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Masticatory coefficient and physical functioning in older frail patients admitted for a Comprehensive Gerontological Assessment

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Highlights

Comprehensive Gerontological Assessment in multi-morbid and frail older patients can include intra-oral exam

In multi-morbid patients impaired mastication capacities are associated with malnutrition

In frail un multi-morbid patients lower limb performance is lower with lower masticatory capacities independently from nutritional status

Masticatory coefficient and physical functioning in older frail patients admitted for a Comprehensive Gerontological Assessment

Running title: Masticatory coefficient in frail older people

Highlights

An intra-oral clinical examination may be a useful complement to a comprehensive Gerontological Assessment in multi-morbid and frail older patients

In multi-morbid and frail patients, impaired chewing capacity is associated with malnutrition and poorer physical performance

In multi-morbid and frail patients physical performance is poorer with lower masticatory capacities independently from nutritional status

Abstract:

Background: Physical functioning may be limited in older, frail patients with missing teeth without prosthetic correction. This cross-sectional study examined the relationship between physical performance and the geriatric masticatory coefficient (GMC) in patients who underwent both a comprehensive gerontological assessment (CGA) to improve poly-pathology management and an intra-oral exam.

Methods: All patients were evaluated based on the following: (corrected) GMC, number of posterior occluding pairs (POPs), short physical performance battery (SPPB) or timed up and go (TUG) test, and mini-nutritional assessment (MNA).

Results: Of the 256 patients (mean age 83.76[SD 6.16], 148F), 75 (29.30%) were malnourished. The corrected GMC was lower in malnourished patients. When adjusted for age, gender, and MNA, the corrected GMC correlated with the TUG time ($r=-0.198$, $p=0.005$) and SPPB score ($r=0.282$, $p=0.009$). Correlations between GMC and POPs were determined for the SPPB ($r=0.269$, $p=0.013$; $r=0.319$, $p=0.004$, respectively) but not for the TUG ($r=-0.108$, $p=0.128$; $r=-0.136$, $p=0.072$).

Conclusion: The correlation between physical performance and decreased masticatory capacity was not fully explained by malnutrition in mildly to severely frail and multi-morbid patients; posture may also be impaired by missing teeth. The study of dental care effects on physical performance will provide further insights.

Keywords: frailty; oral health; poly-morbidity; comprehensive gerontological assessment; physical performance; malnutrition

1. Introduction

The prevention of both decompensation due to chronic disease and functional dependence is an important goal in the care of older people. The comprehensive gerontological assessment (CGA) is based on systematic screening and scoring of four domains: mental health, functionality, medical status and social status (Kenneth Rockwood et al., 1998; Valencia et al., 2017). The resulting care plan has been shown to prevent a worsening of health, particularly in frail patients. In older people, frailty refers to a multifactorial impairment of health that predicts adverse living events, such as loss of independence, hospitalization, adverse drug reactions, decompensation related to chronic disease, admission to a nursing home, or death (Fried et al., 2001; Kenneth Rockwood et al., 1999). Effective preventive strategies in older people may thus rely on the identification of those who are frail. Poor oral health in hospitalized older patients was found strongly associated with poor functional status or malnutrition (Poisson et al., 2016). Thus, frailty may be linked to oral health as a possible determinant of multifactorial development of this syndrome. Indeed, several studies have reported cross-sectional relationships between components of oral health and frailty. Loss of teeth, an unmet need for a fixed prosthesis or removable denture, self-reported poor oral health, and pain or impaired mastication are among the factors associated with an increased prevalence of frailty (Castrejón-Pérez et al., 2012; Kamdem et al., 2017; Semba et al., 2006; Tsai & Chang, 2011; Woo et al., 2018). Finally, masticatory dysfunction, number of missing teeth, and dry mouth were identified among the factors that increase the rate of progression of the prefrail or robust older people to a

frail status (Hakeem et al., 2019; Horibe et al., 2018). Oral health behavior also varies according to frailty status, as older individuals with several health complaints may neglect oral hygiene (Niesten et al., 2013).

CGA is essentially multidisciplinary; evaluation is performed by a basic team consisting of a medical practitioner, a nurse, and a social worker; depending on the patient profile, it may be supplemented by a psychologist, a physiotherapist, an occupational therapist, and/or a pharmacist. Given the importance of oral health in the general health status of older subjects, an intra-oral health examination carried out by a dentist should be performed and care should be proposed if indicated. The oral exam should be conducted as part of the medical section, along with a nutritional assessment (Valencia et al., 2017). In the older adult poor oral health, in particular a loss of teeth is associated with a low-quality diet (Gaewkhiew et al., 2019; Kiesswetter et al., 2018; Mendonça et al., 2018). Impaired mastication may be due to a loss of teeth or to a non-functional removable prosthesis (Iwasaki et al., 2017) and contributes to sarcopenia. An intraoral examination may have added value beyond that of a component of the nutritional assessment.

The functional domain assessment includes scoring of daily living activities and assessments of physical performance and fall risk. Two tools are available for this purpose: the short physical performance battery (SPPB)(Guralnik et al., 1994) and the timed up and go test (TUG) (Podsiadlo & Richardson, 1991). These two tests explore balance, gait speed and rising from a chair.

We hypothesized that in the older frail or dependent subjects, functional impairment assessed using the SPPB or TUG would be more important in the subgroup with missing teeth, particularly individuals with a non-functional removable prosthesis or without a needed prosthesis. The objective of the present study is to analyze relationships between functional impairment and an index of missing teeth recorded as geriatric masticatory coefficient taking into account nutritional status.

2. Materials and Methods

This cross-sectional study included consecutive patients older than 70 years who were admitted to a single geriatric day hospital for CGA as part of routine care during a 2-year period. Based on the usual activity of the unit the duration of the inclusion period was selected to include at least 10 subjects per descriptive variables. Patients received written information about the use of their anonymized health data for clinical research purposes and were given the option of refusal. The study was approved by the Ethical Committee of the CHU (university hospital center) of Bordeaux (GP-CE2020-43).

Patients who had undergone an intra-oral health examination performed by a dentist during the CGA were included in the study. Patients unable to perform the TUG or SPPB were excluded. In case of two or more visits to the day hospital, only the first was considered.

2.1 Comprehensive gerontological assessment (CGA)

Co-variables of this study included age, gender, living place (personal home or care home), education (none or no certificate, primary school certificate, secondary school certificate, bachelor and over). Mental health was assessed for depression and cognitive troubles by screening with the 15-Geriatric depression scale (GDS)(Yesavage & Sheikh, 1986) and the Gréco French version of mini mental status examination (MMSe), respectively (Folstein et al., 1975; Kakafat et al., 2003). A GDS score $> 4/15$ was considered to indicate depression, and an MMSe score $< 23/30$ was taken to indicate cognitive troubles. The functional domain included TUG or SPPB assessment (see 2.3), basic activities of daily living (ADL)(KATZ, 1983) and instrumental activities of daily living (IADL)(Lawton & Brody, 1969). An ADL score $> 1/12$ and an IADL score $< 8/8$ indicated dependence. The medical evaluation included chronic pathologies listing, full treatment list and a nutritional assessment. The latter consisted of a body mass index (BMI, weight (kg)/height (m)², mini nutritional assessment (MNA®)(Kaiser et al., 2009)scoring and dental examination by a dentist (see below). MNA® allows to identify malnutrition (MNA 0-7/14) and at risk for malnutrition (MNA 8-11/14). The version of the MNA based on calf circumference (CC) (< 31 cm vs. ≥ 31 cm) instead of BMI was used because CC

serves as a surrogate of muscle mass(Cruz-Jentoft et al., 2019). Among routine blood sample analyses we selected hemoglobin (g/100 mL), C-reactive protein (mg/L), serum albumin (g/L), and vitamin D (ng/mL) levels. Glomerular filtration rate (eGFR) was estimated using the CKD-Epidemiology Collaboration equation (CKD-EPI)(Levey et al., 2009) which is based on serum levels of creatinine. Patients were categorized according to the Rockwood clinical frailty scale(K. Rockwood, 2005).

2.2 Geriatric masticatory coefficient (GMC)

In routine care, chewing performance is not measured in these older and frail adults; masticatory teeth capacity is assessed. Mastication involves both posterior occluding pairs of teeth (POPs) and anterior grasping teeth.

The masticatory coefficient (masticatory percentage)(Dion et al., 2007) is determined by assigning points as follows to each functional tooth according to its role in mastication as long as the opposite tooth is also functional: 5 points for each molar except the third maxillary molar (2 points) and the third mandibular molar (3 points), 3 points for each premolar, 4 points for each canine tooth, and 1 point for each incisor except the central maxillary incisor (2 points). The maximal masticatory coefficient is 100. A modified index, the geriatric masticatory coefficient (GMC), was used because it takes into account all of the person's remaining teeth, not only those belonging to a functional pair ((Berard et al., 2018) . Because teeth with missing opposite teeth have a non-zero role during mastication, GMC may better reflect the remaining masticatory capacity. With this approach, individuals with several remaining teeth were not assessed as edentulous. Determining the remaining masticatory capacity is an important point for treatment decisions, such as extraction of teeth or placement of dentures.

In patients wearing a prosthesis, a corrected GMC was similarly determined during clinical observation. Prostheses, fixed or movable, have the value of the teeth they replace, provided they allow a normal meshing. Thus, the variable "corrected GMC" represented the best GMC for each

patient, with or without a prosthesis. Finally, the number of POPs (POP, range 0-8) without a prosthesis was also recorded. Pairs of opposite teeth are taken into account providing they allow a correct meshing.

2.3 Functional performance

Motor performance was assessed using either the SPPB(Guralnik et al., 1994) or the TUG test(Podsiadlo & Richardson, 1991) depending on the medical practitioner's preference. Both evaluate gait speed, standing balance, and rising from a chair. The SPPB consists of three 4-point scores: 1, standing balance: participants attempt to maintain side-by-side, semi-tandem, and tandem positions for 10 s; 2, a 4 m walk at normal pace timed from a standing start; and 3, time needed to rise from a chair as quickly as possible five times. Overall, the maximal SPPB score is 12 (4 points per test). The TUG test evaluates the same abilities but in a single test that focuses on the risk of falling. The patient is instructed to rise from a chair (with arms), walk 3 m, turn and return to the chair, and then sit down again. The performance is timed. Cognitive troubles, mainly attention troubles increases time spend in the task. TUG explores the risk of falling.

2.4 Analyses

The inclusion period duration was selected to obtain a sample with at least 10 patients for each described variables based on the usual activity of the unit. Quantitative variables are expressed as the mean and standard deviation (SD), ordinal variables (scores) are shown as median (IQR, interquartile range) and qualitative variables are given as numbers and percentages. SPPB is an ordinal variable and is also expressed as mean (SD). Because the link between dental status and malnutrition is well established, the characteristics of the patients are presented according to MNA categories and the different categories are compared using a chi-square test for qualitative variables and a one-way ANOVA for quantitative variables. Correlations between GMC, corrected GMC, or POPs and the SPPB or TUG test were determined using Spearman coefficient tests. Because SPPB is an ordinal variable and TUG is not normally distributed in frail or dependent patients, partial

correlation tests were performed to analyze the relationships between corrected GMC, GMC, and POPs and SPPB or TUG, controlling for age, sex, and MNA category to identify the role of malnutrition in those relationships. The software SPSS 23 (IBM®) was used for these analyses.

3. Results

During the study period, 302 patients underwent a CGA that included an intra-oral examination. After the exclusion of 39 patients due to a missing physical performance assessment in their CGAs and 7 patients each of whom underwent two CGAs, the study sample included 256 patients.

The characteristics of the study population are presented in Table 1. The SPPB test was performed in 91 patients and the TUG test was performed in 211. Serious chronic diseases had a high prevalence and included heart failure in 76 (29.7%), respiratory diseases in 32 (12.5%), major cognitive troubles in 110 (44.4%), history of cancer in 59 (23.0%), stroke in 43 (16.8%), diabetes mellitus in 82 (32.0%), and hypertension in 185 (72.5%) patients. The number of medications taken daily by these patients was also high: 6.9 (SD 3.5), with five or more different medications taken by 191 (74.9%) patients. Chronic inflammation was of low-medium intensity as reflected by a mean C-reactive protein level of 7.7 (15.3) mg/L. Vitamin D levels were <10 ng/mL in 48 (22.1%) patients; 31 (13.0%) patients had severe renal insufficiency (CKD-EPI<30 mL/min/1.73 m²).

Functional ADL or IADL dependence was present but at low levels. According to the frailty scale most of the subjects were classified in the categories “mildly frail” (79 (32.1%)) or “moderately frail” (77 (31.3%)). The others were either in the category “managing well” (25 (9.8%)) or at the opposite in the other “severely frail” (36(14.6%)).

Malnutrition and risk of malnutrition were frequent, identified in 75 (30.5%) and 126 (51.2%) patients, respectively. Patients living in a nursing home, with a higher 15-GDS, lower MMSe, major cognitive troubles, or a higher level of dependence were more likely to be malnourished or at risk of malnutrition.

The physical performance of the population was poor, evidenced by an SPPB score of $<8/12$ in 59 (64.8%) patients and a TUG score ≥ 20 s in 102 (46.4%) patients. The SPPB score was lower in malnourished patients and in patients at risk for malnutrition than in normo-nourished patients.

The dental examinations showed important impairments, based on a low GMC and the low number of POPs: 53.7/100 (SD 30.6) and 3.1/8 (SD 3.0), respectively. One hundred and five patients had a dental prosthesis. After correction for patients with a prosthesis, the corrected GMC was 75.4 (SD 19.8). While the corrected GMC was related to the MNA category, this was not the case for either the GMC or the number of POPs.

After controlling for age, gender and MNA category, an association between the corrected GMC and both the TUG time (-0.198 , $p = 0.005$) and the SPPB score (0.282 , $p = 0.009$) was determined (Table 2). Both the GMC and POPs were associated with the SPPB score (GMC: 0.269 , $p = 0.013$; POPs: 0.319 , $p = 0.004$) but not with the TUG time (Table 2).

4. Discussion

We found a cross-sectional association between nutritional status, corrected GMC, and physical performance in the mildly to severely frail older adult with complex health problems. The association between the corrected GMC and physical performance was independent of nutritional status. Masticatory capacity was evaluated using two different approaches, pairs of opposing teeth and number of teeth, weighted according to their alleged role in mastication. The adjusted partial correlations showed relationships between both indexes and the SPPB score.

An association between diminished masticatory capacity and malnutrition in the older people has previously been reported (Toniazzi et al., 2018). Because malnutrition is associated with low muscle strength (Veronese et al., 2019) lower muscle performance is expected in patients with impaired corrected masticatory coefficient. However, malnutrition does not fully explain the link between a lower corrected GMC and lower physical functioning of the limbs. Physical performance relies not only on strength but also on balance, proprioceptive functions, and several cognitive

processes, such as attention. Teeth clenching may reinforce balance through a facilitation of the pretibial reflex that is related to applied strength(Takada et al., 2000). Postural balance may be improved during chewing(Alghadir et al., 2015). A loss of teeth may directly impact physical performance, particularly balance. Pain, inflammatory syndromes, and dyspnea also diminish physical performance. In a previous study, these relationships were considered in a fully adjusted model, in which the presence of 19 or less teeth not corrected with a prosthesis was found to increase the risk of falling(Yamamoto et al., 2012).

The most common characteristic of our frail study population was the high prevalence of severe comorbidity, including cardiovascular diseases, diabetes, COPD and asthma, cognitive troubles, or a history of stroke. The physical performance of patients with severe comorbidities is frequently impaired. The comorbidities are possibly secondary to the loss of teeth. In three community studies, each missing tooth increased cardiovascular risk and mortality (Holmlund et al., 2010; Joshy et al., 2016; Lee et al., 2019). In a large cross-sectional study, severe tooth loss and a history of stroke were independently associated with inflammation(You et al., 2009). Missing teeth may predict a higher risk for cognitive impairment(Zhang et al., 2020). In nursing home residents, patients with missing POPs without prostheses have an increased 1-year mortality, independent of nutritional status(Dewake et al., 2020). However, the causal link between missing teeth and the above-listed pathologies is probably multifactorial and bi-directional(Felton, 2016). Furthermore, some risk factors for tooth loss are shared by systemic diseases. Low-medium grade inflammation due to periodontitis can cause both systemic inflammation (and cardiovascular diseases) and a loss of teeth. Chronic oral inflammation may induce dental loss and increase the risk for cardiovascular disease, malnutrition, and muscle functional impairment. Finally, the behavioral changes that occur with severe disease are likely to impair both self-care and access to professional care, thus worsening oral health.

In our study population, the association between masticatory capacity and physical performance was better described by the corrected GMC than the GMC, given that prosthetic adaptation protects

against a physical decline. As demonstrated by a previous study showing an improvement in cardiovascular risk with better oral care (Park et al., 2019) dental care within the scope of the CGA holds promise in the management of complex health problems in the older adults.

The limitations of our study should be noted. First, it was a cross-sectional study and causality could not be determined. Second, masticatory capacity, not function, was assessed. Tests for chewing ability, such as using color-indicator gums and measures of masseter or hand grip strength, are not done in routine care. However, an association between impaired chewing ability and weaker occlusal forces with sarcopenia was determined in a previous study of the community-dwelling elders (Murakami et al., 2015). Therefore, low muscle strength may also affect the muscles involved in mastication (masseter, tongue, cheeks). In routine clinical practice, a “static” assessment of masticatory capacity in frail, older patients can be easily and reliably performed. Third, several subject characteristics potentially associated with the study variables were not recorded and therefore not analyzed: smoking and alcohol use and usual physical activity. Finally, this study did not permit to clarify the role of multi-morbidity in the relationship between masticatory capacities and physical performance. Among the strengths of our study were the large sample population and the inclusion of frail older individuals engaged in preventive action to decrease the burden of multi-morbidity. Our results show that oral care has a role to play in preventing functional decline in the frail elderly. Finally the magnitude of the correlation is not outstanding.

5. Conclusions

In older mildly to severely frail and multi-morbid patients, the physical performance will be limited in those with a loss of teeth. In addition, malnutrition is not the only link between chronic diseases, oral health and posture. An impaired posture may be due to missing teeth. A longitudinal study should explore the effects of dental care on physical performance in multi-morbid older patients.

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Table 1. Characteristics of the patients according to Mini-Nutritional Assessment (MNA) category.

Characteristics	All subjects N = 256	MNA 0-7 Malnutrition N = 75	MNA 8-11 At risk of malnutrition N = 126	MNA 12-14 Normal N = 45	P value* Comparison according to MNA classes
Age	83.8 (6.2)	83.3 (5.4)	84.6 (5.5)	84.0 (4.3)	<0.001
Gender (F/M)	148/108	47/28	79/47	18/27	0.020
Educational level					0.389
-no certificate	63 (25.2)	20 (27.8)	34 (27.6)	8 (17.8)	
-primary school certificate	87 (34.8)	27 (37.5)	46 (37.4)	11 (24.4)	
-secondary school certificate	43 (17.2)	11 (15.3)	19 (15.4)	10 (22.2)	
-bachelor and over	57 (22.8)	14 (19.4)	26 (19.5)	16 (35.5)	
Living place (nursing home)	20 (7.8)	13 (17.3)	4 (3.2)	0 (0)	<0.001
BMI (kg / m ²)	26.5 (5.3)	24.1 (5.0)	26.4 (3.9)	28.2 (5.8)	<0.001
Calf circumference (cm)	33.0 (3.9)	31.6 (3.5)	33.6 (3.6)	36.1 (3.7)	<0.001
GMC (0-100)	53.7 (30.6)	43.6 (4.3)	58.9 (31.0)	71.3 (9.3)	0.096
Corrected GMC (0 - 100)	75.4 (19.8)	75.9 (20.9)	77.6 (15.9)	77.3 9.4)	<0.001
POPs (n)	3.1 (3.0)	2.6 (3.6)	3.6 (3.2)	4.3 (2.2)	0.056
TUG (s)	22.0 (14.6)	22.0 (11.4)	25.3 (11.5)	18.8 (7.3)	0.303
SPPB (0-12)	6 (7)	4 (4)	4 (6)	10 (3)	<0.001
MMSe (0-30)	23 (9)	23 (7)	22 (9)	29 (3)	<0.001
15-GDS (0-15)	6 (6)	8 (6)	7 (6)	4 (3)	<0.001
ADL (0-12)	1 (4)	3 (6)	2 (5)	0 (0)	0.005
IADL (0-8)	4 (6)	2 (3)	2 (5)	7 (3)	<0.001
Diabetes (yes)	82 (32.0)	26 (34.7)	36 (28.6)	18 (40.0)	0.333
Stroke history	43 (16.8)	15 (20.0)	15 (11.9)	11 (24.4)	0.099
Cognitive troubles	110 (44.4)	42 (59.2)	60 (48.8)	4 (9.1)	<0.001
Hypertension	185 (72.5)	57 (76.0)	84 (67.2)	38 (84.4)	0.065
History of cancer	59 (23.0)	16 (21.3)	27 (21.4)	14 (31.1)	0.377
Heart failure	76 (29.7)	18 (24.0)	38 (30.2)	17 (37.8)	0.274
COPD-asthma	32 (12.5)	8 (10.7)	14 (11.1)	9 (20.0)	0.253
Number of medication	6.9 (3.48)	6.7 (3.2)	6.7 (3.5)	8.5 (3.8)	0.479
eGFR (CKD-EPI, mL/min / 1.73m ²)	65.0 (19.9)	66.4 (15.1)	65.2 (14.0)	62.4 (28.9)	<0.001
C-reactive protein (mg /L)	7.7 (15.7)	23.4 (51.2)	9.3 (14.0)	3.9 (4.1)	0.553
Serum albumin (g /L)	37.7 (4.0)	36.8 (4.5)	36.9 (3.1)	38.3 (4.0)	0.123
Hemoglobin (g / 100 mL)	13.0 (1.5)	12.6 (1.6)	13.1 (1.4)	12.9 (1.2)	0.231
Vitamin D (ng / mL)	22.3 (13.0)	27.2 (14.1)	28.2 (19.3)	19.5 (9.7)	0.162

Variables are presented as Mean (SD), Median (Interquartile range) or N (%). POPs: posterior occluding pairs of teeth; GMC: geriatric masticatory coefficient; TUG: timed up and go test; SPPB: short physical performance battery; MMSe : mini mental state examination; GDS geriatric depression scale; ADL basic activities of daily iiving; IADL: instrumental activities of daily living; eGFR: estimated glomerular filtration rate;. *Quantitative variables were compared using one-way ANOVA and qualitative variables using Chi2 test.

Table 2. Correlations between physical performance assessment and masticatory capacity assessment based on the number of teeth

Correlation	TUG						SPPB					
	Spearman coefficient	<i>P</i>	Partial correlation controlled by age and gender	<i>P</i>	Partial correlation controlled by age, gender and MNA classes	<i>P</i>	Spearman coefficient	<i>P</i>	Partial correlation controlled by age and gender	<i>P</i>	Partial correlation controlled by age, gender and MNA classes	<i>P</i>
Corrected GMC (0-100)	-0.116	0.093	-0.240	0.337	-0.198	0.005	0.220	0.036	0.465	0.052	0.282	0.009
GMC (0-100)	-0.261	<0.001	-0.141	0.577	-0.108	0.128	0.318	0.002	-0.583	0.011	0.269	0.013
POPs (0-8)	-0.257	<0.001	-0.133	0.599	-0.136	0.072	0.358	0.001	0.528	0.024	0.319	0.004