



Letter to the editor

Agreement between skeletal muscle mass measurements using computed tomography imaging and magnetic resonance imaging in head and neck cancer patients



Research on skeletal muscle mass (SMM) has increasingly gained interest over the past several decades. Pre-treatment low SMM, often referred to as sarcopenia, has shown to be a predictive and prognostic factor in a variety type of cancers [1–6]. In head and neck cancer (HNC), sarcopenia has shown to be a predictive factor for dose-limiting toxicity [7,8] and for the development of fistulas after total laryngectomy [9,10]. Sarcopenia has also shown to have negative prognostic impact in HNC patients [11–13].

Computed tomography (CT) has become the most used imaging modality in research on SMM because of relatively easy, fast and accurate segmentation of muscle by use of the muscle specific radiodensity range of -29 to $+150$ Hounsfield units (HU). Currently, the most used method is to assess SMM on abdominal CT, which uses the axial slice at the level of the third lumbar vertebra (L3) for segmentation of abdominal muscles as cross-sectional area (CSA). However, abdominal CT imaging is not routinely performed in HNC patients and is often only available in patients with advanced disease. Measurements of CSA of both sternocleidomastoid muscles and the paravertebral muscles at the level of the third cervical vertebra (C3) have shown to correlate well with CSA measurements at the level of L3 [17]. In order to avoid selection bias in research on SMM in HNC, measurement at the level of C3 is the preferred method [17].

Magnetic resonance imaging (MRI) does not allow for segmentation of muscle tissue based on a muscle specific radiodensity range, and therefore it is subject to the interpretation of the observer. However, MRI is considered one of the most accurate methods for analyzing quantitative and qualitative changes in body composition and is associated with an error in quantifying muscle that ranges between 1.1% and 4.4% [14]. CT, like MRI, is also considered as a highly precise imaging modality in investigating human body composition and has a reported precision error of about 1.4% for tissue areas [15]. Both scanning methods are able to distinguish muscle mass from fat. CT imaging can reveal fat infiltration within muscle by identifying areas in the range of -190 to -30 HU [16].

In the management of HNC, not all patients receive routinely CT scans. A large proportion of HNC patients receive MRI only. The agreement of CSA measurements of skeletal muscle (SM) based on CT

and MRI at the level of C3 is unknown. In order for SMM to be analyzed and routinely (without additional imaging and eventually retrospectively) used in the clinical practice of oncologic patients, it is paramount to study the concordance between SMM measurements based on CT and MRI. For this reason we investigated the correlation in CSA measurements of SM on CT and MRI in HNC patients.

We conducted a brief retrospective study in patients with oropharyngeal squamous cell carcinoma (OPSCC), who were diagnosed and treated at the University Medical Center Utrecht, The Netherlands, between 2010 and 2015. Patients were included if they had pretreatment head and neck CT and MRI imaging of sufficient quality performed within 1 month of each other.

Segmentation of muscle tissue on CT and MRI was manually performed using the Volumetool v.1.6.5 research software package [18] by a single researcher (N.C). The researcher was blinded to the outcome since all CSA values were retrieved at the end of the study. The axial imaging slide which showed both the transverse processes and the entire vertebral arch was selected for segmentation of muscle tissue. For CT imaging, muscle area was defined as the pixel area between the radiodensity range of -29 and $+150$ Hounsfield Units (HU), which is specific for muscle tissue. For MRI, muscle area was manually segmented, and fatty tissue was manually excluded. The CSA was calculated as the sum of the delineated areas of the paravertebral muscles and both sternocleidomastoid muscles. CSA at the level of C3 measured by CT and MRI was used for variability analysis.

Data analysis was performed using IBM SPSS statistics 25. Variability between CT and MRI in CSA measurements of SM was determined by the intraclass correlation coefficient (ICC) which is based on analysis of variance [19]. The ICC was calculated using a two-way mixed-effects model with absolute agreement. An ICC of 1 represents no variance in CSA assessment of SM by CT and MRI. Bland and Altman method was used to calculate the mean difference and to evaluate the 95% limits of agreements between CSA measurements of SM by CT and MRI [20].

In total, 50 OPSCC patients were included. Demographic and clinical data are presented in Table 1. Low SMM (according definition used by Wendrich et al. [7]) was identified by MRI in 30 (60%) patients and

Table 1
Demographic and clinical characteristics of included patients.

Variables	N	%
HPV status		
<i>Positive</i>	18	36
<i>Negative</i>	21	42
<i>Unknown</i>	11	22
Sex		
<i>Female</i>	14	28
<i>Male</i>	36	72
Age (years) (M, SD)	61.3	9.4
BMI (kg/m ²)		
< 20	9	18
20–24.9	24	48
25–29.9	8	16
≥ 30	9	18
Weight loss 6 months prior to diagnosis		
<i>Non</i>	32	64
< 10%	9	18
≥ 10%	9	18
Smoker		
<i>No</i>	3	6
<i>Former</i>	29	58
<i>Current</i>	18	36
Pack-years		
0	3	6
1–15	9	18
16–25	5	10
26–40	12	24
≥ 41	11	22
Alcohol use		
<i>No</i>	3	6
<i>Yes</i>	36	72
<i>Former</i>	11	22
Alcohol units/day (M, SD)	3.7	3.6
ACE-27 score		
<i>Non</i>	12	24
<i>Mild</i>	14	28
<i>Moderate</i>	17	34
<i>Severe</i>	7	14
Localization		
<i>Tonsil</i>	12	24
<i>Base of tongue</i>	7	14
<i>Soft palate</i>	1	2
<i>Oropharynx n.o.s</i>	30	60
Tumor stage		
T1	8	16
T2	20	40
T3	11	22
T4a	10	20
T4b	1	2
Nodal stage		
N0	16	32
N1	11	22
N2a	2	4
N2b	7	14
N2c	12	24
N3	2	4
TNM stage		
I	3	6
II	8	16
III	11	22
IV	28	56

N = number of patients.

M = Mean, SD = standard deviation.

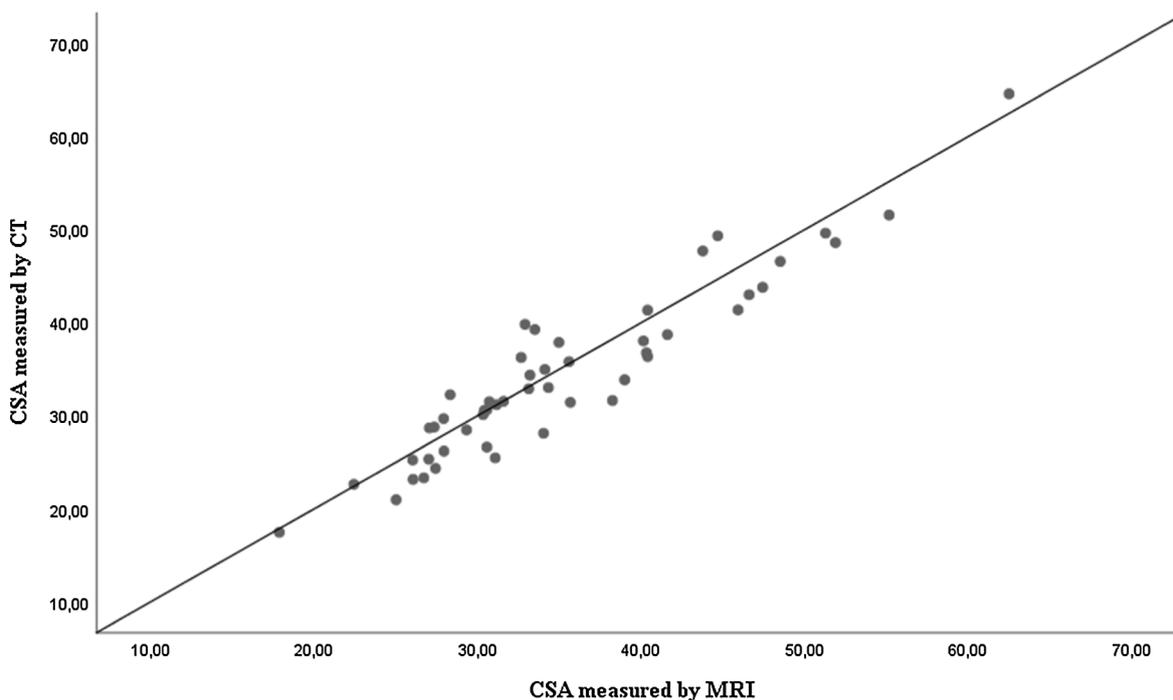


Fig. 1. Scatterplot of the correlation between CSA measurements on CT and MRI.

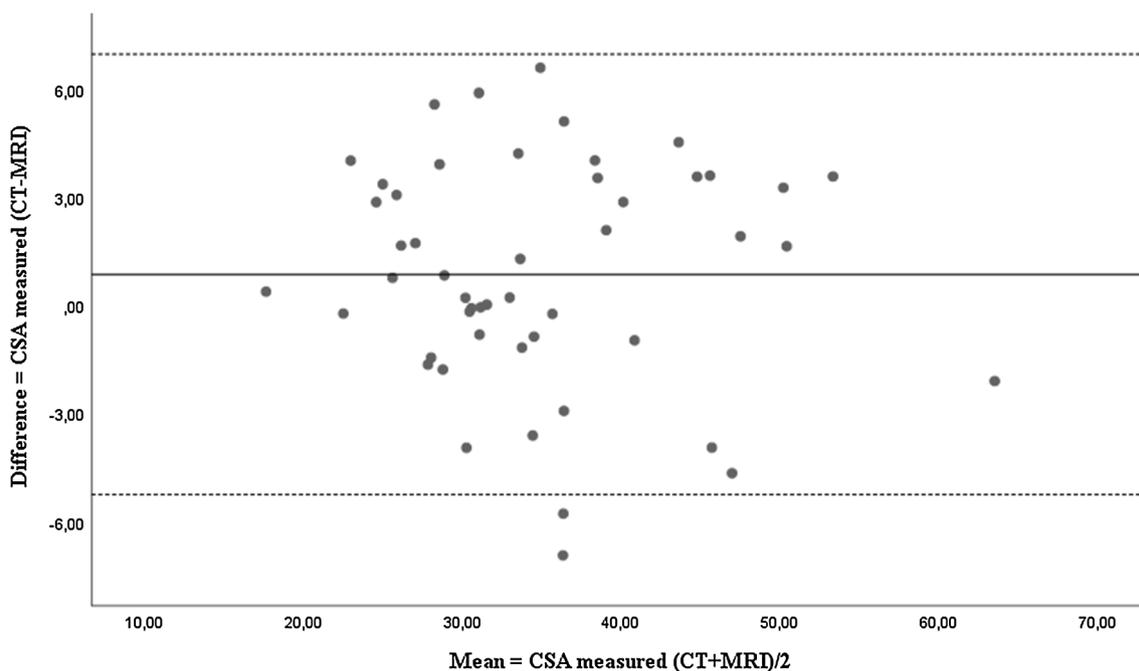


Fig. 2. Bland-Altman Plot showing the mean difference (straight line) and 95% limits of agreement (dotted lines) between CSA measurement on CT and MRI.

by CT in 31 (62%) patients. The overall ICC for the CSA measurements of SM obtained by CT and MRI was excellent (0.97; 95% CI 0.94–0.98, $p < 0.01$). Fig. 1 shows the scatter plot of the correlation between CSA measurements by CT and MRI. As shown in this figure, there is a positive linear and a statistically significantly strong ($r^2 = 0.94$, $p < 0.01$) relationship. Fig. 2 shows the Bland and Altman plot with the corresponding 95% limits of agreements; the mean difference of CSA measurements between CT and MRI was less than 1 cm^2 (0.87; 95% CI -5.24 – 6.98).

The main finding from this study is that the two different imaging modalities CT and MRI show significant correlation in quantifying SMM when measured by CSA at the level of C3. In a study on liver transplant

patients a significant intraclass correlation coefficient between CT and MRI to measure CSA at L3 was found [21]. Consistent with this, measurements based on MRI and CT can also be used interchangeably for measuring CSA at the level of C3. This knowledge contributes to the growing knowledge concerning the role of SMM in head and neck oncology and could be used to conduct further research using both CT and MRI for the assessment of SMM.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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