



Impact of oral care on thirst perception and dry mouth assessments in intensive care patients: An observational study

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1 **Impact of oral care on thirst perception and dry mouth assessments in intensive care**
2 **patients: An observational study**

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28

29 **Author Contributions**

30 SD and YK contributed to study design, acquisition and interpretation of the data, and drafting of
31 the manuscript. NN took part in the critical revision of the manuscript. SN took part in study
32 concept and design. All authors read and approved the final manuscript.

33

34 **Competing interests** None declared.

35

36 **Clinical Trial Registration**

37 Trial registration: UMIN000043412

38

39 **Ethics approval** Ethics approval was obtained from the clinical research ethics committees of
40 nursing department in Tokushima University Hospital (#201801).

41

42 **Data sharing statement** Data are available upon reasonable request for academic, non-
43 commercial research purpose.

44

45 **Figure:** color was not used fir any figures in print.

ABSTRACT

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Objectives: To investigate the impact of oral care on thirst perception and dry mouth assessments.

Research design: Single-center observational study

Setting: Intensive care unit in a university hospital

Main Outcome: We assessed thirst perception and dry mouth in adult patients before and after oral care. Thirst perception was assessed using a numerical rating scale (NRS), and dry mouth was assessed using an oral moisture checking device and the modified Revised Oral Assessment Guide (mROAG) including tongue, mucous membranes, and saliva.

Results: Eighty-six patients were included. After oral care, thirst NRS scores decreased by 1 (0 to 3, $p < 0.01$) and remained low only for 1 hour. Oral moisture was maintained in a normal level $\geq 27.0\%$, and mROAG was in a low level ≤ 4 before and after the oral care. NRS score did not correlate with oral moisture ($\rho = -0.01$, $p = 0.96$) or mROAG ($\rho = 0.09$, $p = 0.42$). Among patients with thirst, 60 (70%) patients complained of thirst at the assessment timepoints, but only 17 (20%) patients complained independently.

Conclusion: Thirst perception was dissociated from dry mouth before and after oral care. Thirst must be frequently assessed and treated.

Key words:

Oral care, Thirst, Dry mouth, Critical illness

Implications for Clinical Practice:

- Thirst and dry mouth are common among critically ill patients.
- Oral care impacts on thirst perception only for 1 hour.
- Dry mouth assessments do not reflect thirst perception.
- Thirst and dry mouth should be frequently assessed and treated by the ICU staff.

INTRODUCTION

72
73 Thirst and dry mouth are common problem in the Intensive Care Unit (ICU), and these are
74 associated with physical discomfort (Schitteck et al., 2020). In a previous study, thirst has been
75 observed in 70.8% of critically ill patients as the most intense and the second most common
76 symptom among ten symptoms (Puntillo et al., 2010). However, thirst is often undetected and
77 remains untreated (Landström et al., 2009). Particularly in critically ill patients, it is difficult to
78 detect patient's thirst perception because they cannot express their thirst under sedation or
79 intubation (Kawahara et al., 2020).

80 Thirst is perceived by brain stimuli, which is caused by increased plasma osmolality and
81 hypovolemia (Arai et al., 2013). Increased osmolality releases antidiuretic hormone, while
82 hypovolemia activates renin-angiotensin aldosterone system. Unsuccessful compensation leads
83 to thirst perception. On the other hand, dry mouth is the result of inadequate saliva secretion,
84 which may reflect hypovolemia. Although thirst perception and dry mouth may be associated,
85 these relationships have not been clearly investigated yet.

86 Thirst should be treated because thirst persisting for more than 24 hours is associated
87 with delirium (Sato et al., 2019). Furthermore, thirst experience leads to posttraumatic stress
88 disorder (PTSD) (Chanques et al., 2015), which is experienced by 25% of patients a year after
89 discharge (Parker et al., 2015). Thirst perception must be recognized in nursing care because
90 relieving thirst is an important part of humanized care. Proper management of thirst will mitigate
91 patients' stress and prevent delirium and PTSD.

92 In general, treatment of thirst requires oral drinking (Obika et al., 2009), but it is often
93 difficult in critical situations. In critical illness, oral care is an important to preserve oral moisture
94 (Atay and Karabacak, 2017) as well as prevent ventilator-associated pneumonia (Mori et al.,
95 2006). Therefore, patients are treated by oral care, but thirst is commonly experienced by
96 patients. It is important to find some features to detect thirst. We hypothesized that dry mouth
97 assessment could help detect thirst perception. Therefore, we conducted a prospective

98 observational study to evaluate the impact of oral care on thirst perception and dry mouth
99 assessments in intensive care patients.

100

101

METHODS

102 **Objectives**

103 We investigated the impact of oral care on thirst perception and dry mouth assessments in
104 intensive care patients.

105

106 **Setting**

107 This single-center observational study was conducted in the mixed medical-surgical ICU of
108 Tokushima University Hospital between July 2018 and July 2019. This study was registered in
109 University Hospital Medical Information Network Clinical Trials Registry (UMIN000043412).

110

111 **Ethical approval**

112 This study was approved by the clinical research ethics committees of the nursing department in
113 Tokushima University Hospital (#201801). Written informed consent was obtained from patients
114 at the time of enrollment.

115

116 **Participants**

117 We included adult patients who were aged ≥ 20 years old. Subject recruitment was conducted
118 when trained research nurses (S.D. or Y.K.) were present during the day shift (7 am to 5 pm).

119 We excluded patients who could not communicate due to disorientation or delirium, which were
120 assessed using the verbal Glasgow Coma Scale ≤ 4 and confusion assessment method for the
121 ICU (CAM-ICU), respectively.

122

123 **Data collection**

124 Nurses assessed thirst perception using the following protocol (Figure 1). The intensity of thirst
125 perception was assessed using a thirst numerical rating scale (NRS) ranging from 0 to 10, in
126 which 0 was no thirst and 10 was worst thirst ever. Objective dry mouth was assessed by an oral
127 moisture-checking device (Moisture Checker for Mucus; Scalar, Tokyo, Japan) and modified
128 Revised Oral Assessment Guide (ROAG). The moisture-checking device measures the
129 percentage of water content in the oral mucosa (Yamada et al., 2005). We used the device to
130 assess the buccal mucosa as previously reported (Takahashi et al., 2005). We did not measure the
131 surface of the tongue because the measurement was inconsistent in our preliminary tests. Normal
132 and dry mouth were defined as $\geq 27.0\%$ and < 27.0 , respectively (Minakuchi et al., 2018). ROAG
133 is a tool used to assess oral health with a high sensitivity and specificity (Ribeiro et al., 2014). To
134 assess dry mouth, we used the original modified ROAG, which included only tongue, mucous
135 membrane, and saliva assessments. The median of three modified ROAG scores was used for the
136 assessments. The modified ROAG score ranges from 3 to 9, in which a higher score indicates dry
137 mouth.

138 Nurses conducted thirst perception and dry mouth assessments before and after oral
139 care, and then hourly until 4 hours after oral care. We used this time period because routine oral
140 care is recommended every 4 hours (Hua et al., 2016). At each timepoint, nurses assessed
141 whether thirst was present and if oral care was required. The assessments were halted if patients
142 desired oral care or oral intake in patients who are permitted to drink. The permission of oral
143 intake was based on clinical practice. When patients required oral care or oral intake, a final
144 assessment was conducted. Oral care included brushing teeth with water followed by cleaning
145 with foam swabs. We did not use antiseptic mouthwash because of the safety concerns (Blot,
146 2021). In our facility, oral care is usually conducted every 8 hours on all patients admitted to the
147 ICU.

148 The primary outcome of this study was the change of thirst perception and dry mouth
149 assessments before and after oral care. Secondary outcomes included the correlation between

150 thirst perception and dry mouth assessments before oral care. Another secondary outcome is the
151 potential risk factors for thirst perception in patients with the following score ranges: Thirst NRS
152 < 4, 4–7, and ≥ 7 . Risk factors included sex, age, the Acute Physiology and Chronic Health
153 Evaluation (APACHE) II score, plasma osmolality (calculated as $2 \times \text{sodium} + \text{glucose}/18 +$
154 $\text{blood urea nitrogen}/2.8$), blood urea nitrogen, sodium, permitted oral intake, and respiratory
155 managements (mechanical ventilation, high flow nasal cannula, and nasal cannula or mask).
156 Furthermore, we conducted multiple regression analysis to identify the risk factors for thirst
157 perception. The eight risk factors were included in the analysis.

158

159 **Data analysis**

160 Categorical data were presented as numbers (%). Continuous data were presented as mean \pm
161 standard deviation or median (interquartile range). Correlation was assessed using the Spearman
162 rank correlation coefficient. The Wilcoxon signed-rank test was used to examine the longitudinal
163 changes over time, and the Kruskal-Wallis test and multiple regression analysis were used to
164 determine the risk factors for thirst perception. Sample size was not determined a priori due to
165 the exploratory nature of this study. Data analyses were conducted using JMP version 13.1.0
166 (SAS Institute Inc., Cary, NC). A p-value of <0.05 was considered statistically significant.

167

168

RESULTS

169 A total of 86 patients were included. The average age was 70 (62–77) years, and 54 (63%) were
170 male (Table 1). The APACHE II score was 20 (14–29), and the median length of ICU stay was 4
171 (2–9) days. The examination was conducted at 2 (2–5) days after ICU admission. Eighteen
172 (21%) patients were mechanically ventilated. The reasons for admission were cardiovascular
173 disease (31%), digestive disease (27%), and respiratory disease (14%). Oral intake was permitted
174 in 24 (28%) of patients, but patients did not drink until withdrawal from the study.

175 After oral care, all 86 patients remained immediately after oral care, 70 at 1 hr, and 29 at

176 2 hr, 10 at 3 hr, 9 at 4 hr. During the study, 77 (90%) patients withdrew within 4 hours due to
 177 thirst. Among them, 60 (70%) complained of thirst at the observational timepoints, but only 17
 178 (20%) patients complained independently.

179 Before oral care, the median thirst NRS score was 6 (IQR, 5–8). Immediately after oral
 180 care, thirst NRS scores significantly changed by -1 (-3 to 0 , $p < 0.01$, $n = 86$) and remained low
 181 until the 1-hour timepoint (0 [-1.25 to 1], $p = 0.04$, $n = 70$, Figure 2, Figure S1, Table S4). The
 182 change of thirst NRS score was 0 (-1 to 0.5 , $p = 0.32$, $n = 29$) at 2 hr, -0.5 (-3.5 to 1.25 , $p =$
 183 0.41 , $n = 10$) at 3 hr, 0 (-4.5 to 1.5 , $p = 0.34$, $n = 9$) at 4 hr. All data were presented in
 184 supplemental file (Table S1–S3).

185 Contrary to thirst NRS, oral moisture was maintained at a normal level before and after
 186 oral care (Figure 3, Figure S2). Before oral care, oral moisture was 28.9% (27.7%–30.2%), and
 187 the change was 0.1 (-0.7 to 1.1), $p = 0.43$, $n = 86$ immediately after oral care, -0.25 (-1.1 to
 188 1.0), $p = 0.79$, $n = 70$ at 1 hr, -0.6 (-1.3 to 0.9), $p = 0.35$, $n = 29$ at 2 hr, 0.4 (-0.6 to 1.9), $p =$
 189 0.34 , $n = 10$ at 3 hr, and 0.3 (-1.5 to 2.8), $p = 0.73$, $n = 9$ at 4 hr.

190 The median modified ROAG score was 4 (3–5) before oral care, and the score changed
 191 by -1 (-1 to 0), $p < 0.01$, $n = 86$ immediately after oral care, and 0 (-1 to 0), $p < 0.01$, $n = 86$ at
 192 the last evaluation (Figure 4, Figure S3). Before oral care, the tongue, mucous membrane, and
 193 saliva were 1 (1–2), 1 (1–1), and 2 (1–2). Immediately after oral care, tongue, mucous
 194 membrane, and saliva changed by 0 (0 to 0 , $p < 0.01$, $n = 86$), 0 (0 to 0 , $p < 0.01$, $n = 86$), -1 (-1
 195 to 0 , $p < 0.01$, $n = 86$), respectively. At the last evaluation, these changed by 0 (0 to 0 , $p = 0.03$, n
 196 $= 86$), 0 (0 to 0 , $p = 0.01$, $n = 86$), 0 (-1 to 0 , $p < 0.01$, $n = 86$), respectively.

197 Thirst perception did not correlate with objective dry mouth assessments (Figure 5).
 198 Thirst NRS score was not correlated with oral moisture ($\rho = -0.01$, $p = 0.96$) or modified ROAG
 199 ($\rho = 0.09$, $p = 0.42$). However in the objective assessments, modified ROAG and oral moisture
 200 were correlated ($\rho = -0.22$, $p = 0.04$).

201 There was no significant difference in the risk factors investigated in our study (Table

202 2). In multiple regression analysis, all risk factors were not significantly associated with thirst
203 NRS score: sex ($p = 0.17$), age ($p = 0.48$), APACHE II score ($p = 0.54$), plasma osmolality ($p =$
204 0.81), blood urea nitrogen ($p = 0.11$), sodium ($p = 0.48$), permitted oral intake ($p = 0.60$), and
205 respiratory managements ($p = 0.19$).

206

207

DISCUSSION

208 In this study, contrary to our hypothesis, we found a disparity between thirst perception and dry
209 mouth assessments before and after the oral care in intensive care patients. Although mouth
210 moisture was in normal level, thirst was observed before oral care. After oral care, thirst
211 perception was relieved only for 1 hour. Despite the common thirst prevalence, only 20% of
212 patients complained of thirst independent of the set timepoints. It is important to note that
213 nursing staff need to actively assess for thirst in critically ill patients without depending on
214 objective assessments.

215 In our study, oral care slightly decreased thirst perception by NRS 1 (0 to 3)
216 immediately after oral care. This result was consistent with a previous study, which reported
217 bundle intervention including oral swab wipe, sterile ice-cold water sprays, and a lip moisturizer,
218 improved thirst perception by the thirst NRS 2.3 (Puntillo et al., 2014). However, the previous
219 study did not investigate the sustained effect of the intervention. In our study, oral care
220 contributed to relieving thirst perception only for 1 hour. Because oral care does not have a
221 sustained effect on thirst perception, the frequent nursing care is needed to treat thirst perception.
222 Indeed, VonStein et al. found that treating thirst hourly relieved thirst perception (VonStein et
223 al., 2019). The previous study used ice water oral swabs and lip moisturizer with menthol hourly
224 during a 7-hour period, and this intervention lessened thirst perception. These results are
225 reasonable because thirst perception is elevated in dehydrated patients and complete modulation
226 is difficult without drinking (Obika, Idu, 2009).

227 It is important to note there is a disparity between thirst perception and objective dry

228 mouth assessments. Before oral care, the median thirst NRS score was 6 (5–8), which means
229 patients had thirst perception. In contrast, the objective dry mouth assessment appeared to be
230 normal because the oral moisture measurement was at a normal level $\geq 27.0\%$ and the median
231 modified ROAG score (normal range: 3–9) was limited to 4 (3–5). This thirst perception was not
232 correlated with oral moisture and modified ROAG. Furthermore, the impact of oral care was
233 different between thirst perception and oral moisture. We found the objective dry mouth
234 assessment contributes to assessing oral moisture but did not contribute to assessing patients’
235 thirst perception. This finding is reasonable because thirst perception is caused by various brain
236 stimuli. It is difficult to assess the existence of thirst objectively by solely depending on oral
237 observation. Therefore, frequent assessment of thirst perception is important. Especially,
238 critically ill patients often experience difficulty communicating and expressing their desires (Ten
239 Hoorn et al., 2016). Indeed, in our study, only 20% of patients in the ICU complained of thirst
240 independently in this study. In many facilities, nurses practice oral care every 4 hours (Collins et
241 al., 2020), but oral care can relief thirst only for 1 hour. Therefore, nursing staff need to assess
242 thirst perception more frequently in critically ill patients.

243 In our secondary analysis including multivariate analysis, there were no significant risk
244 factors related to thirst perception. In contrast, previous studies have reported that increased
245 plasma osmolality, hypovolemia, and mechanical ventilation were associated with thirst (Arai,
246 Stotts, 2013, Hua, Xie, 2016). Our study was primarily conducted to assess the disparity between
247 thirst perception and dry mouth assessments. Therefore, the sample size was not sufficient to
248 statistically analyze the risk factors. Indeed, plasma osmolality, blood urea nitrogen, sodium, and
249 the degree of mechanical ventilation increased in those patients with mild to severe thirst NRS
250 scores, but there was no statistical difference. A large study is needed to clarify this observation
251 because critically ill patients have numerous risk factors related to thirst.

252

253 **Limitations**

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313 **Figure legends**

314 Figure 1. Protocol of our observational study

315 Thirst NRS, oral moisture, and modified ROAG were evaluated before and after the oral care.

316 The arrows show the timing of assessments.

317 NRS = numerical rating scale, ROAG = revised oral assessment guide

318

319 Figure 2. Thirst numerical rating scale before and after the oral care

320 We showed the thirst numerical rating scale after the oral care. Before oral care, numerical rating

321 scale was 6 (5–8), and it significantly decreased 0 and 1 hour after the oral care. Data were

322 presented as median (interquartile range), and compared using the Wilcoxon signed-rank test.

323 * Significant at $p = 0.04$, ** Significant at $p < 0.01$

324 NRS = numerical rating scale

325

326 Figure 3. Oral moisture before and after the oral care

327 We showed oral moisture after the oral care. Before oral care, oral moisture was 28.9% (27.2%–

328 30.3%), and it did not change significantly after the oral care. During the study period, the

329 median oral moisture was maintained in a normal level $\geq 27.0\%$. Data were presented as median

330 (interquartile range), and compared using the Wilcoxon signed-rank test.

331

332 Figure 4. Modified Revised Oral Assessment Guide before and after the oral care

333 We showed modified ROAG before and after the oral care. Modified ROAG included only

334 tongue, mucous membrane, and saliva. Before oral care, the modified ROAG was limited to 4

335 (3–5), 1 (1–2), 1 (1–1), and 2 (1–2) at sum, tongue, mucous membrane, and saliva. These low

336 scores further decreased immediately after oral care and at the last evaluation.

337 Data were presented as median, and the changes were compared using the Wilcoxon signed-rank

338 test.

339 ROAG = revised oral assessment guide

340

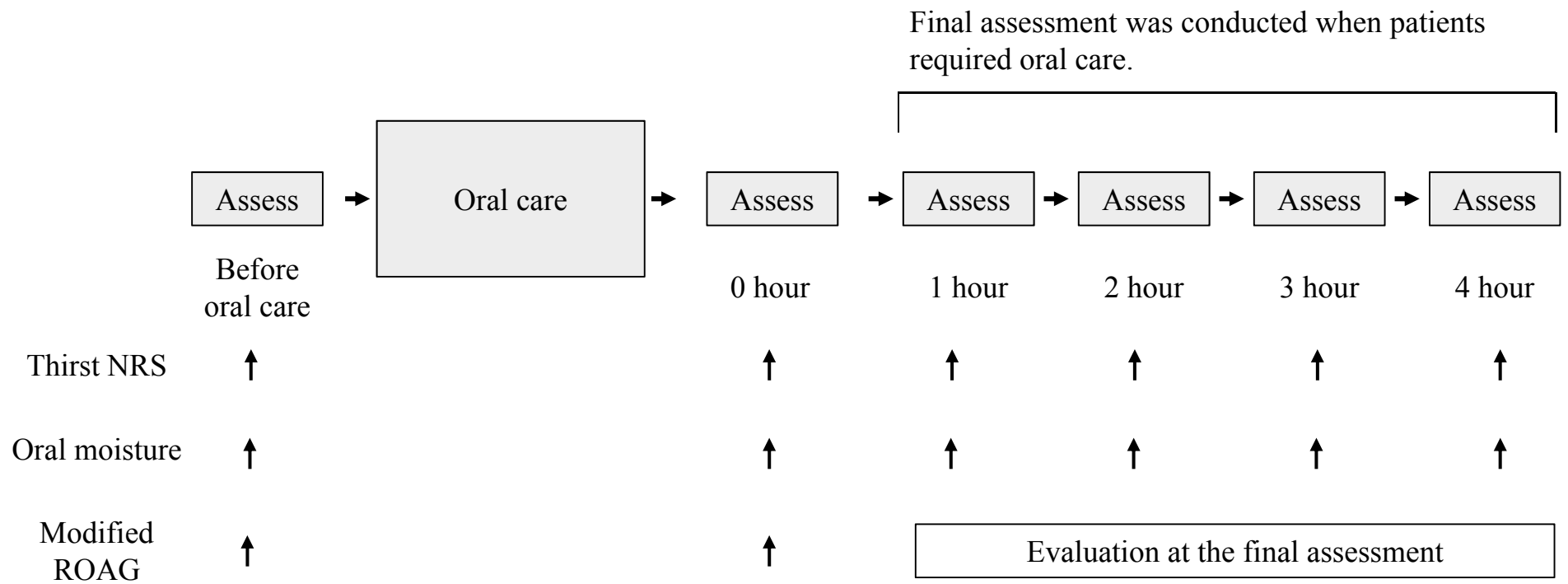
341 Figure 5. The correlation among numerical rating scale, oral moisture, and modified ROAG.

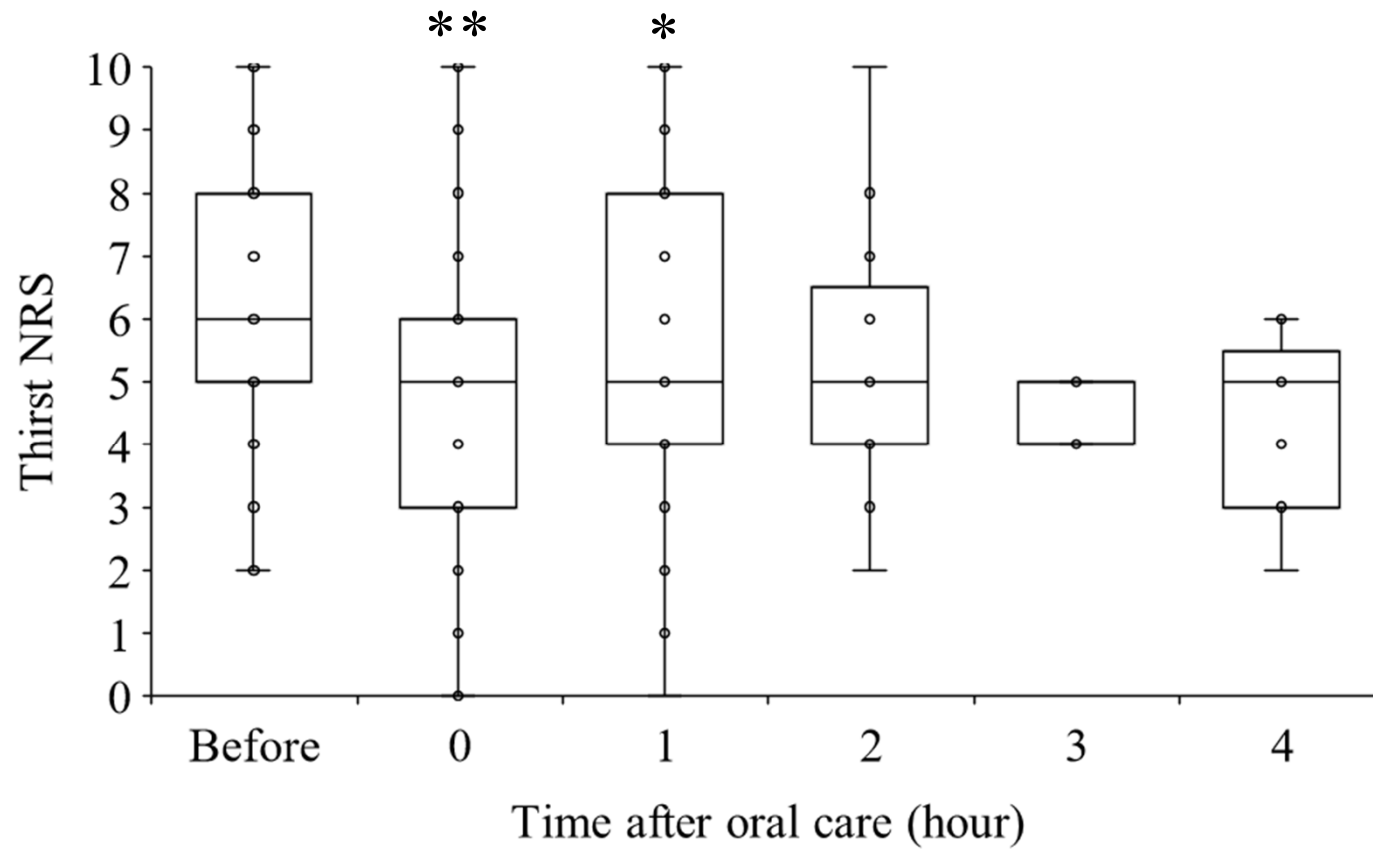
342 There was no significant correlation between numerical rating scale and oral moisture or

343 modified ROAG, while there was a negative correlation between modified ROAG and oral

344 moisture.

345 ROAG = revised oral assessment guide





No. of patients

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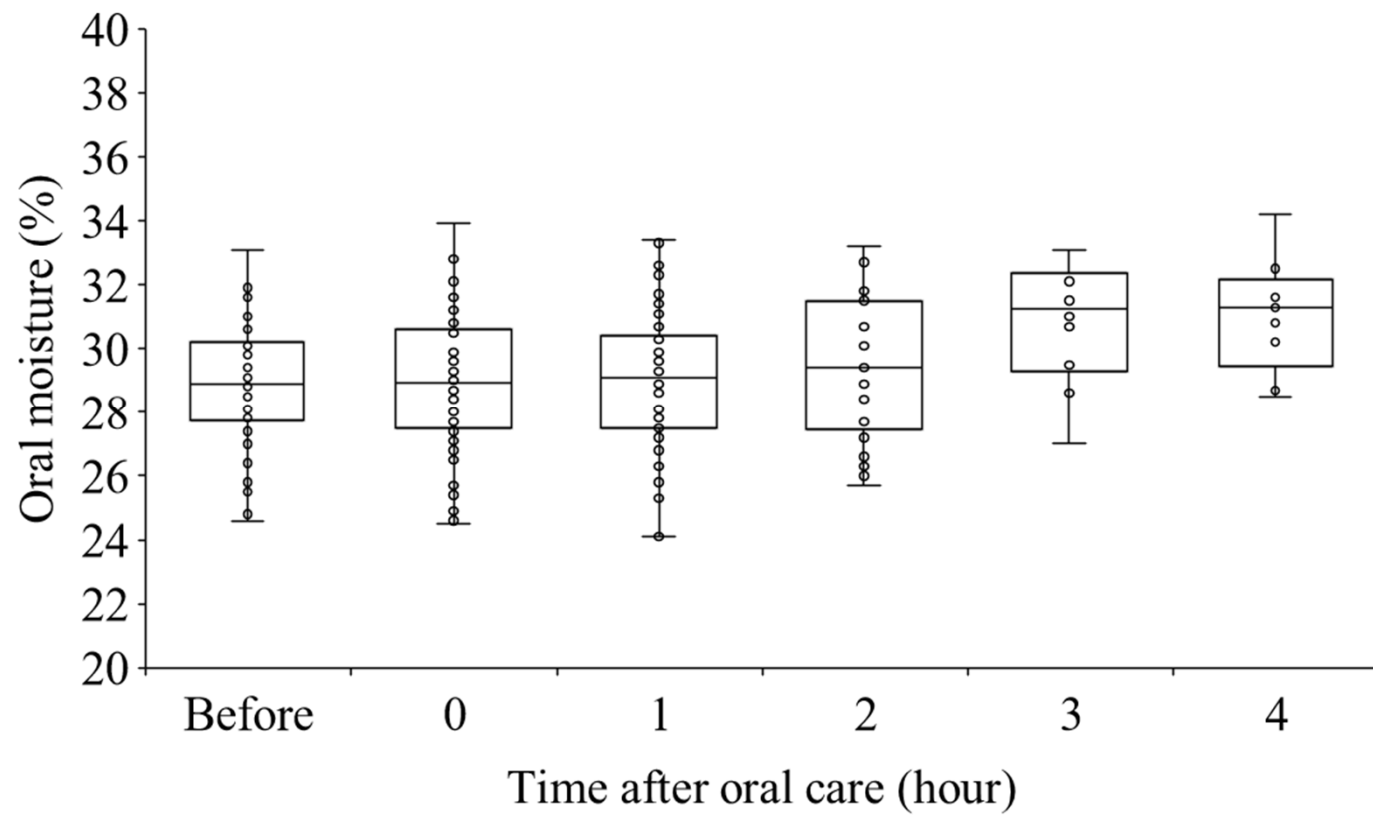
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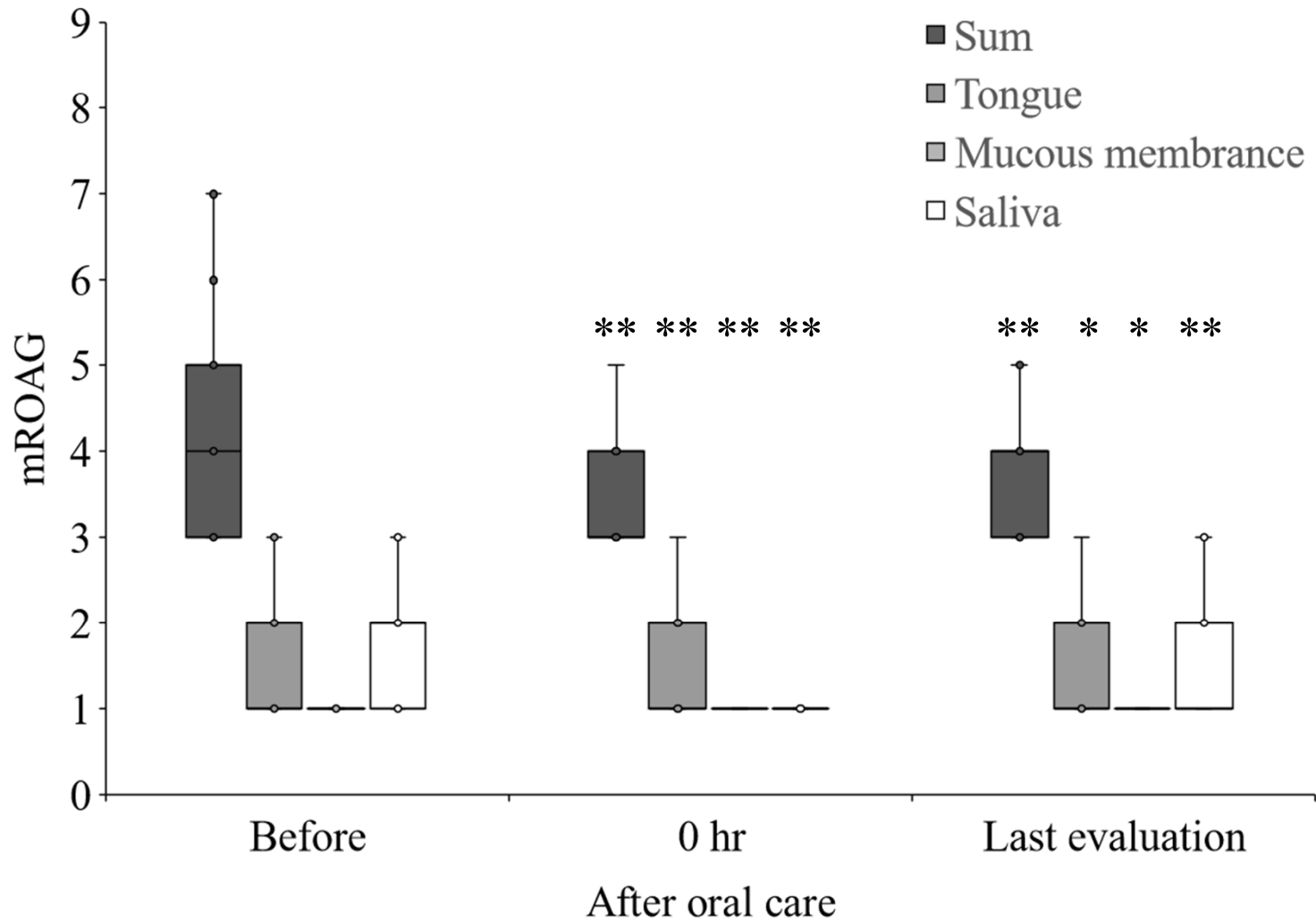
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9



No. of patients	86	86	70	29	10	9
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No. of patients

86

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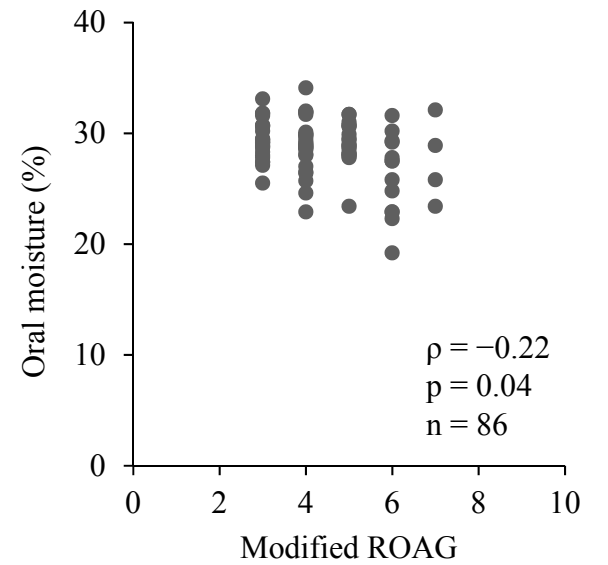
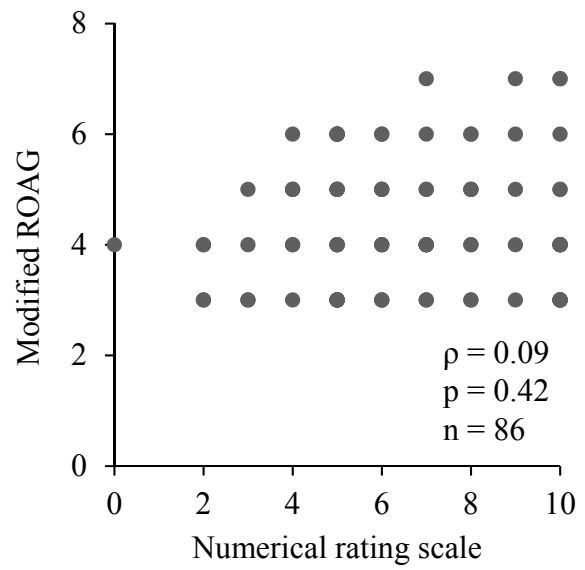
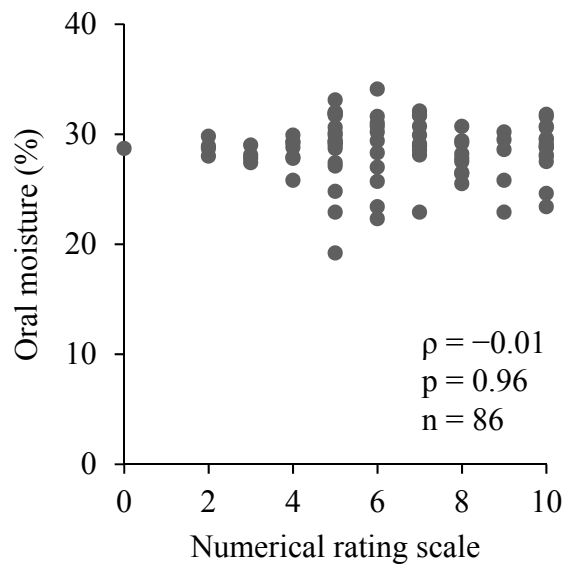


Table 1 Patient characteristics

Variables	Overall (n = 86)
Age, years	70 (62–77)
Sex (Men), n (%)	54 (63)
APACHE II score	20 (14–29)
Length of ICU stay, days	4 (2–9)
Examination day after ICU admission	2 (2–5)
ICU admission reasons, n (%)	
Cardiovascular	27 (31)
Digestive	23 (27)
Respiratory	12 (14)
Sepsis	7 (11)
Cerebrovascular	5 (6)
Other	12 (14)
Postoperative admission, n (%)	51 (61)
Mechanically ventilation, n (%)	18 (21)
High flow nasal cannula, n (%)	13 (15)
Permitted oral intake state, n (%)	24 (28)
Plasma osmolality, mosmol/kg	297 (290–305)

APACHE II = Acute Physiology and Chronic Health

Evaluation II, ICU = intensive care unit

Data were presented as median (interquartile range) unless otherwise indicated.

Table 2 Risk factor of thirst perception

Variables	<u>Mild</u>	<u>Moderate</u>	<u>Severe</u>	p value
	NRS = 0–3 (n = 9)	NRS = 4–6 (n = 37)	NRS = 7–10 (n = 40)	
Sex (Male), n (%)	5 (56)	21 (57)	28 (70)	0.43
Age, years	61 (60–76)	73 (64–80)	69 (56–75)	0.12
APACHE II score	21 (16–26)	20 (16–28)	18 (12–32)	0.85
Plasma osmolality, mosmol/kg	291 (283–295)	296 (290–304)	300 (290–310)	0.12
Blood urea nitrogen, mg/dL	15 (11–23)	21 (15–40)	22 (13–39)	0.19
Sodium, mmol/L	138 (136–140)	139 (137–143)	140 (138–144)	0.10
Permitted oral intake, n (%)	3 (33)	14 (38)	7 (18)	0.15
Mechanical ventilation, n (%)	1 (11)	6 (16)	11 (28)	
High flow nasal cannula, n (%)	3 (33)	7 (19)	3 (8)	0.29
Nasal cannula or mask, n (%)	4 (44)	13 (35)	18 (45)	

APACHE II = Acute Physiology and Chronic Health Evaluation II

Data were presented as median, and the data were compared using the Kruskal-Wallis test.