

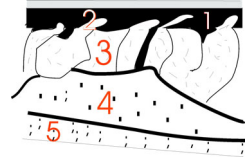
Pilot study of Dermal and Subcutaneous Fat Structures by MRI in Individuals that differ in Gender, BMI, and Cellulite Grading.

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Abstract: A pilot study was performed to evaluate MR micro-imaging as a tool for the investigation of cellulite. We show in-vivo micro-MRI is able to detect the effects of cellulite and demonstrate gender differences. We found tissue parameters correlated with cellulite and how MRI can differentiate skin tissues of differing cellulite grades. The diffuse pattern of extrusion of underlying adipose tissue into dermis was clearly imaged and quantified. This parameter and the percentile of adipose versus connective tissue in a given volume of hypodermis were correlated with cellulite grade.

Introduction: Puckered, dimply skin on the thighs, hips and buttocks is known as cellulite (1-2). A schematic diagram of skin is shown. The five zones in this diagram are as follows: (1) coarse fibrous corium called dermis. (2) small papillae adiposae break up into the corium. Subcutaneous tissue composed of three layers of fat (zones 3, 4, and 5) with two planes of connective tissue between them. (3) Upper zone of subcutis with standing fat-cell chambers and radially running septa of connective tissue. (4) Middle zone of subcutis layer with squat fat chambers and septa of connective tissue that runs tangentially to the fascia. (5) Lower zone of subcutis. **Note:** fascia is a linear connective tissue that connects deep fat layers of the skin to muscle. Fibrous septa are thin vertical streaks of connective tissue which connect the deep dermis to fascia concurrent with fat lobules.



Subject recruitment: The post-lateral thigh skin of 6 men and 12 women were imaged in six groups, (age range: 18-46 years). Subjects were categorized by their BMI and cellulite grading as shown in the table. In this study BMI 18-25 is defined as low BMI and BMI 30+ is high BMI. Cellulite is graded over the range of 0.0 – 4 where 0.0- 0.5 is low cellulite and 2- 4 is high cellulite.

Subjects	Low BMI	High BMI
Male with no cellulite	3	3
Female, with low cellulite	3	3
Female, with high cellulite	3	3

Materials and methods: Imaging was carried out on a 3T whole body magnet (Magnex, UK) with an SMIS console (SMIS, England) with an inductively coupled surface coil. Transverse multislice gradient echo, (TR/TE =340/19 ms, FOV=40x40mm, matrix 256x256; slice 1mm; resolution <160µm. Coronal GE were also obtained, (TR/TE=1215/26 ms; FOV=75x75mm; matrix 512x512; resolution <150µm; slice 1mm.)

Method of image analysis Pixels were classified as either fat or connective tissue by applying threshold levels, assuming within hypodermis and /or dermis there are only two compartments namely fat (i.e. bright pixels) and fibrous tissue (i.e. dark pixels) and furthermore no partial volume effects exist regarding that the slices are as thin as 1mm. The percentage of fat and fibrous tissue in hypodermis and dermis was calculated as follows. Firstly the maximum pixel intensity within a region identified as 100% fibrous tissue was obtained. Secondly, the minimum pixel intensity within a region identified as 100% fat was obtained. Finally the threshold was calculated as the intensity average of these two reference intensities. From number of pixels below and above the threshold for each slice the percentile area of the fibrous tissue and fat were measured respectively. **Statistics:** Comparison of data between the groups were made by using 1- way ANOVA to detect an overall difference between the 3 groups, where differences were considered significant at p≤ 0.05. We also used Duncan's multiple range test, to detect differences between groups, where differences were considered significant at p≤ 0.05. **Results:** Typical MRI thigh skin shown with in plane resolution of 273 x273 µm. Right to left is the surface of the skin toward the muscle. Zone 1 is dermis layer, zone 2, the bright pixels shown in the box is extrusion of hypodermic tissue inside dermis. Zones 3-5 are upper, middle and lower part of hypodermis. Fibrous septa and fascia are clearly visible. Typical images of male and female are shown in Figure 1.

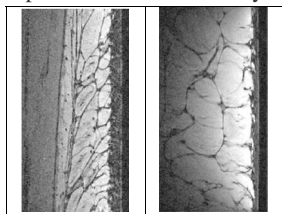
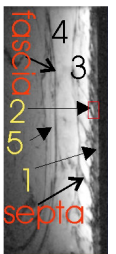


Fig. 1. (Left) male, (Right) female thigh skin with cellulite grade=0. The fibrous septa in male compared to female are thicker and are arranged in planes oblique in smaller capsules, hence smaller size of fat lobules while the septa are more radial and fat lobules are in larger dimension in women compared to male. Quantitative measurements obtained for high BMI group is shown in the table below. Low BMI group have thin skin layers, hence less data are obtained for this group. Among women, in the affected skin compared to unaffected, the dermis is thinner (p=0.09) and hypodermis is thicker (p=0.07).



Discussion: These results explain why cellulite affects 90% of all women but not many men.

In women, because the upper part of the subcutaneous tissue is thicker and the fat –cell chambers are bigger and radial (Fig 1, left), the compression and bulging of the upper fat cell chamber system can cause the overlying skin to protrude and produce deformation and pits (i.e. the mattress phenomenon or cellulite). In the comparable skin of thighs of men (Fig 1, right) the adipose tissue is thinner and has a network of criss-crossing septa of connective tissue that divide the fat cell chambers into small, polygonal units. This strong network of connective tissue in the fat layer and thicker dermis in male's skin compared to female's skin prevent the papillae adiposae protrude upon the overlying cutis. **Conclusions:** In vivo MRI micro imaging shows structural alterations of skin architecture which are correlated with cellulite grade.

Parameters of Skin architecture	Men, no cellulite	Female, high cellulite
Dermis thickness	1	Less (p<0.05)
Hypodermis thickness	1	-
Amount of fat inclusion into dermis	1	More (p<0.05)
Amount of fibrous tissue inside hypodermis	1	Less (p<0.05)

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Acknowledgments: we thank Dr R Summer for his helpful discussion in data analysis, our collaborator: Hill Top Research, Inc. Winnipeg. The research supported by Procter and Gamble Company, Ross, Ohio, U.S.A.