A novel prosthesis presentation test to screen for cognitive and functional decline

Srinivasan, Murali ; Duong, Stephan ; Trombert, Veronique ; Kalberer, Nicole ; Zekry, Dina ; Herrmann, François R ; Delavy, Joris ; Gold, Gabriel ; Müller, Frauke

Abstract: Objectives and background To validate a novel screening test for cognitive and functional decline in older patients rehabilitated with complete removable dental prostheses (CRDPs). Materials and methods Edentate old in-patients rehabilitated with CRDPs were included in this study. Participants were requested to remove their prostheses before their intraoral examinations. The prostheses were then presented in an inverted orientation. Participants had to correct the orientation of the prostheses and insert them in the appropriate jaws. The test was repeated after the intraoral exam. Appropriate statistical models were used (⍰ = .05) to associate the test results with the participants' mini-mental state examination (MMSE) score, functional independence measure (FIM), age and sex. Results Among the 86 participants (mean-age: 85.4 ± 6.4 years; mean MMSE: 19.8 ± 5.5; mean FIM: 77.9 ± 20.8), 21 (24.4%) failed to correctly insert the prosthesis. The prosthesis presentation test (PPT) was associated with the FIM but not the MMSE. Regression models further confirmed an association with age (P = .043), but not sex. Additional analyses revealed the PPT test is associated with the FIM's cognitive sub-sets of memory, problem solving and social interaction. Conclusion The PPT is a novel, simple and quick screening tool that can help detect functional difficulties in older people. It can easily be performed during an oral examination. Future studies are needed to determine whether the PPT can be used to detect deficits in executive function, as a complement to the MMSE and also as a first assessment of a patient's ability to manage dentures independently.

DOI: https://doi.org/10.1111/ger.12708

Accepted: 16 July 2023

DOI: 10.1111/ger.12708

ORIGINAL ARTICLE

Gerodontology WILEY

A novel prosthesis presentation test to screen for cognitive and functional decline

Murali Srinivasan[1,2] | Stephan Duong[2] | Veronique Trombert[3] | Nicole Kalberer[2] | Dina Zekry[3] | François R. Herrmann[4] | Joris Delavy[2] | Gabriel Gold[5] | Frauke Müller[2,4]

[1]Clinic of General, Special Care and Geriatric Dentistry, Center of Dental Medicine, University of Zurich, Zurich, Switzerland

[2]Division of Gerodontology and Removable Prosthodontics, University Clinics of Dental Medicine, University of Geneva, Geneva, Switzerland

[3]Division of Internal Medicine for the aged, Department of Rehabilitation and Geriatrics, Geneva University Hospitals, Thônex, Switzerland

[4]Division of Geriatrics and Rehabilitation, Department of Rehabilitation and Geriatrics, Geneva University Hospitals, Thônex, Switzerland

[5]Department of Rehabilitation and Geriatrics, University of Geneva, Geneva, Switzerland

Correspondence

Frauke Müller, Division of Gerodontology and Removable Prosthodontics, University Clinics of Dental Medicine, University of Geneva, Rue Michel-Servet 1, 1211 Geneva 4, Switzerland.
Email: frauke.mueller@unige.ch

Objectives and background: To validate a novel screening test for cognitive and functional decline in older patients rehabilitated with complete removable dental prostheses (CRDPs).

Materials and methods: Edentate old in-patients rehabilitated with CRDPs were included in this study. Participants were requested to remove their prostheses before their intraoral examinations. The prostheses were then presented in an inverted orientation. Participants had to correct the orientation of the prostheses and insert them in the appropriate jaws. The test was repeated after the intraoral exam. Appropriate statistical models were used ($\alpha = .05$) to associate the test results with the participants' mini-mental state examination (MMSE) score, functional independence measure (FIM), age and sex.

Results: Among the 86 participants (mean-age: 85.4 ± 6.4 years; mean MMSE: 19.8 ± 5.5; mean FIM: 77.9 ± 20.8), 21 (24.4%) failed to correctly insert the prosthesis. The prosthesis presentation test (PPT) was associated with the FIM but not the MMSE. Regression models further confirmed an association with age ($P = .043$), but not sex. Additional analyses revealed the PPT test is associated with the FIM's cognitive sub-sets of memory, problem solving and social interaction.

Conclusion: The PPT is a novel, simple and quick screening tool that can help detect functional difficulties in older people. It can easily be performed during an oral examination. Future studies are needed to determine whether the PPT can be used to detect deficits in executive function, as a complement to the MMSE and also as a first assessment of a patient's ability to manage dentures independently.

KEYWORDS

cognitive decline, dementia, geriatric dentistry, gerodontology, mild cognitive impairment, removable prosthesis

Murali Srinivasan and Stephan Duong equally contributed as first author.

1 | INTRODUCTION

World demographic trends indicate that life expectancy increases along with growing numbers of individuals with dementia, disabilities and dependence for care.[1–3] The most common diseases affecting cognition in older adults include vascular dementia, Lewy body dementia and especially Alzheimer's disease.[4] Although neuroimaging and biomarkers can be used to help diagnose dementing diseases, cognitive impairment and dementia per se are detected thanks to neuropsychological testing tools.[5] These tools may vary depending on the selected test battery and this heterogenicity may explain discrepancies in estimates of the true prevalence of dementia.[1,6] The MMSE is one of the most commonly used tests to screen for cognitive impairment and is a good reflection of global cognitive function but it does have its drawbacks, in particular, it is not sensitive to changes in executive function so that it is often used in conjunction with other screening tests.[7–9]

Functional decline is common in older people. It affects their quality of life and may require environmental adaptations and supportive care interventions depending on their level of independence and their needs.[10] It is therefore essential to measure the functional level of older individuals. A well-established test for this purpose is the functional independence measure (FIM), which indicates the level of disability of the patient and thus can help determine the amount of care and support required for people to perform their activities of daily living. The FIM evaluates personal care, sphincter control, mobility in transfers, locomotion, communication and social behaviour. Of the 18 items, 13 items concern motor functioning and 5 items concern cognitive functioning.[11,12]

Cognitive impairment and functional decline both play an important role in prosthodontic treatment planning. A prosthesis which is too complex to manage leaves the patient without replacement teeth and with all the consequential disadvantages. Hence, a single test that can accurately detect cognitive and functional decline and that can be performed with ease within the context of a dental examination may be of great value.[13] In older adults with complete removable dental prostheses (CRDPs), we suggest that the task of orientating and inserting the CRDPs correctly into the mouth may be used as a screening tool for cognitive and functional decline. This test is simple to perform and may be accomplished with minimal additional time or effort. Importantly, it can be performed relatively easily during any routine dental examination for individuals suspected of cognitive or functional decline relevant to restorative treatment planning. We performed the current study to validate this novel screening test for cognitive and functional decline in edentulous denture wearing old in-patients by associating their existing MMSE and FIM scores with their ability to correct the orientation of a CRDP before inserting it in their mouth. The hypothesis set for this study is that older adults with cognitive and functional decline who are presented with an inverted CRDP will not be able to identify and correct the orientation before inserting it in their mouth.

2 | MATERIALS AND METHODS

This study received approval from the research ethics committee in Geneva (CCER no. 2017-00409). The study is presented as per the guidelines provided by "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE).[14]

2.1 | Study design and study setting

This study was designed as a single-centre, cross-sectional study on edentate hospitalised older patients. The study was executed in several geriatric wards of a university hospital (Trois-Chêne) in Geneva, Switzerland.

2.2 | Study population

The participants included in this study were hospitalised old edentate patients rehabilitated with a CRDP. The inclusion and exclusion criteria were a sub-set of the ones used in a previously published report where all dental states were included.[15] The participants were included if they were:

- hospitalised older patients from the geriatric wards of the university hospitals of Geneva and
- able to understand simple instructions.

Participants were excluded if they were:

- not cooperative,
- not responsive or comatose,
- unable to consent and their caregivers were not willing to provide a signed informed consent on their behalf.

The first part of this study reporting on the awareness and prevalence of oral hygiene tools in hospitalised old patients (n = 100) was published elsewhere.[15] Recruitment continued to include more edentate participants with CRDPs for the prosthesis presentation test outcome.

2.3 | Endpoints/outcome measures

The endpoint/outcome parameter assessed in this validation study was the prosthesis presentation test (PPT). This custom-designed test for denture wearing patients was based on this study's hypothesis that a cognitively and functionally impaired individual would fail to recognise that the prosthesis was presented in an incorrect orientation and would fail to correct the orientation before inserting it in the mouth. The prosthesis was handed over to the participant with the correct side of insertion inversely oriented. The patients were

kept naïve with regard to the principle of the PPT and the investigator gave no instructions to the participant other than the request to insert the CRDP while handing over the prosthesis. The participant had to independently reorient the prosthesis to the correct side up before inserting it back in the mouth. If the participant identified the wrong orientation and corrected it before inserting it in the mouth, then the test was considered a success. The results of the test were noted with a binomial response of either "success" or "fail" accordingly. Various demographic variables such as age, sex, mean denture calculus index, period of edentulism, along with MMSE and functional independence measure (FIM) scores were analysed.

2.4 | Sample size

A sample size calculation was not done as no previous publication analysing this outcome exists. Hence, an attempt to include a maximum number of willing hospitalised edentate old patients with CRDPs was made. However, recruitment was stopped on 30/11/2018, for logistic reasons. A post-hoc sample size calculation was planned for non-significant results.

2.5 | Statistical analysis

Continuous data collected were checked using Shapiro-Francia tests for a Gaussian distribution; unpaired t, Mann–Whitney u and Chi-Squared tests were applied to verify the association of the results of the PPT (failure versus success) with the participants' continuous variables (MMSE, FIM, age), respectively ordinal (education) and binary variable (sex). Univariate and multiple logistic regression models were used to confirm the association of the test results with the various demographic parameters ($\alpha = .05$). All statistical analyses were performed by a biostatistician (FRH) using a statistical software package (STATA, version 17.0, StataCorp). Post hoc power analysis was performed using the free software (G*Power 3.1.9.6 for Mac OS X).[16,17]

2.6 | Study protocol

The study was conducted in several geriatric wards of the university hospitals of Geneva. In an introductory session, all staff involved in the study were informed of the study protocol. Aims, protocol and outcome measures were explained in detail and appropriate dates and times were fixed for patient screening and enrollment. The investigator (VT) in charge of the geriatric ward initially screened the patients' medical files for eligibility. She approached first the participants and/or their guardians and provided information and consent sheets. Participation was completely voluntary and no benefits other than a free dental examination were provided to the participants, along with detailed instructions on oral hygiene maintenance and an oral health status report. They were also given recommendations for treatment, if indicated. If the participant desired subsequent treatment, logistic help was offered to arrange for a dental appointment at a dental practice of the participant's choice or the Hospital's internal dental practice. Upon receiving the signed consent form the participants were included in the study. Four investigators (SD, JD, MS and NK) performed a first PPT, followed by the clinical intraoral examination and finally a second PPT, while being blinded to the participants' MMSE and FIM scores. Results were considered a "fail" if participants failed both PPTs. Only after completion of the protocol, the most recent MMSE and FIM scores were communicated by VT.

3 | RESULTS

A total of 86 participants consented to participate in this study. The screening and recruitment process are displayed in Figure 1. The mean age of the participants was 85.4 ± 6.4 years (range

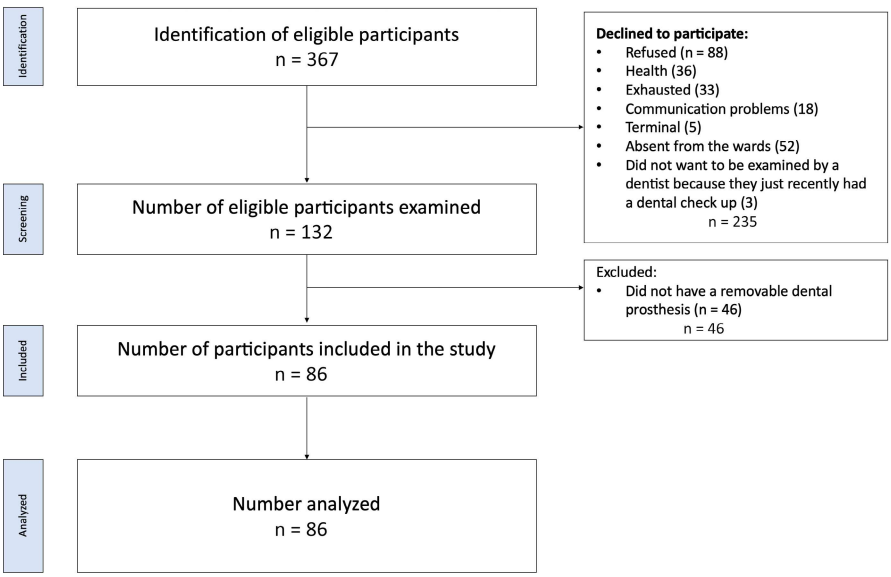

FIGURE 1 Flow diagram of the participants' identification, screening, inclusion process and analyses.

70–102 years). The average denture calculus scores in the maxillary- and mandibular- CRDPs were 2.0 ± 0.9, and 1.9 ± 1.0, respectively. The participants were edentulous for an average time lapse of 10.6 ± 14.5 and 8.8 ± 12.7 years, in the maxilla and mandible, respectively. The participants' mean MMSE score was 19.8 ± 5.5 (range 6–30) and the mean FIM score was 77.9 ± 20.8 (range 37 to 126). The mean time since the participants' last known dental visit was 3.4 ± 6.0 years and ranged between 3 months and 30 years. Demographic information is listed in Table 1.

TABLE 1 Demographic characteristics of participants (brackets contain Standard Deviations).

	Number (±SD)	Percentage (%)
Number of participants	86	100
Sex		
Female	51	59.3
Male	35	40.7
Mean age (years)	85.4 (6.4)	
Mean denture calculus index		
Maxillary prostheses	2.0 (0.9)	
Mandibular prostheses	1.9 (1.0)	
Mean period of edentulism (years)		
Maxilla	10.6 (14.5)	
Mandible	8.8 (12.7)	
Mean MMSE score	19.8 (5.5)	
Mean FIM scores	77.9 (20.8)	
Mean duration since last dental visit (years)	3.4 (6.0)	
Education (n = 20)		
University degree (Bachelor/Master/Higher)	1	5.0
Middle school	10	50.0
Primary school	1	5.0
Vocational training	8	40.0

Abbreviations: FIM, functional independence measure; MMSE, mini-mental state examination.

Twenty-one participants (24.4%) failed to correctly insert the prosthesis in their mouths (Figure 2). Their mean age was 88.4 ± 5.7 years and their mean MMSE and MIF scores were 17.9 ± 4.9 and 67.8 ± 16.3, respectively. 57.1% (n = 12) of those who failed the test were men. The participants who failed the test were on average 3.3 years older, and had lower MMSE (−2.6) and MIF (−12.3) scores than those who succeeded in the PPT. Using univariate logistic regression, the PPT was associated with FIM ($P = .0189$) scores but not with the MMSE ($P = .058$). Logistic regression models further confirmed an association with age ($P = .044$); but did not show an association with the sex ($P = .734$). The test also did not show any association with the period of edentulism ($P = .484$).

Additional univariate logistic analyses revealed that the PPT success was associated with better performances of the various cognitive sub-sets of FIM: memory (OR 1.47, 95% CI 1.07–2.01), problem solving (OR 1.66, 95% CI 1.15–2.41), and social interaction (OR 1.43, 95% CI 1.07–1.91).

4 | DISCUSSION

The present study confirmed the association of the novel PPT screening test using an inversely presented CRDP with functional impairment in older in-patients, but not with global cognitive impairment as measured by the MMSE. However, among the sub-sets of FIM, problem solving showed the closet association followed by memory and social interaction. Not surprisingly the PPT test was associated with age.

Several issues may explain why the PPT was associated to several cognitive sub-sets of the FIM but not to the MMSE. The FIM subsets are not neuropsychological tests, their score is generally determined by health professionals in repeated close contact with the patient such as the nursing staff. The emphasis is on function and their score is based on observation of the patient performing activities of daily living rather than a precise evaluation of specific cognitive abilities. The main cognitive domains that may affect the performance of the PPT include praxis (learned motor activity and gestures), procedural memory (remembering how to ride a bike or tie one's shoes) and executive function (ability

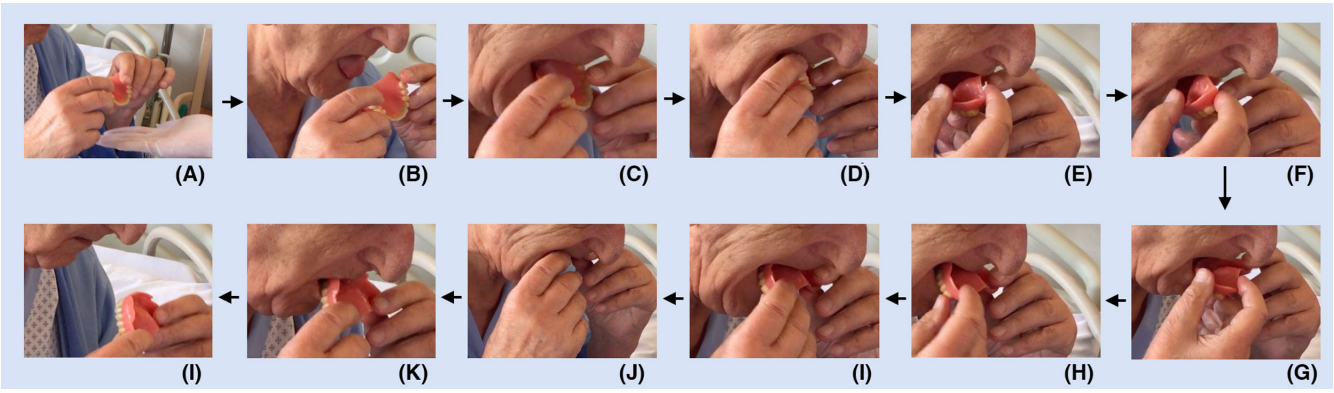

FIGURE 2 Demonstration of how a study participant is failing the PPT: (A) an investigator hands the inverted maxillary complete denture to the participant; (B) participant fails to identify the correct orientation of the presented prosthesis; (C, D) participant inserts it initially in the wrong jaw; (E–J) participant then inserts in the correct jaw but with a wrong orientation; and (K, L), participant finally gives up.

to organise and plan, etc.). The MMSE does not sufficiently test any of these cognitive abilities; it is more heavily weighted towards screening of orientation and other types of memory (they account together for 16 out of a maximum of 30 points for a perfect score). In fact, screening for dementia often includes a supplemental test of executive function (such as the clock drawing test for example) to account for this weakness of the MMSE. Our results suggest that the PPT may detect cognitive impairments not picked up on the MMSE. Another explanation may be lack of power. The post hoc power analysis revealed an actual power (1−β err prob) of 0.503 for the current study and to achieve a sufficient power (1−β err prob) of 95% with the computed effect size (d) of 0.503 from the current results would require a total sample size calculated to be 208 (n = 104 per group). Thus, further studies with a larger sample size are needed to better explore the relationship between the PPT and neuropsychological test scores, especially the MMSE.

The study has several strengths. The PPT test was included in a larger study on oral health and oral hygiene tools in a geriatric hospital. In order to obtain reliable and robust results, we chose to repeat the test after the oral examination had been completed. Only a repeated failure to turn the denture in the correct orientation for insertion counted as a failure. Another strength of the method was that the operators who performed the clinical examination had no access to the medical record of the patient and no prior knowledge of MMSE and FIM scores which were only provided after the testing had taken place. A weakness of the PPT is that it is limited to patients who already wear a removable denture.

The PPT has the advantage of being fast and easy to perform and it does not require any special tools or equipment. Contrary to an MMSE or other cognitive testing which patients would not expect a dentist to perform, it can be carried out very naturally within the context of a dental appointment. If the PPT is abnormal, the patient can then be referred to a specialist such as a geriatrician for further functional and cognitive evaluation.

With age, manual dexterity, vision and tactile sensitivity decline which renders not only oral hygiene measures but also denture management difficult. The PPT may also be a first indicator of problems in denture management and the need for help in this regard. Since we did not include any long-term follow-up, this will need to be explored in further studies.

5 | CONCLUSIONS

One quarter of hospitalised older patients were unable to reorient their prosthesis and insert it correctly. The prosthesis presentation test (PPT) is a novel, simple and quick screening tool that can help detect functional difficulties in older people. It can easily be performed during an oral examination. In the current study, it was associated with the FIM, a global physical and mental function test but not with the cognitive domains of the MMSE. Future studies are needed to determine whether the PPT can be used to detect deficits in executive function, as a complement to the MMSE, and also as a first assessment of a patient's ability to manage dentures independently.

AUTHOR CONTRIBUTIONS

M. S. contributed to the conception, design, data acquisition, analysis, interpretation, manuscript writing, critical revision of the manuscript and is accountable for all aspects of the work. S. D. contributed to the design, data acquisition, interpretation, manuscript writing, critically revised the manuscript and is accountable for all aspects of the work. V. T. contributed to the design, data acquisition, interpretation, manuscript writing, critical revision of the manuscript and is accountable for all aspects of the work. N. K. contributed to the data acquisition, critically revised the manuscript and is accountable for all aspects of the work. D. Z. contributed to the design, interpretation, manuscript writing, critical revision of the manuscript and is accountable for all aspects of the work. J. D. contributed to the design, data acquisition, critically revised the manuscript and is accountable for all aspects of the work. G. G. contributed to the design, interpretation, manuscript writing, critical revision of the manuscript and is accountable for all aspects of the work. F. R. H. performed the statistical analysis and contributed to the interpretation, manuscript writing, critical revision of the manuscript and is accountable for all aspects of the work. F. M. contributed to the conception, design, analysis, interpretation, manuscript writing, critical revision of the manuscript and is accountable for all aspects of the work.

ACKNOWLEDGEMENTS

Open access funding provided by Universite de Geneve.

FUNDING INFORMATION

This project was entirely funded by the university divisional funds allotted to the Division of Gerodontology and Removable Prosthodontics, University Clinics of Dental Medicine, University of Geneva, Geneva, Switzerland. No external funding was received for the conception, planning or execution of this project.

CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

The data present this in study will be available on request from corresponding author.

ORCID

Murali Srinivasan https://orcid.org/0000-0003-3365-576X
François R. Herrmann https://orcid.org/0000-0003-1312-1517
Frauke Müller https://orcid.org/0000-0003-3981-0134

REFERENCES

1. Cao Q, Tan CC, Xu W, et al. The prevalence of dementia: a systematic review and meta-analysis. *J Alzheimers Dis*. 2020;73:1157-1166.
2. Sousa RM, Ferri CP, Acosta D, et al. Contribution of chronic diseases to disability in elderly people in countries with low and middle incomes: a 10/66 dementia research group population-based survey. *Lancet*. 2009;374:1821-1830.
3. Sousa RM, Ferri CP, Acosta D, et al. The contribution of chronic diseases to the prevalence of dependence among older people in

Latin America, China and India: a 10/66 dementia research group population-based survey. *BMC Geriatr*. 2010;10:53.
4. Kalaria RN, Maestre GE, Arizaga R, et al. Alzheimer's disease and vascular dementia in developing countries: prevalence, management, and risk factors. *Lancet Neurol*. 2008;7:812-826.
5. Zekry D, Herrmann FR, Grandjean R, et al. Demented versus non-demented very old inpatients: the same comorbidities but poorer functional and nutritional status. *Age Ageing*. 2008;37:83-89.
6. Llibre Rodriguez JJ, Ferri CP, Acosta D, et al. Prevalence of dementia in Latin America, India, and China: a population-based cross-sectional survey. *Lancet*. 2008;372:464-474.
7. Folstein MF, Folstein SE, McHugh PR. "mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12:189-198.
8. Tombaugh TN, McIntyre NJ. The mini-mental state examination: a comprehensive review. *J Am Geriatr Soc*. 1992;40:922-935.
9. Pan FF, Huang L, Chen KL, Zhao QH, Guo QH. A comparative study on the validations of three cognitive screening tests in identifying subtle cognitive decline. *BMC Neurol*. 2020;20:78.
10. Lebrun LL, Rhyner Y, Theodoloz M, Joz-Roland ND. Comment prévenir le déclin fonctionnel pendant l'hospitalisation: l'apport des soins aigus aux seniors. *Rev Med Suisse*. 2019;15:221-225.
11. Calmels P, Ebermeyer E, Bethoux F, Gonard C, Fayolle-Minon I. Relation entre la charge en soins à domicile et le niveau d'indépendance fonctionnelle à la suite d'un accident vasculaire cérébral. *Ann Readapt Med Phys*. 2002;45:105-113.
12. Buia JM, Carlier P, Belkacemi A. Intérêt de la mesure d'indépendance fonctionnelle (MIF) dans un service de rééducation et de réadaptation gériatriques. *Ann Readapt Med Phys*. 1995;38:435-441.
13. Zhuang L, Yang Y, Gao J. Cognitive assessment tools for mild cognitive impairment screening. *J Neurol*. 2021;268:1615-1622.
14. von Elm E, Altman DG, Egger M, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol*. 2008;61:344-349.
15. Srinivasan M, Delavy J, Schimmel M, et al. Prevalence of oral hygiene tools amongst hospitalised elders: a cross-sectional survey. *Gerodontology*. 2019;36:125-133.
16. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*power 3.1: tests for correlation and regression analyses. *Behav Res Methods*. 2009;41:1149-1160.
17. Faul F, Erdfelder E, Lang AG, Buchner A. G*power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39:175-191.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Srinivasan M, Duong S, Trombert V, et al. A novel prosthesis presentation test to screen for cognitive and functional decline. *Gerodontology*. 2023;00:1-6. doi:10.1111/ger.12708