14850	787.9	83	178.9	9.49277	298.9	24.4
11/7/02	3 month HC	95	RT02064	1	p	5975.1	429.6	59.3	100.8	7.24452	176	13.1
11/7/02	3 month HC	95	RT02064	2	p	5745.8	429.9	54.4	105.6	7.90257	174.5	13.1
11/7/02	3 month HC	95	RT02064	3	p	5692.1	410.6	54.8	103.9	7.4927	170.1	13
12/3/02	3 month HC	121	RT02064	1	p	5764.6	529.6	60.5	95.3	8.75372	194.8	15.1
12/3/02	3 month HC	121	RT02064	2	p	5705	472.2	55.3	103.2	8.53888	179.2	14.7
12/3/02	3 month HC	121	RT02064	3	p	5268.4	490.6	54.3	97	9.03499	173.3	14.1
4/30/02	3 month HC	146	RT01071	1	s	1903.1	.	11.9	159.9		.	4.2
4/30/02	3 month HC	146	RT01071	2	s	1929.1	.	13.8	139.8		.	4.4
4/30/02	3 month HC	146	RT01071	1	r	5576.6	.	50.4	110.6		.	16.4
4/30/02	3 month HC	146	RT01071	2	r	6604.3	.	53.4	123.7		.	17.4

Biochemistry averages per specimen

GAG/DNA

type	specimen	day	N	mean	sem	stdev
FLC	fetal E1-2	82	2	47.34	5.663	8.0089
FLC	fetalb1-3	89	2	40.95	5.281	7.4687
FLC	fetal E	120	3	74.87	7.5	12.993
FLC	fetalB1-3	131	4	98.08	4.77	9.5392
FLC	fetal d1-2	131	2	43.37	1.404	1.9859
FLC	fetalA2-3	133	3	60.27	4.151	7.1897
FLC	fetalA1	133	3	57.65	4.437	7.6859
FLC	fetal D1-2	207	3	38.53	3.29	5.7015
FLC	fetalB	311	6	99.42	3.176	7.7788
LC	lamb15	117	4	74.5	7.362	14.723
LC	lamb14	158	4	51.26	4.277	8.5537
LC	lamb8	208	4	88.92	14.4	28.79
HC	11001735 6wk	143	4	144.4	11.17	22.343
HC	RT02055 3wk	54	3	98.77	5.332	9.236
HC	RT02055 3wk	90	3	116.5	3.167	5.4857
HC	RT02055 3wk	120	3	170.3	4.319	7.4806
HC	RT02064 3mth	95	3	103.4	1.405	2.4338
HC	RT02064 3mth	121	3	98.5	2.401	4.1581
HC	RT01071 3mth	146	4	133.5	10.63	21.269

Hypro/DNA

type	specimen	day	N	mean	sem	stdev
FLC	fetal E1-2	82	2	8.76	1.071	1.514
FLC	fetalb1-3	89	2	7.651	0.407	0.576
FLC	fetal E	120	3	11.65	1.115	1.932
FLC	fetalB1-3	131	4	17.47	0.603	1.205
FLC	fetal d1-2	131	2	8.857	0.289	0.409
FLC	fetalA2-3	133	3	11.37	0.138	0.239
FLC	fetalA1	133	3	13.86	0.927	1.606
FLC	fetal D1-2	207	3	10.63	0.612	1.06
FLC	fetalB	311	6	16.76	0.601	1.471
LC	lamb15	117	4	7.492	0.434	0.867
LC	lamb14	158	4	9.558	0.136	0.272
LC	lamb8	208	4	7.469	3.334	6.667
HC	11001735 6wks	143	4	8.676	0.465	0.929
HC	RT02055 3wk	61	3	8.65	0.077	0.134
HC	RT02055 3wk	96	3	8.308	0.07	0.121
HC	RT02055 3wk	120	3	9.436	0.089	0.154
HC	RT02064 3mth	95	3	7.547	0.192	0.332
HC	RT02064 3mth	121	3	8.776	0.144	0.249
HC	RT01071 3mth	146	4	8.624	0.549	1.098

Appendix C – Ovine Biomechanics

Legend for Ovine Biomechanics Data

Site Definitions

LMA – left medial a
LMB – left medial b
LLA – left lateral a
LLB – left lateral b
RMA – right medial a
RMB – right medial b
RLA – right lateral a
RLB – right lateral b

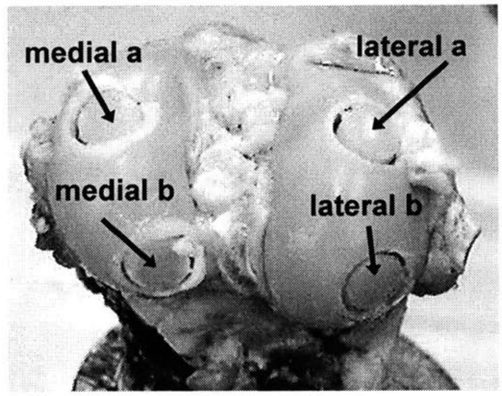


Figure 3. Sheep knee with cores

Other Definitions

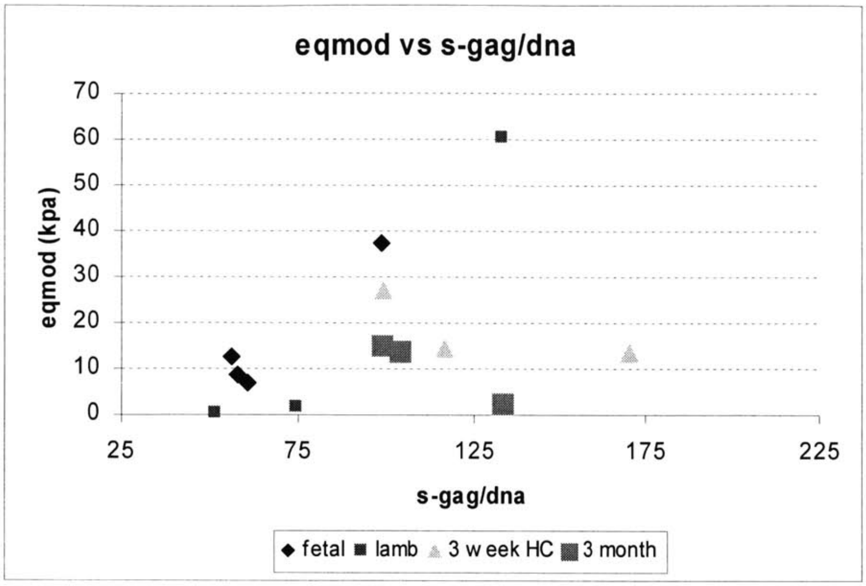
Eqmod = Equilibrium Compression Modulus (H_A)
Shear = shear stiffness
Dyn = Dynamic compressive stiffness
tTG = tissue transglutaminase

date of test	ID #	heal time (days)	tTG?	weight bearing (weeks)	graft?	site	eqmod (kPa)	shear 1 Hz (MPa)	shear 0.5 Hz (MPa)	shear 0.3Hz (MPa)	shear 0.1Hz (MPa)	dyn 1Hz (MPa)	dyn 0.8Hz (MPa)	dyn 0.5Hz (MPa)	dyn 0.3Hz (MPa)	dyn 0.2Hz (MPa)	dyn 0.1Hz (MPa)	dyn 0.05 Hz (MPa)	dyn 0.03Hz (MPa)	dyn 0.02Hz (MPa)	dyn 0.01Hz (MPa)
11/13/01	20	62	n	0	n	LMB	153.78	0.3592	0.3358	0.313	0.283	1.169	1.1604	1.141	1.101	1.077	1.014	0.9504	0.902	0.862	0.783
11/13/01	20	62	n	0	n	LLA	104.09	0.0654	0.0584	0.054	0.046	1.071	1.066	1.04	1.011	0.983	0.929	0.8638	0.8104	0.7712	
11/13/01	20	62	n	0	n	LLB	87.168	0.1511	0.1391	0.133	0.125	1.176	1.1699	1.146	1.116	1.089	1.022	0.9517	0.8957	0.8488	0.7748
11/13/01	20	62	n	0	n	RMA	68.939	0.1891	0.1762	0.165	0.159	0.4	0.3999	0.388	0.374	0.362	0.336	0.3079	0.2918	0.2801	0.2492
11/13/01	20	62	n	0	n	RMB	83.936	0.1509	0.1437	0.14	0.122	1.12	1.1144	1.097	1.074	1.048	0.997	0.9405	0.8992	0.8668	0.8094
11/13/01	20	62	n	0	n	RLB	122.11	0.2347	0.2232	0.208	0.189	0.727	0.7235	0.705	0.679	0.658	0.609	0.5606	0.523	0.4934	0.4306
11/13/01	20	62	n	0	y	LMA	101.66	0.0482	0.0344	0.036	0.037	0.915	0.9092	0.888	0.864	0.841	0.794	0.7407	0.699	0.6663	0.6129
11/13/01	21	62	n	0	n	LMB	80.315	0.0279	0.0272	0.025	0.025	0.946	0.9446	0.92	0.894	0.868	0.817	0.7607	0.7123	0.6751	0.6069
11/13/01	21	62	n	0	n	LLA	87.704	0.2424	0.2263	0.223	0.192	0.843	0.8377	0.815	0.789	0.769	0.727	0.6853	0.6483	0.6227	0.5769
11/13/01	21	62	n	0	n	RMA	51.324					0.451	0.4485	0.437	0.422	0.407	0.38	0.3491	0.3253	0.3076	0.2719
11/13/01	21	62	n	0	n	RMB	92.936					0.637	0.6329	0.617	0.599	0.581	0.547	0.508	0.4784	0.4537	0.4073
11/13/01	21	62	n	0	n	RLA	56.816					0.819	0.815	0.797	0.772	0.745	0.707	0.6606	0.6212	0.5964	0.5464
11/13/01	21	62	n	0	n	RLB	53.924					0.808	0.8041	0.788	0.765	0.745	0.703	0.6607	0.6267	0.582	0.5168
11/13/01	21	62	n	0	y	LMA	46.984	0.0378	0.0326	0.034	0.034	0.601	0.5973	0.583	0.563	0.547	0.512	0.4769	0.4474	0.4254	0.3881
11/19/01	1	81	n	4	n	LMB	28.684					0.6	0.5934	0.578	0.557	0.538	0.507	0.4659	0.4382	0.4182	0.3827
11/19/01	1	81	n	4	n	LLA	59.064					0.684	0.6769	0.659	0.633	0.61	0.567	0.5238	0.4828	0.4529	0.3979
11/19/01	1	81	n	4	y	LMA	28.728					0.403	0.3954	0.38	0.361	0.346	0.321	0.2926	0.2748	0.2619	0.2405
11/19/01	4	82	y	4	n	LMB	37.833					0.827	0.8171	0.789	0.767	0.74	0.7	0.6527	0.6121	0.5888	0.5344
11/19/01	4	82	y	4	n	LLA	53.897					0.674	0.668	0.65	0.626	0.606	0.565	0.5216	0.4888	0.4633	0.4133
11/19/01	4	82	y	4	n	LLB	38.144					0.578	0.5686	0.553	0.53	0.518	0.487	0.4592	0.4381	0.4184	0.3888
11/19/01	4	82	y	4	y	LMA	38					0.415	0.4082	0.393	0.378	0.365	0.345	0.3155	0.2954	0.2841	0.2569
11/26/01	16	70	y	0	n	LMB	78.294	0.0424	0.0462	0.041	0.038	0.778	0.7616	0.743	0.716	0.696	0.658	0.6199	0.589	0.5623	0.5148
11/26/01	16	70	y	0	n	LLA	95.4	0.0338	0.0375	0.037	0.034	0.739	0.7281	0.705	0.68	0.661	0.618	0.58	0.5485	0.5259	0.4883
11/26/01	16	70	y	0	n	RMA	41.578	0.1398	0.1369	0.127	0.12	0.496	0.489	0.474	0.454	0.435	0.402	0.3667	0.34	0.3176	0.2784
11/26/01	16	70	y	0	n	RMB	35.064	0.0257	0.0231	0.022	0.026	0.385	0.3816	0.368	0.351	0.335	0.306	0.2735	0.2496	0.2309	0.2008
11/26/01	16	70	y	0	n	RLA	57.968	0.0143	0.0209	0.016	0.019	0.609	0.601	0.58	0.555	0.542	0.511	0.4783	0.4572	0.4429	0.414
11/26/01	16	70	y	0	n	RLB	58.141					0.605	0.5949	0.579	0.559	0.553	0.506	0.4695	0.4448	0.423	0.3891
11/26/01	16	70	y	0	y	LMA	3.1797	0.0104	0.0123	0.011	0.013	0.047	0.0452	0.042	0.039	0.037	0.033	0.0291	0.0266	0.0245	0.0212
11/27/01	9	70	y	0	n	LMB	30.719	0.0428	0.0396	0.04	0.039	0.269	0.2631	0.254	0.242	0.233	0.221	0.2058	0.195	0.1878	0.1737
11/27/01	9	70	y	0	n	LLA	61.915	0.0121	0.0078	0.012	0.016	0.182	0.1786	0.172	0.16	0.151	0.137	0.1268	0.1099	0.1	0.0884
11/27/01	9	70	y	0	n	LLB	25.342	0.0081	0.0091	0.004	0.008	0.218	0.2158	0.208	0.199	0.193	0.178	0.164	0.1549	0.1487	0.1404
11/27/01	9	70	y	0	n	RMA	53.037	0.0249	0.0188	0.02	0.02	0.68	0.6801	0.663	0.64	0.619	0.58	0.5364	0.5033	0.4794	0.4323
11/27/01	9	70	y	0	n	RMB	31.087	0.028	0.027	0.03	0.035	0.303	0.2942	0.284	0.271	0.259	0.242	0.2266	0.2045	0.1919	0.1748
11/27/01	9	70	y	0	n	RLA	61.173	0.0358	0.0358	0.039	0.034	0.349	0.3431	0.333	0.319	0.308	0.281	0.2622	0.2513	0.2397	0.2179
11/27/01	9	70	y	0	n	RLB	29.144					0.308	0.3057	0.297	0.286	0.276	0.257	0.236	0.2232	0.2115	0.1906
11/27/01	9	70	y	0	y	LMA	10.018	0.0062	0.0055	0.007	0.008	0.131	0.1288	0.124	0.117	0.111	0.101	0.0921	0.0856	0.0809	0.0721
12/3/01	18	81	n	4	n	LMB	22.486	0.0684	0.0618	0.064	0.063	0.445	0.4386	0.422	0.403	0.388	0.361	0.3318	0.309	0.2914	0.2535

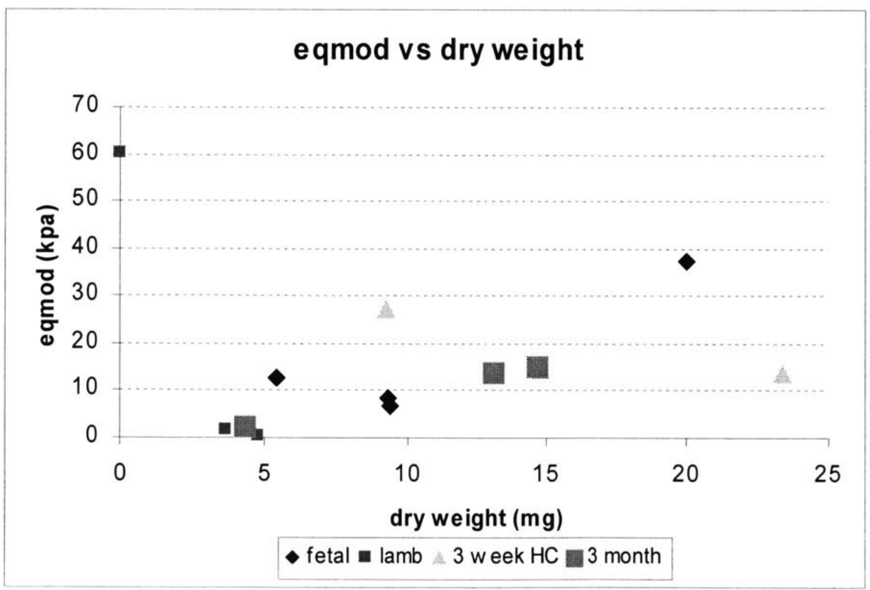
date of test	ID #	heal time (days)	tTG?	weight bearing (weeks)	graft?	site	eqmod (kPa)	shear 1 Hz (MPa)	shear 0.5 Hz (MPa)	shear 0.3Hz (MPa)	shear 0.1Hz (MPa)	dyn 1Hz (MPa)	dyn 0.8Hz (MPa)	dyn 0.5Hz (MPa)	dyn 0.3Hz (MPa)	dyn 0.2Hz (MPa)	dyn 0.1Hz (MPa)	dyn 0.05Hz (MPa)	dyn 0.03Hz (MPa)	dyn 0.02Hz (MPa)	dyn 0.01Hz (MPa)
12/3/01	18	81	n	4	n	LLA	59.915	0.04	0.0399	0.041	0.044	0.482	0.4756	0.461	0.443	0.43	0.405	0.3767	0.3541	0.3358	0.3024
12/3/01	18	81	n	4	n	LLB	37.655	0.0186	0.0188	0.019	0.028	0.49	0.4852	0.474	0.461	0.45	0.423	0.3974	0.377	0.3609	0.3308
12/3/01	18	81	n	4	n	RMA	44.072	0.0679	0.0656	0.063	0.068	0.415	0.4116	0.399	0.384	0.373	0.356	0.3281	0.3084	0.2925	0.2665
12/3/01	18	81	n	4	n	RMB		0.0326	0.0331	0.03	0.039										
12/3/01	18	81	n	4	n	RLA	74.558	0.087	0.0732	0.074	0.071	0.546	0.537	0.521	0.506	0.489	0.465	0.4329	0.4054	0.3896	0.3511
12/3/01	18	81	n	4	n	RLB	56.232	0.0241	0.0227	0.024	0.024	0.432	0.4297	0.42	0.407	0.395	0.372	0.3425	0.3221	0.3063	0.2797
12/3/01	18	81	n	4	y	LMA	26.633	0.0143	0.0144	0.014	0.019	0.297	0.2899	0.277	0.261	0.248	0.224	0.2	0.1827	0.1704	0.1514
12/5/01	14	82	n	4	n	LMB	56.949	0.0595	0.0522	0.042	0.049	0.626	0.6104	0.59	0.567	0.547	0.514	0.4741	0.4393	0.4129	0.3672
12/5/01	14	82	n	4	n	LLA	54.56	0.0511	0.0396	0.04	0.033	0.551	0.5397	0.52	0.495	0.474	0.442	0.4063	0.383	0.3668	0.3413
12/5/01	14	82	n	4	n	RMA	84.616	0.0645	0.0588	0.068	0.064	0.73	0.7193	0.701	0.675	0.651	0.614	0.5685	0.5322	0.5058	0.4501
12/5/01	14	82	n	4	n	RMB	65.979					0.469	0.4609	0.449	0.433	0.419	0.391	0.3634	0.3416	0.3256	0.2902
12/5/01	14	82	n	4	n	RLA	57.294					0.688	0.6789	0.658	0.632	0.619	0.582	0.5456	0.5146	0.486	.
12/5/01	14	82	n	4	n	RLB	79.414	0.0972	0.0945	0.086	0.097	0.859	0.8499	0.828	0.799	0.772	0.725	0.6736	0.6352	0.6044	0.5521
12/5/01	14	82	n	4	n	LTM	50.596	0.0441	0.0447	0.044	0.048	0.7	0.6946	0.68	0.657	0.641	0.6	0.5605	0.5285	0.5049	0.4578
12/5/01	14	82	n	4	y	LMA	71.961	0.077	0.0635	0.067	0.061	0.616	0.6087	0.591	0.569	0.55	0.514	0.4766	0.448	0.4234	0.3791
12/10/01	11	82	y	4	n	LMB	56.863	0.1502	0.1435	0.132	0.122	0.789	0.7782	0.752	0.727	0.696	0.656	0.6083	0.5652	0.5316	0.4752
12/10/01	11	82	y	4	n	RMA	54.585	0.1416	0.1214	0.135	0.121	0.492	0.4829	0.472	0.461	0.448	0.429	0.4084	0.3909	0.3741	0.3504
12/10/01	11	82	y	4	n	RMB	111.84	0.1121	0.1111	0.104	0.109	1.166	1.1495	1.12	1.08	1.052	0.988	0.9207	0.8692	0.8448	0.7535
12/10/01	11	82	y	4	n	RLA	141.47					1.242	1.2326	1.203	1.17	1.134	1.067	0.998	0.9379	0.8905	0.8036
12/10/01	11	82	y	4	y	LMA	41.047	0.0522	0.051	0.044	0.044	0.636	0.6256	0.605	0.581	0.561	0.522	0.4838	0.4556	0.4349	0.3988
12/11/01	13	82	y	4	n	LMB	.	0.0563	0.0462	0.043	0.045	0.599	0.5875	0.568	0.553	0.532	0.505	0.4728	0.44	0.4204	0.3823
12/11/01	13	82	y	4	n	LLA	110.51					0.795	0.7902	0.775	0.752	0.73	0.688	0.6437	0.6071	0.5758	0.5187
12/11/01	13	82	y	4	n	RMA	131.47	0.1662	0.1581	0.155	0.149	0.918	0.9119	0.892	0.861	0.841	0.797	0.7583	0.7161	0.692	0.6312
12/11/01	13	82	y	4	n	RMB	50.047	0.0917	0.0775	0.084	0.075	1.273	1.258	1.226	1.179	1.138	1.058	0.9653	0.8821	0.818	0.7181
12/11/01	13	82	y	4	y	LMA	123.95	0.028	0.0212	0.016	0.021	1.068	1.0579	1.036	1.002	0.971	0.912	0.8488	0.7948	0.7562	0.6857
10/22/02	26	182	n	18	n	Lla	146.55	0.0659	0.0566	0.052	0.051	1.532	1.5028	1.423	1.33	1.264	1.139	1.0307	0.9421	0.8811	0.7473
10/22/02	26	182	n	18	n	LLb	185.73	0.0784	0.0729	0.068	0.062	1.734	1.6952	1.602	1.496	1.401	1.249	1.1007	0.9752	0.89	0.7595
10/22/02	26	182	n	18	n	LMb	113.36	0.0072	0.0074	0.009	0.009	1.114	1.0885	1.047	0.995	0.95	0.878	0.7913	0.7267	0.675	0.5792
10/22/02	26	182	n	18	n	Rla	117.17	0.0802	0.0703	0.068	0.057	0.944	0.9195	0.863	0.808	0.756	0.672	0.5883	0.5211	0.4632	0.3744
10/22/02	26	182	n	18	n	Rma	158.16	0.044	0.0357	0.039	0.034	1.469	1.4367	1.369	1.284	1.211	1.095	0.9741	0.8814	0.8086	0.659
10/22/02	26	182	n	18	n	RMb	172.29	0.0405	0.0385	0.036	0.033	1.923	1.8689	1.75	1.618	1.501	1.328	1.1586	1.0515	0.9532	0.7983
10/22/02	26	182	n	18	y	Lma	60.33	0.0781	0.0715	0.069	0.063	1.192	1.0533	1.044	0.996	0.949	0.878	0.8016	0.7453	0.7056	0.6561
10/24/02	48	182	n	18	n	Lla	46.201	0.0702	0.0624	0.056	0.051	0.522	0.4981	0.459	0.415	0.383	0.327	0.277	0.2407	0.2098	0.1692
10/24/02	48	182	n	18	n	LLb	49.506					0.455	0.4432	0.42	0.394	0.37	0.325	0.2825	0.2493	0.2267	0.1885
10/24/02	48	182	n	18	n	Lma	206.06	0.1325	0.1207	0.111	0.101	1.775	1.7311	1.656	1.559	1.486	1.358	1.2196	1.1169	1.0471	0.9117
10/24/02	48	182	n	18	n	LMb	54.286	0.0534	0.0513	0.051	0.043	0.845	0.7838	0.679	0.592	0.546	0.473	0.4054	0.3543	0.3115	0.2366
10/24/02	48	182	n	18	n	Rla	79.016					0.819	0.7999	0.759	0.712	0.669	0.598	0.525	0.4688	0.4228	0.3559

date of test	ID #	heal time (days)	tTG?	weight bearing (weeks)	graft?	site	eqmod (kPa)	shear 1 Hz (MPa)	shear 0.5 Hz (MPa)	shear 0.3Hz (MPa)	shear 0.1Hz (MPa)	dyn 1Hz (MPa)	dyn 0.8Hz (MPa)	dyn 0.5Hz (MPa)	dyn 0.3Hz (MPa)	dyn 0.2Hz (MPa)	dyn 0.1Hz (MPa)	dyn 0.05Hz (MPa)	dyn 0.03Hz (MPa)	dyn 0.02Hz (MPa)	dyn 0.01Hz (MPa)
10/24/02	48	182	n	18	n	RMb	45.351	0.0588	0.049	0.049	0.037	0.559	0.5424	0.511	0.473	0.441	0.383	0.322	0.2767	0.2415	0.1843
10/24/02	48	182	n	18	y	Rma	27.256	0.0773	0.0659	0.064	0.057	0.411	0.3951	0.371	0.343	0.318	0.285	0.2512	0.2282	0.2142	0.1873
10/31/02	29	182	n	18	n	Lla	168.93	0.0493	0.0458	0.04	0.037	1.634	1.5966	1.518	1.424	1.345	1.222	1.0936	0.9937	0.9023	0.7571
10/31/02	29	182	n	18	n	LMb	137.88	0.0244	0.0209	0.022	0.019	2.36	2.2955	2.207	2.084	1.982	1.794	1.5923	1.429	1.2995	1.1038
10/31/02	29	182	n	18	n	Rla	164.73	0.0357	0.0314	0.029	0.025	1.458	1.4253	1.335	1.236	1.159	1.024	0.9061	0.8191	0.7521	0.6306
10/31/02	29	182	n	18	n	RLb	99.519	0.0389	0.0348	0.036	0.026	0.983	0.9546	0.896	0.822	0.764	0.666	0.5633	0.4883	0.4269	0.3388
10/31/02	29	182	n	18	n	Rma	136.78	0.0624	0.0589	0.057	0.05	1.941	1.8562	1.76	1.648	1.561	1.427	1.3162	1.2423	1.1829	1.0759
10/31/02	29	182	n	18	n	RMb	137.58	0.0332	0.0303	0.029	0.026	1.925	1.8516	1.751	1.632	1.54	1.404	1.272	1.1922	1.1427	1.0514
10/31/02	29	182	n	18	y	Lma	13.1					0.13	0.1256	0.118	0.111	0.105	0.094	0.0853	0.0785	0.0746	0.066
11/5/02	33	182	n	18	n	Lla	29.647	0.0355	0.0338	0.03	0.03	0.71	0.6693	0.623	0.575	0.549	0.497	0.4573	0.4371	0.4193	0.383
11/5/02	33	182	n	18	n	LLb	48.258	0.0552	0.05	0.05	0.043	0.576	0.5568	0.519	0.478	0.448	0.392	0.3384	0.2982	0.2688	0.225
11/5/02	33	182	n	18	n	LMb	17.504	0.0076	0.008	0.005	0.004	0.258	0.2501	0.233	0.219	0.204	0.182	0.1596	0.1427	0.1299	0.1076
11/5/02	33	182	n	18	n	Rla	143.07	0.035	0.032	0.029	0.026	1.576	1.5225	1.43	1.325	1.247	1.132	1.0308	0.9724	0.9203	0.8204
11/5/02	33	182	n	18	n	RLb	54.835	0.0195	0.021	0.017	0.015	0.803	0.7756	0.729	0.671	0.628	0.556	0.4843	0.4302	0.3895	0.3127
11/5/02	33	182	n	18	n	Rma	82.163	0.0281	0.0244	0.026	0.021	0.981	0.9373	0.871	0.797	0.737	0.654	0.5815	0.5408	0.5138	0.4713
11/5/02	33	182	n	18	n	RMb	25.501	0.0111	0.0081	0.007	0.006	0.365	0.3526	0.328	0.304	0.283	0.25	0.215	0.1879	0.1698	0.1392
11/5/02	33	182	n	18	y	Lma	16.77	0.0721	0.0662	0.06	0.051	0.184	0.1783	0.169	0.157	0.148	0.133	0.1155	0.1054	0.0968	0.0794
11/7/02	45	182	n	18	n	Lla	198.11	0.0568	0.0525	0.052	0.046	1.645	1.5962	1.51	1.415	1.345	1.204	1.0853	1.0051	0.9402	0.8202
11/7/02	45	182	n	18	n	LLb	176.96	0.0239	0.0191	0.017	0.016	1.85	1.809	1.729	1.639	1.562	1.432	1.2878	1.1811	1.0951	0.9375
11/7/02	45	182	n	18	n	LMb	202.61	0.0237	0.0243	0.021	0.018	1.637	1.6009	1.55	1.482	1.425	1.317	1.1951	1.1024	1.0226	0.8887
11/7/02	45	182	n	18	n	Rla	231.63	0.0278	0.0251	0.024	0.017	2.528	2.4669	2.364	2.227	2.13	1.934	1.7433	1.6108	1.5074	1.3101
11/7/02	45	182	n	18	n	RLb	233.72	0.0562	0.0513	0.048	0.043	1.869	1.8247	1.733	1.628	1.543	1.391	1.2463	1.1454	1.0679	0.931
11/7/02	45	182	n	18	n	Rma	254.08	0.0389	0.0351	0.035	0.026	2.212	2.1797	2.086	2	1.917	1.763	1.6004	1.4653	1.3749	1.1895
11/7/02	45	182	n	18	n	RMb	125.96	0.0132	0.0144	0.011	0.012	1.114	1.0936	1.055	1.004	0.963	0.886	0.8039	0.7447	0.6894	0.5876
11/7/02	45	182	n	18	y	Lma	3.3727					0.055	0.0527	0.048	0.043	0.04	0.034	0.0287	0.0255	0.0229	0.0193
11/12/02	35	182	n	18	n	LLb	87.63	0.0239	0.0191	0.017	0.016	0.94	0.9144	0.861	0.792	0.739	0.65	0.5601	0.4938	0.4428	0.3721
11/12/02	35	182	n	18	n	LMb	67.559	0.0237	0.0243	0.021	0.018	0.797	0.7788	0.743	0.702	0.668	0.605	0.5369	0.4853	0.4367	0.3559
11/12/02	35	182	n	18	n	Rla	121.72	0.0278	0.0251	0.024	0.017	1.231	1.1935	1.112	1.019	0.952	0.848	0.7499	0.6769	0.6168	0.5127
11/12/02	35	182	n	18	n	RLb	98.289	0.0562	0.0513	0.048	0.043	0.976	0.9552	0.897	0.826	0.773	0.685	0.5988	0.539	0.4872	0.3977
11/12/02	35	182	n	18	n	Rma	299.27	0.0389	0.0351	0.035	0.026	2.934	2.8659	2.754	2.627	2.53	2.344	2.1621	2.0095	1.8753	1.6508
11/12/02	35	182	n	18	n	RMb	128.95	0.0132	0.0144	0.011	0.012	1.265	1.2442	1.199	1.153	1.109	1.028	0.9383	0.8748	0.818	0.7121
11/12/02	35	182	n	18	y	Lma	27.116	0.0568	0.0525	0.052	0.046	0.409	0.3966	0.377	0.358	0.339	0.309	0.2765	0.2519	0.2317	0.1984
11/14/02	44	182	n	18	n	Lma	60.758	0.0712	0.0697	0.069	0.06	0.474	0.4595	0.435	0.412	0.392	0.354	0.3068	0.284	0.2588	0.2182
11/14/02	44	182	n	18	n	LMb	189.99	0.0817	0.0745	0.068	0.066	1.395	1.3639	1.308	1.245	1.19	1.094	0.9947	0.9268	0.8633	0.7548
11/14/02	44	182	n	18	y	Rma	10.634					0.129	0.1259	0.115	0.108	0.099	0.092	0.0813	0.0727	0.0665	0.0586
11/14/02	44	182	n	18	n	RMb	198.05	0.0619	0.0574	0.049	0.046	1.5	1.4693	1.42	1.356	1.3	1.212	1.1157	1.0383	0.9775	0.8646

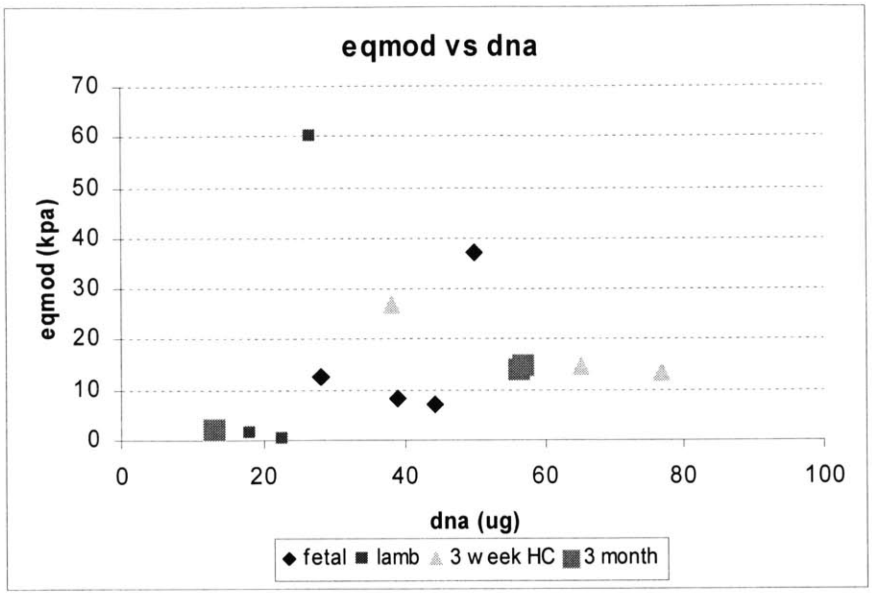
Appendix D – Construct Data Correlations



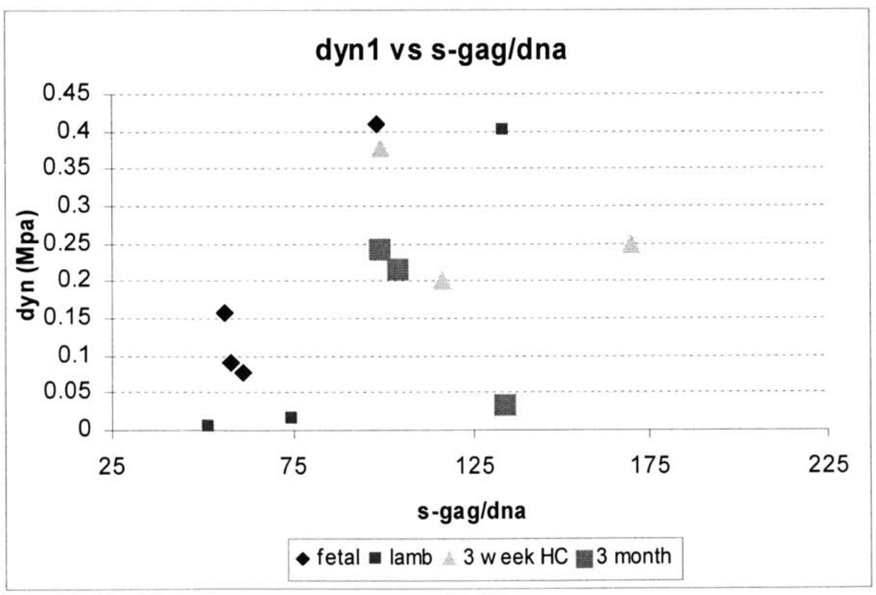
type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	0.680388	0.931871	27.356	18.5	y
lamb	3	0.780395	0.935349	14.46757	161	n
3weekHC	3	-0.15025	0.543865	1.192333	161	n
3monthHC	3	-0.36964	0.996846	316.1	161	y



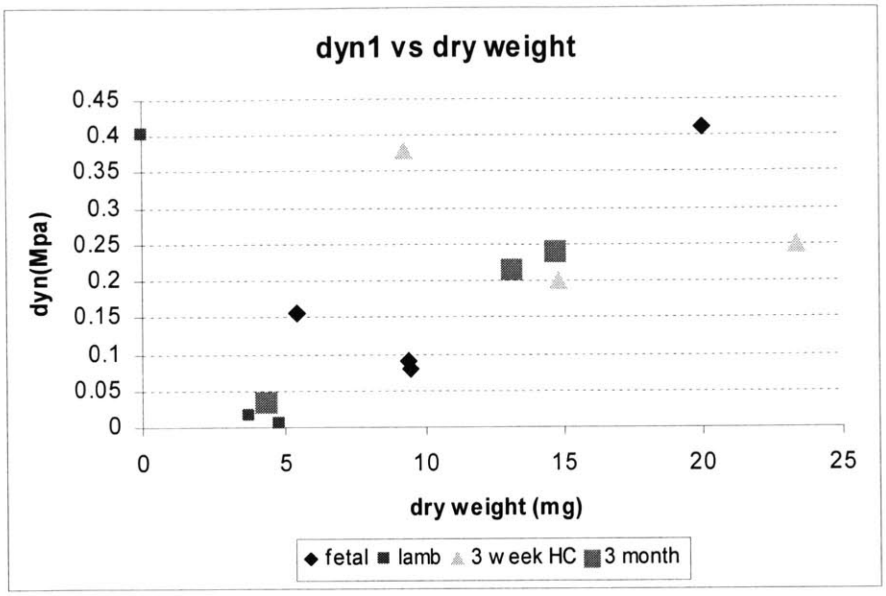
type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	2.019484	0.793996	7.708569	18.5	n
lamb	3	-13.3351	0.96043	24.27164	161	n
3weekHC	3	-0.8893	0.696613	2.296121	161	n
3monthHC	3	1.256588	0.995553	223.8662	161	y



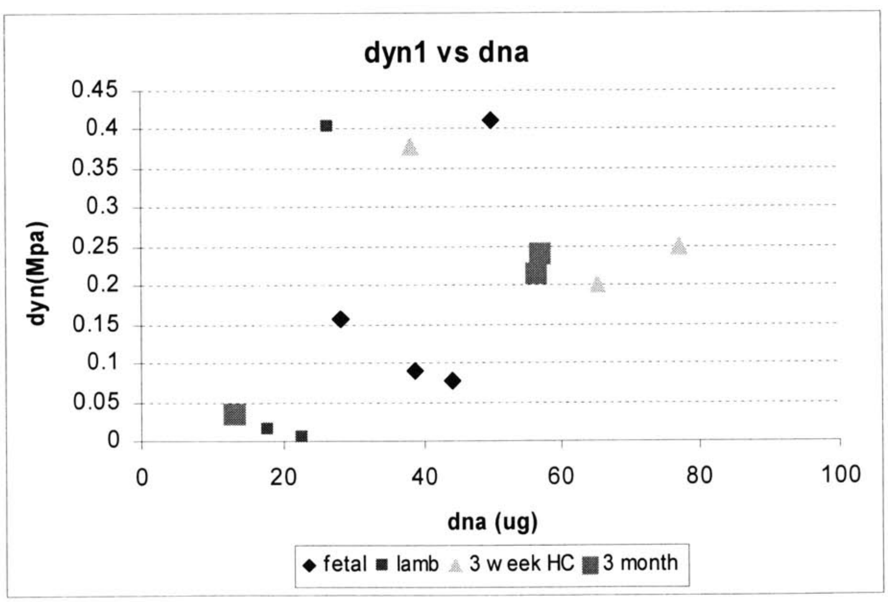
type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	0.859703	0.320247	0.942244	18.5	n
lamb	3	6.623554	0.674259	2.069927	161	n
3weekHC	3	-0.36903	0.947668	18.10863	161	n
3monthHC	3	0.278147	0.995936	245.0629	161	y



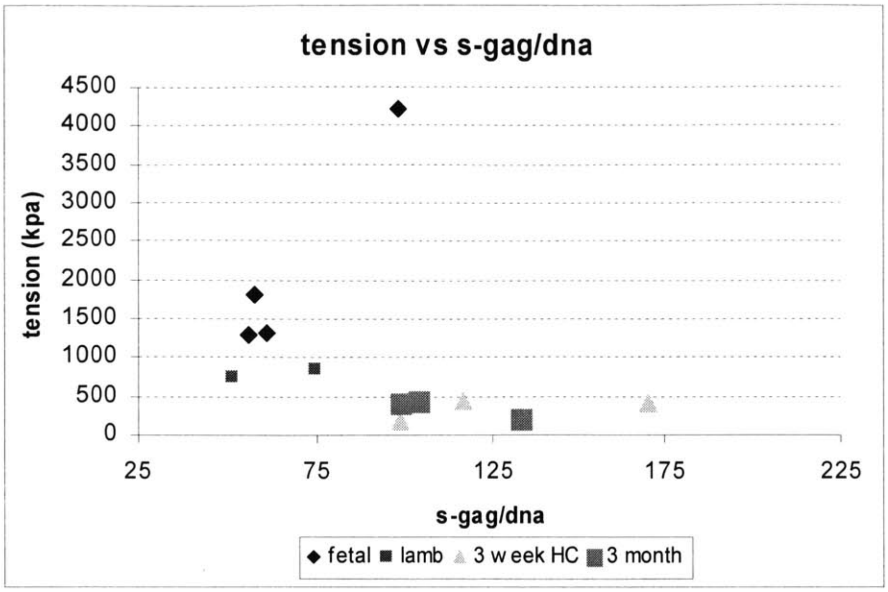
type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	0.007355	0.905733	19.21627	18.5	y
lamb	3	0.005162	0.935715	14.55573	161	n
3weekHC	3	-0.00116	0.222037	0.285408	161	n
3monthHC	3	-0.00595	0.999862	7226.903	161	y



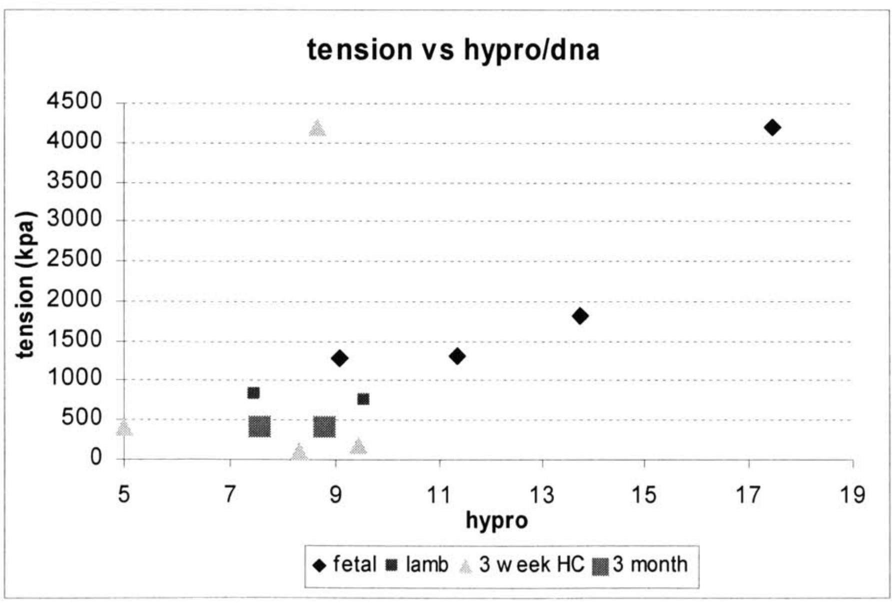
type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	0.021496	0.095332	5.942657	18.5	n
lamb	2	-0.00864				NA
3weekHC	3	-0.0078	0.365101	0.575055	161	n
3monthHC	3	0.020221	0.999502	2008.007	161	y



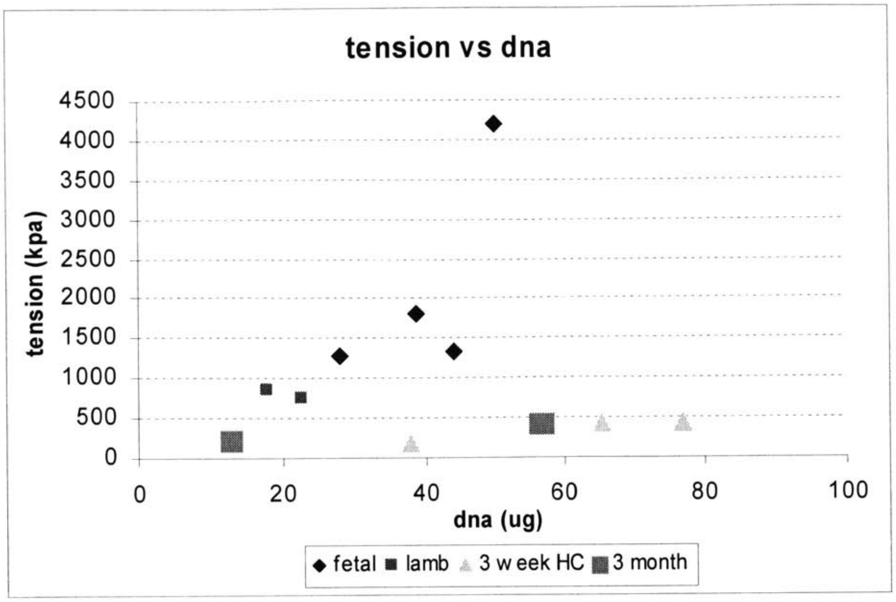
type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	0.00874	0.275285	0.759706	18.5	n
lamb	3	0.04378	0.67356	2.063349	161	n
3weekHC	3	-0.36903	0.947668	18.10863	161	n
3monthHC	3	0.00445	0.988335	84.72536	161	n



type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	67.586	0.957444	44.99671	18.5	y
lamb	2	4.247978				NA
3weekHC	3	2.522851	0.426267	0.74297	161	n
3monthHC	3	-6.32868	0.971019	33.50593	161	n



type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	353.9685	0.839813	10.48539	18.5	n
lamb	2	-47.2086				NA
3weekHC	3	32.51819	0.444892	0.801451	161	n
3monthHC	2	-8.01367				NA



type	n	slope	R^2	F	Fcrit(0.05)	F>Fcrit?
fetal	4	106.8127	0.514744	2.121534	18.5	n
lamb	2	-20.9868				NA
3weekHC	3	6.757034	0.883237	7.564375	161	n
3monthHC	3	4.828686	0.997392	382.4362	161	y