Age Estimation of Soft Tissue Hematomas

Bernhard Neumayer[1], Eva Hassler[1,2], Thomas Widek[1], Kathrin Ogris[1], and Eva Scheurer[1]
[1]*Clinical Forensic Imaging, Ludwig Boltzmann Institute, Graz, Styria, Austria,* [2]*Department of Radiology, Medical University of Graz, Graz, Styria, Austria*

Target Audience: This study is important for radiologists and forensic experts evaluating MRI data of soft tissue injuries, and MR physicists working on quantitative parameters of contrast in different tissues.

Purpose: The estimation of the time of the origin of soft tissue injuries such as bruises is important for the reconstruction of accidents and criminal acts such as child abuse, and often has legal consequences. However, visual assessment of hematoma color, the current standard for the evaluation of hematoma age, is unreliable due to its great variability[1], and is additionally hindered by individually varying color perception[2]. First studies showed that the contrast of hematomas in MRI could be used to get objective information on hematoma age[3,4]. The aim of this study was to model the temporal behavior of different contrast parameters of soft tissue hematomas to improve the accuracy of hematoma age estimation.

Methods: In 20 volunteers own blood (4ml) was injected into the subcutaneous tissue of the thigh. The hematomas were repetitively examined with MRI (0h, 3h, 1d, 3d, 1w, and 2w after injection) on a clinical 3T scanner (TimTrio, Siemens AG, Germany) using a superficial coil and 3 sequences: PDw FatSat TSE SPAIR (TR/TE=3400/11ms), IR (TR/TE/TI=7000/11/50,200,500,1000,2000ms), and MSE (TR/τ=5000/12ms, 16 echoes). For the analysis of T2-weighted images echo 9 of the MSE sequence was used. Data of 12 persons (6f, 6m, age 26.9±3.98y) were analyzed for model creation (6 were excluded due to artefacts, and 2 were statistical outliers). Signal intensities were determined in 3 ROIs, one each in the hematoma, muscle and subcutaneous fat, respectively, and the Michelson Contrast $C_M=(I_1-I_2)/(|I_1|+|I_2|)$[5] was calculated. For model creation averaged results of C_M between hematoma and muscle of the PDw and the IR sequence for TI=200 and TI=1000 were used as separate inputs. Baseline values were calculated from averaged fat-muscle contrast of all measurements leading to 2-parameter mono-exponential fits for these 3 contrasts. The resulting curves were used as lookup tables, and single age estimates were then averaged to provide a final estimate, which was cross-validated using the leave-one-out method.

Results: The Michelson contrast over time for the different sequences (except for T2w which did not provide useful results) is shown in **Fig 1**. The PDw sequence (blue curve) shows the largest dynamic range with a continuous decrease over the entire investigation period of 2 weeks, and a transition from hyper- to hypo-intensity at about 115 hours after injection. The contrast provided by the IR sequence for TI=200ms (green solid curve) shows a steady increase up to 2 weeks, however, with a clearly flatter slope. Both curves provide a similar variability in relation to their dynamic range. The curve for TI=1000ms (dashed green curve) shows a considerable increase between 0 and 72 hours; however, after 3 days the hematomas cannot be clearly delineated anymore. In **Fig 2a**, the estimated hematoma age is plotted with its 95% confidence interval (23.56±1.3h for all study dates) versus true age and compared to identity: linear regression yields R^2=0.928 with a slight underestimation of hematoma age particularly with increasing time. The Bland Altman plot (**Fig 2b**) shows no systematic deviations (μ=-0.38h) and a remarkable decrease of the *levels of agreement* (~20h) for the combined use of sequences compared to estimates based on PDw contrast only.

Discussion & Conclusion: The decrease of the contrast in the PDw data reflects the degradation of the hematoma blood in the fatty tissue. The contrast curves of the IR sequence document a steady decrease of the blood's T_1 (TI=200) which is stronger in the first hours (TI=1000). The reduction of one free parameter lead to an enhancement of hematoma age estimation using only PDw data, and the improvement of the new method in comparison to using PDw contrast only[4] is considerable. The 95% confidence interval shows the applicability especially for older hematomas and, thus, the potential of MRI to overcome this still unsolved problem in forensics. The estimation of more recent hematomas could be further improved by the incorporation of IR results for TI=1000. Additionally, relaxometry data is also expected to lead to an improvement. The presented model based on simple contrast measurements allows for objective hematoma age estimation with a 95% confidence interval of ~1 day and, thus, surpasses existing methods. This application is a good example to show the importance of radiologic methods in forensics.

References: 1. Pilling et al. Visual assessment of the timing of bruising by forensic experts. JForensic LegMed 2010;17:143. 2. Hughes et al. The perception of yellow in bruises. JClinForensicMed 2004;11:257. 3. Hassler et al. Contrast Evaluation of Artificial Hematomas in Different MRI Sequences Over Time. Proc ESMRMB 2012;364. 4. Neumayer et al. Modelling of Contrast Changes in Soft Tissue Hematomas. Proc ESMRMB 2012;643. 5. Michelson. *Studies in Optics*. 1927.

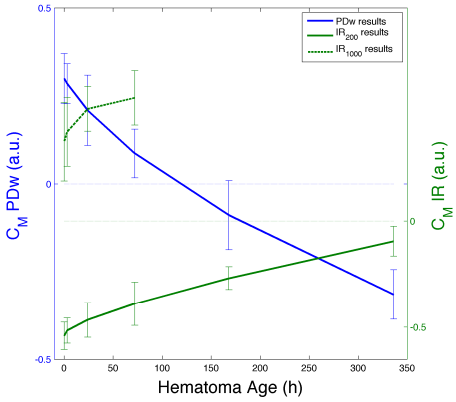

Fig 1: Michelson contrast (±SD) between hematoma and muscle of PDw FatSat (blue) and IR sequence (green) over time

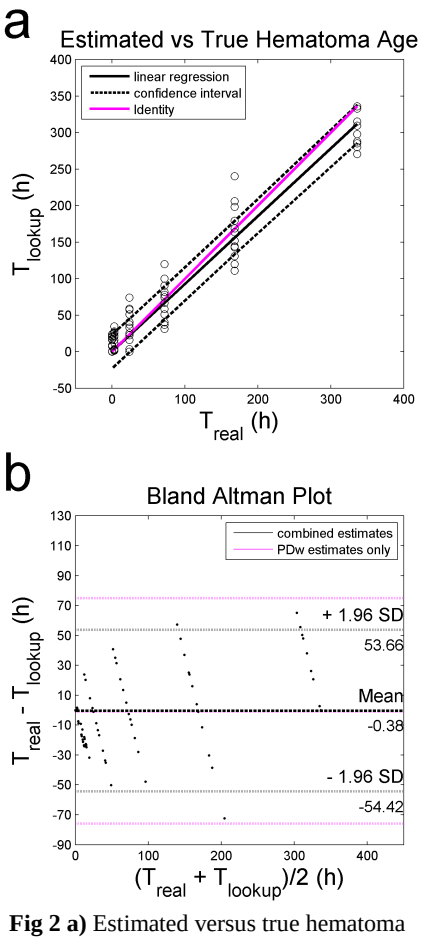

Fig 2 a) Estimated versus true hematoma age with 95% confidence interval, **b)** Bland Altman plot comparing method based on combined parameters to estimation using PDw data only