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Assessment of Dentally-related Function in Patients with Cognitive Impairment: The Dental Activities Test (DAT)

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Abstract

OBJECTIVES—To develop and validate the Dental Activities Test (DAT), a clinical tool for measuring dentally-related function in cognitively-impaired older adults.

DESIGN—Cross-sectional study design.

SETTING—Three assisted living (AL) residences in North Carolina.

PARTICIPANTS—90 AL residents ranging from normal to impaired cognition who were 50 years of age or older; not blind, deaf, or severely physically disabled; and English speaking.

MEASUREMENTS—Items for the DAT were developed based on focus group discussions, a literature review, and clinical relevance. Cronbach's alpha, interrater reliability, and test-retest reliability were examined, and construct validity was assessed in relation to correlations with

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cognitive and functional assessments. Correlations between the DAT and oral health measures, were also analyzed to evaluate the concurrent validity of the DAT.

RESULTS—The DAT has excellent internal consistency reliability (Cronbach's alpha = 0.90), test-retest reliability ($r=0.84$) and inter-rater reliability ($r=0.90$). In terms of construct validity, higher scores on the DAT were significantly associated with better cognitive function, along with better physical and instrumental activities of daily living function. Finally, the DAT was significantly associated with oral hygiene and gingival health.

CONCLUSION—The DAT is a reliable and valid instrument to measure dentally-related function in older adults with cognitive impairment.

Keywords

Cognitive impairment; Functional assessment; Oral self-care function; Oral health

INTRODUCTION

Cognitive impairment, which affects more than one-third of Americans aged 71 and older,^{1, 2} is a major determinant of functional loss.^{3, 4} For many persons with cognitive impairment (PWCI), these losses also affect dentally-related function (DRF). For example, impaired prospective memory³ can disrupt daily oral and denture hygiene routines. Impaired executive function³ compromises oral self-care activities such as brushing and flossing. Anosognosia, language impairment and altered pain interpretation can compromise help seeking for pain and other oral health needs⁵. Difficulties consenting for treatment and following clinical and homecare instructions can affect clinical care^{3, 4, 6}. Apraxia⁷ can compromise prosthetic treatment outcomes. Taken together, these impairments can lead to worse oral hygiene and a higher incidence of dental carries, periodontal disease, tooth loss, oral soft tissue pathology, and denture related problems compared to persons without impairment⁸⁻¹⁰, resulting in lower quality of life, malnutrition, increased insulin resistance, recurrent respiratory infections, delirium and other life-threatening conditions¹¹⁻¹⁴.

Given the relationship between cognitive impairment and oral health, it is essential that DRF assessment be a standard part of geriatric dental care. Unfortunately, no objective, standardized approach is available. Existing cognitive (e.g., the Mini Mental State Examination [MMSE]¹⁵ and the Montreal Cognitive Assessment [MoCA]¹⁶) and functional (e.g., the Katz Index of Independence in Activities of Daily Living [ADL]¹⁷ and the Lawton Instrumental Activities of Daily Living [IADL] Scale¹⁸) assessment tools are not specific to DRF, nor are they designed for use in dental environments. As a result, dental professionals tend to rely on idiosyncratic, informal impressions rather than evidence-based approaches,¹⁹ raising concerns of suboptimal clinical outcomes and increased risk of avoidable complications.

In response, we have developed and validated the Dental Activities Test (DAT), an objective and reliable instrument for quickly assessing DRF among PWCI.

MATERIALS AND METHODS

Design Phase

The DAT was grounded in our work on the mediation effect of oral self-care function on the association between cognitive impairment and dental caries among dementia patients²⁰ and a survey of the need for such a tool among the members of the Special Care Dentistry Association.¹⁹ Development was further informed by clinical observations and an extensive literature review, which identified five DRF domains essential to maintain oral health in PWCIs. These include the capacity to: (1) manage dentally-related medications (e.g., use analgesics), (2) comprehend and follow instructions (e.g., implement post-surgical instructions), (3) perform oral hygiene (e.g., brush teeth), (4) perceive and react to oral health problems (e.g., verbalize complaints), and (5) manage dentures. Examples of oral health related activities (OHRAs) were also identified for each domain (Online supplementary Table S1). Next, cognitive (e.g., executive function, prospective memory, language, praxis) and other factors (e.g., vision, eye-hand coordination, manual dexterity) that can contribute to these DRF domains were identified, and 17 candidate DAT items that originated from the OHRAs commonly performed in clinics or at home by PWCIs were also developed. Additional literature review and focus group discussion with geriatric dentists, dental hygienists, neurologists, geriatricians, occupation therapists and neuropsychologists were used to review and revise the DRF domains and candidate items. Two domains (oral hygiene and denture management) had sufficient overlap to combine into a single domain titled oral care capacity. Some candidate items were also eliminated. The prototype DAT included 9 items designed to measure the factors underlying four DRF domains. Items with similar underlying cognitive/physical factors were grouped together, not necessary reflecting the sequence of a particular OHRA.

Evaluation Phase

1. Expert review, cognitive testing and instrument revision—The prototype DAT was presented to eight dental experts including geriatric dentists, general dentists, and dental hygienists for feedback on clinical relevance, completeness and validity of domains, and anticipated barriers of use in dental/non-dental settings. Revisions were made to make the DAT suitable for use by non-dental professionals (e.g., dental jargon was removed).

We then pilot tested the DAT with five cognitively and functionally intact assisted living (AL) residents aged 65 and older. In addition to completing the DAT, participants were asked to interpret the instructions in their own words. Based on these results, the DAT items and instructions were re-worded to avoid confusions and reduce complexity.

2. Final instrument—The final DAT is a 9-item assessment (Figure 1). One point is assigned for each activity completed exactly as directed and without help. The summative score (ranging from 0–9) reflects overall function in performing OHRAs, with a higher score indicating higher DRF.

3. Psychometric testing

Measures: To assess construct validity, the DAT was compared to scores on standardized and widely used assessments of cognition (the Saint Louis University Mental Status [SLUMS]²¹ and the Minimum Data Set Cognition Scale [MDS-COGS]²²) and function (the MDS Activities of Daily Living [MDS-ADL] scale²³ and the IADL¹⁸). Concurrent validity was evaluated via the association between the DAT and residents' oral hygiene status [Debris Index (DI) of the Oral Hygiene Index²⁴, Gingival Index (GI)²⁵ and Denture Plaque Index (DPI)²⁶].

Sample: Study participants included 90 older adults with normal to impaired cognition, recruited from three AL communities in North Carolina. Sample size was determined based on measurement development literature²⁷ that recommends at least 5–10 subjects per test item. Eligibility included: 50 years of age or older; not blind, deaf, or with a severe physical disability (e.g., hemiplegia); and English speaking. Individuals with an oral health condition that required antibiotic prophylaxis prior to dental treatment and/or an immediate dental referral were excluded. All procedures were approved by the University of North Carolina Institutional Review Board and the University of Iowa Institutional Review Board.

Data collection: Oral assessments were completed by a geriatric dentist (XC) and dental hygienist. Within one week, a research staff who had no dental background and was blind to the oral exam results visited the resident to complete the DAT and the SLUMS and interviewed staff to obtain information for the MDS-COGS, MDS-ADL and IADL.

Inter-rater Reliability Assessment: Forty-three subjects completed the DAT and SLUMS twice within three days by two different research staff, but at the same general time of day. These subjects were evenly divided among the three research sites and had a range of cognitive status.

Test-retest Reliability Assessment: Two weeks after the initial test, 43 residents different those involved in inter-rater reliability testing were re-administered the DAT. The same examiner who completed the first assessment completed the second assessment.

Throughout these assessments, the research and dental teams did not communicate about the real or perceived oral, cognitive or functional status of any residents.

Statistical Analysis

Means and frequencies were generated for descriptive statistics. Pearson correlations were calculated for inter-rater reliability, test-retest reliability, and construct validity associations. Cronbach's alpha was used to assess internal consistency reliability, and analysis of variance was used to determine whether DAT scores differentiated residents on cognitive and functional measures. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated to identify a single item for screening.

RESULTS

Characteristics of the Study Subjects

Subjects mean age was 83.71 years old (SD=8.88, rang=53–102, Online supplementary Table S2). Seventy-nine percent were female, 68% were white and 30% were black. The mean MDS-COGS was 3.56 (SD=3.40, rang=0–10), with 37.4% cognitively intact or mildly impaired, 25.3% moderately impaired, 25.3% severely impaired, and 12.1% very severely impaired. The mean SLUMS was 8.21 (SD=7.81, rang=0–27), with 88.9% of the subjects showing dementia. Mean MDS-ADL and IADL scores were 11.4 (SD=9.6, range=0–32) and 4.8 (SD=3.0, range=0–12), respectively.

Reliability

The DAT has showed excellent internal consistency ($\alpha=0.90$). Except for item-1 (understanding medication schedule), all items correlated well with the total scale. However, removal of this item increased alpha only by 0.008, and because it seems to address a component of DRF not clearly evident in the other items, it was retained in the final measure.

The DAT also showed excellent interrater ($r=0.90$) and test-retest reliability ($r=0.84$).

Construct and Concurrent Validity

Because OHRAs are associated with, but not exactly the same as, basic ADLs and IADLs, the DAT should significantly but less strongly correlate with these functional assessments. As expected, individuals who performed better on the DAT had lower MDS-ADL scores (which indicate better function; $r=-0.52$) and higher IADL scores ($r=0.47$; see Table 1). Stronger correlations were seen with the cognitive measures, where the correlation coefficients ranged from -0.78 with the MDS-COGS (lower scores are better) and 0.74 for the SLUMS, indicating that individuals with better cognitive function also performed better in the DAT exam.

DAT score was significantly but moderately correlated with the DI ($r=-0.32$, $P=0.01$) and GI scores ($r=-0.36$, $P<0.01$), indicating that individuals with better DAT performance had better oral hygiene and less severe gingival inflammation. However, the correlation between the DAT score and the DPI score was not significant ($P=0.37$).

DRF categories

The mean DAT score overall was 5.9 (SD 3.0; range 0–9). To understand the connection between DAT scores and differing DRF levels, we examined the distribution (mean, standard deviation and 95% confidence interval) of DAT scores within the levels of cognition and function. We then proposed four DRF level categories: those scoring 0–2 (full care), 3–5 (needs assistance), 6–8 (needs supervision), and 9 (independent, Table 2). Post hoc analysis indicated that cognitive (MDS-COGS and SLUMS) and functional (MDS-ADL and IADL) scores all significantly differed according to these categories ($P<.001$, Table 2). Significant differences with regard to cognitive and functional measures (especially the MDS-COGS

and SLUMS) also were observed in most pairwise comparisons between the DRF categories (data not shown).

Identifying a Pre-Screen Item

To allow quick identification of patients who might benefit from the DAT, we examined items and item combinations to find one item for use as a pre-screen. The item relating to understanding a medication schedule (Item 1) demonstrated 97% sensitivity and 100% specificity, meaning failure in this item identified 97% of those whose full score indicated a need for supervision, assistance, or full care. It also demonstrated an excellent PPV (1.00) and NPV (0.88).

Administration time

The DAT took 4–15 minutes (mean=6, SD = 2). Eighty-one percent of subjects required 7 minutes or less. PWCIs took longer than those without, but the difference was not significant. The screening item took 30–40 seconds to complete for cognitively intact subjects and 1–2 minutes for those with impairment.

DISCUSSION

PWCIs can vary in their DRF in ways that do not necessarily parallel their cognitive status. Those with mild cognitive impairment can show significant decline in oral hygiene, indicating impaired oral self-care ability,²⁸ while those with mild dementia do not.²⁹ Reasons for this can include “overlearning” of oral self-care through lifelong practice. Geriatric dentists therefore need an easy-to-us tool for specifically evaluating DRF for PWCIs.

The DAT showed excellent internal consistency, interrater reliability, and test-retest reliability, as well as excellent construct and concurrent validity. Correlations with cognitive measures were strong, suggesting that the DAT performs well in assessing the cognitive deficits contributing to functional loss among PWCIs. Significant but less strong correlations with functional measures demonstrate that the oral health related dysfunction captured by the DAT is related to, but different than, general functional impairment. Additionally, the DAT is moderately associated with the DI and GI, but not with the DPI. This may be due to the small sample size of denture wearers (N=25) and other factors (e.g., denture designs, denture care skills and frequency, and level of caregiver support), but should be explored in future studies.

The excellent psychometric properties of the DAT enables dental professionals to reliably stage patients' DRF and design functionally-tailored interventions to achieve desired oral health outcome. For mildly-impaired patients who are still able to learn new skills, home care interventions should target both patients and their caregivers, helping patients regain/maintain oral care function while teaching caregivers how to effectively supervise/assist patients in oral care. For moderately-impaired patients, oral care intervention should target more on caregivers to improve their oral caregiving skills and ability to work with PWCIs with behavior symptoms. Medication instructions should also be directed to caregivers. In-office fluoride/chlorhexidine varnish treatment can be considered to reduce the risk of

mishandling of these medications. Due to an impaired ability to adapt to new dentures, it may be best to design treatment plans involving minimal changes to the existing dentures of these patients (e.g., relining dentures rather than remaking them when possible). For severely-impaired patients, especially for those with a short life expectancy, stage-appropriate palliative dental care should be considered.³⁰ Besides oral caregiving skills, it is also important to teach caregivers how to recognize signs, symptoms, and behavior change indicating dental pain/infection for nonverbal patients.

When using the DAT, it is important to note three issues. First, the DAT was designed to measure global DRF via a summative score. Based on direct observation of a particular item (e.g., Rinse and Spit), one may obtain insights regarding a related OHRA (e.g., use of chlorhexidine oral rinse), but should not judge a particular DRF domain (e.g., medication management) based on the patient's performance on a subset of items. Second, due to the complex intercorrelations among the cognitive and functional determinants of DRF function, it is difficult to specify the underlying cause(s) for any particular item. Finally, Item 1, understanding a medication schedule, can serve as a triage, which can be completed in 30–40 seconds in individuals with normal cognition. Failure suggests a high likelihood of impaired DRF and the full assessment is recommended. This highly-reliable, valid and easy-to-use pre-screen addresses dentists' concerns regarding the use of a functional assessment in dental practices¹⁹.

In addition to the pre-screen item, several aspects of the DAT increase its attractiveness for clinicians in daily practice. The incorporation of OHRAs that are highly relevant to oral health and/or clinical care allows dental professionals with little training in cognitive and functional assessment to easily understand and administer the tool. The instructions were written in a way that allied dental professionals and individuals without a healthcare background can also easily administer the DAT with minimal training. Finally, all the materials required for assessment (e.g., paper cups, toothbrush and toothpaste) are readily available in dental offices, increasing the feasibility of this instrument to be used in daily practices.

Nevertheless, several limitations exist in the present study. First, the DAT is a performance-based assessment that provides an objective, quantifiable measure of a patients' capacity, not skill, in performing OHRAs. When interpreting DAT scores, one should bear in mind that a high score does not necessarily imply good quality oral care, especially in patients with lower oral health literacy, poor oral hygiene skills, and/or inadequate caregiver support. Therefore, DAT assessment must be considered in relation to a clinical oral assessment. Although direct observation of these activities may clarify discrepancies between self- or proxy-reports and what a person can actually do, the DAT may fail to capture the typical performance of this individual in his/her home where the familiar environment may serve as a cue. Further, the DAT cannot distinguish unmotivated from incapable persons. Finally, the sensitivity of this instrument in detecting and predicting functional loss over time has yet to be established.

In summary, the DAT appears to be a reliable, easy-to-use and objective tool to measure DRF, providing useful information for clinicians when designing functionally-tailored oral health interventions for individuals with cognitive impairment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Patient: _____	Exam date: ___/___/___	Examiner: _____	Total score: _____/9
MANAGEMENT OF MEDICATIONS			SCORE
Item 1. Medication schedule			
Hand the person a sign that reads in 14-point bold font: "Take a pain pill every five hours."			
Say: <i>These are the instructions for taking a medication for pain. (In case of visual impairment, read sign aloud)</i>			
Say: <i>"Based on these instructions, if you take the first pill at 8:00 in the morning, what time will you take..."</i>			
Say: <i>"The second pill?"</i> Response: _____ [correct answer=1:00pm] Wait 5 seconds			
Say: <i>"The third pill?"</i> Response: _____ [correct answer =6:00pm] Wait 5 seconds			
Say: <i>"The fourth pill?"</i> Response: _____ [correct answer=11:00pm]			
If correct in all responses, score 1 and stop here. Otherwise, proceed to the next item			_____/1
Item 2. Rinse and spit			
Put two paper cups, one with 10ml water, in front of the person.			
Say: <i>"Rinse your mouth with the water in this cup (point to cup with small amount of water), and then spit the water back into the cup (point to the 2nd cup)."</i>			
			_____/1
COMPREHENSION AND FOLLOWING INSTRUCTION			
Item 3. Open, close mouth			
Say: <i>"Open your mouth"</i> Once open, give second instruction. Say: <i>"Close your mouth."</i>			
			_____/1
Item 4. Tongue movement			
Say: <i>"Stick out your tongue, move your tongue from side-to-side, and then lift your tongue up."</i>			
			_____/1
ORAL SELF CARE			
Item 5a. Tooth brushing – person with teeth or denture (If the person has no teeth or denture, skip to item 5b)			
Put a toothbrush in front of the person.			
Point to the toothbrush and Say: <i>"Using this toothbrush, gently brush your teeth. Start by brushing the outside of your teeth. Brush until I say to stop."</i>			
After five seconds of brushing:			
Say: <i>"Now brush the insides of your teeth. Brush until I say to stop."</i>			
Item 5b. Tooth brushing – person without teeth or denture only			
Put a cotton tipped swab in front of the person.			
Point to the cotton tipped swab and Say: <i>"Using this swab, rub your gums. Start by rubbing the outside of your gum. Rub until I say to stop."</i>			
After five seconds of rubbing:			
Say: <i>"Now rub the insides of your gum. Rub until I say to stop."</i>			
			_____/1
Item 6. Putting toothpaste on toothbrush			
Put a toothbrush and a toothpaste in front of the person.			
Say: <i>"Take the cap off of the toothpaste tube (point to the toothpaste) and then put the toothpaste on the toothbrush (point to the toothbrush)."</i>			
			_____/1
PERCEPTION AND RESPONSE TO ORAL HEALTH PROBLEMS			
Item 7. Finding a tooth			
Say: <i>"Use your finger to show me where your lower front teeth are (were)."</i>			
Note: wording of this question ("are" vs. "were") is based on the availability of the lower front teeth.			
			_____/1
Item 8. Perceiving an oral health condition			
Say: <i>"Which of the following best describes how your upper right front tooth looks?"</i>			
A. It looks broken; B. It looks fine; C. It is missing.			
D. Other response (record below and confirm accuracy): _____			
Say "Can I see your upper front teeth?" to verify the answer. Score 1 if correctly describe the condition.			
			_____/1
Item 9. Response to oral infection			
Say: <i>"What would you do if you have a bad toothache, high fever, and a swollen face?"</i>			
Note: The criterion focuses on patient's ability to engage in a rational process of manipulating the information given. Score 1 for all sensible responses. Examples of sensible response include, but are not limited to: call or visit dentist or doctor, inform nurse or caregiver, or self-medicate. If "unreasonable" choices are given, ask why decisions were made.			
Response: _____			
			_____/1

* Score only if a task is completed as directed without help. ** DAT score 0-2 – Full Care; 3-5 – Need Assistance; 6-8 – Need Supervision; 9 – Independent

Figure 1.
The Dental Activities Test

Table 1

Correlations among the Dental Activities Test (DAT) and cognitive, functional, and oral hygiene measures

Measure		Pearson Correlation Coefficient	P value
Functional measures	MDS-ADL ^{*§}	-.52	<.001
	IADL [§]	.47	<.001
Cognitive measures	MDS-COGS ^{*§}	-.78	<.001
	SLUMS [§]	0.74	<.001
	Debris Index [*]	-.32	0.01
Oral hygiene measures	Gingival Index [*]	-.36	<.01
	Denture Plaque Index [*]	-.19	.37

* Lower scores are favorable

[§]MDS-ADL – Minimum Data Set Activities of Daily Living; IADL – Instrumental Activities of Daily Living, MDS-COGS – Minimum Data Set Cognition Scale; SLUMS – St Louis University Mental Status Exam;

Table 2 Categories differentiating levels of dentally-related function as measured by the Dental Activities Test (DAT)

	DRF level (Score)					P value
	Independent (9)	Needs supervision (6-8)	Needs assistance (3-5)	Full care (0-2)	Total	
MDS-COGS* (Mean, SD)	0.87 (1.41)	2.12 (2.29)	5.47 (2.76)	8.00 (2.59)	3.60 (3.40)	<.001
SLUMS (Mean, SD)	18.80 (5.92)	10.22 (5.79)	1.53 (1.02)	0.60 (1.18)	8.21 (7.81)	<.001
IADL (Mean, SD)	6.40 (3.54)	5.39 (2.90)	4.37 (2.41)	1.93 (1.39)	4.77 (3.04)	<.001
MDS-ADL* (Mean, SD)	7.60 (9.05)	8.07 (7.32)	15.21 (10.05)	19.93 (8.57)	11.48 (9.58)	<.001

* Lower scores are favorable

§ MDS-ADL – Minimum Data Set Activities of Daily Living; IADL – Instrumental Activities of Daily Living; MDS-COGS – Minimum Data Set Cognition Scale. Score 0-1 represents cognitively intact – mild cognitive impairment; 2-4 represents mild-moderate impairment; 5-8 represents moderate-severe impairment and 9-10 represents severe-very severe impairment; SLUMS – St Louis University Mental Status Exam. Score 1-19 dementia; 20-24 mild cognitive impairment; 25-30 normal.