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# Latent Changes in Oral Symptom Burden Before and After Root Canal Treatment in Patients with Pulpitis: Association with Oral Frailty

**Liping Hu**
SCHOOL & HOSPITAL OF STOMATOLOGY WENZHOU MEDICAL UNIVERSITY
**Yao Jin**
SCHOOL & HOSPITAL OF STOMATOLOGY WENZHOU MEDICAL UNIVERSITY
**Haibin Bai**
SCHOOL & HOSPITAL OF STOMATOLOGY WENZHOU MEDICAL UNIVERSITY
**Qiaoqiao Liu**
1067422538@qq.com

SCHOOL & HOSPITAL OF STOMATOLOGY WENZHOU MEDICAL UNIVERSITY

**Research Article**

**Keywords:** Pulpitis, Root canal treatment, Oral symptom burden, Oral frailty, Latent profile analysis, Latent transition analysis, Impact

**Posted Date:** November 20th, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-11478208/v1

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**Additional Declarations:** No competing interests reported.

# Abstract

**Aim**: To investigate the dynamic characteristics of oral symptom burden in patients with pulpitis before and after root canal treatment and its association with oral frailty, so as to provide a basis for the early identification and intervention of high-risk groups.

**Design**: A prospective cohort study.

The Chinese version of the Oral Health Impact Profile (OHIP-14) was used to assess symptom burden before treatment (T1), 1 month after treatment (T2), and 2 months after treatment (T3). The Oral Frailty Index 8 (OFI-8) was used to assess oral frailty. Latent class transition analysis (LTA) was used to identify symptom burden trajectories, and Logistic regression was used to analyze the effects of different trajectories on oral frailty, after controlling for confounding factors including demographics, disease characteristics and baseline frailty status.

**Results**: Symptom burden and oral frailty scores decreased significantly over time (all P<0.001), and a positive correlation was observed between the two indicators at each time point (r>0, P<0.001). LTA identified five symptom burden trajectories: the continuously low burden group (34.92%), the continuously moderate burden group (15.87%), the continuously severe burden group (12.30%), the symptom worsening group (5.55%), and the symptom improvement group (31.36%). Logistic regression showed that after controlling for confounding factors, compared with the continuously low burden group, the continuously severe burden group (OR=14.614, 95%CI: 6.255-34.147), the symptom worsening group (OR=7.523, 95%CI: 3.579-15.813), the continuously moderate burden group (OR=4.043, 95%CI: 1.997-8.187) and the symptom improvement group (OR=3.522, 95%CI: 1.863-6.659) all had significantly increased risk of oral frailty (all P <0.05).

**Conclusions**: Symptom burden and oral frailty in patients with pulpitis generally improve after root canal treatment, but there is significant heterogeneity in the trajectory of changes. continuously high symptom burden and worsening trajectories are independent risk factors for oral frailty, and even patients with improving symptom burden still have a higher risk of oral frailty than those with continuously low burden. In clinical practice, attention should be paid to monitoring the dynamic trajectory of symptom burden, and early intervention should be implemented for high-risk populations to prevent oral frailty.


# Introduction

With the acceleration of global population aging, the bidirectional association between oral health and general functional decline has become a research hotspot in the field of public health[1]. Oral frailty, a new multidimensional geriatric syndrome, refers to a state of comprehensive decline in physical, psychological, and social function caused by the deterioration of oral function[2, 3]. The core pathological mechanism of oral frailty lies in the interaction between insufficient nutritional intake induced by reduced masticatory function and systemic low-grade inflammation, which ultimately accelerates the progression of physical frailty[4].

Pulpitis is one of the most common infectious diseases in clinical dentistry, characterized by spontaneous severe pain, sensitivity to cold and heat stimulation, and occlusal discomfort. These symptoms not only cause local tissue damage, but also seriously impair patients' nutritional intake, sleep quality, and social interaction through pain-related catastrophic cognition and masticatory dysfunction, thus forming latent stressors that induce oral frailty[5, 6]. Root canal therapy is the standardized minimally invasive treatment for irreversible pulpitis. Its core is to completely remove infected pulp tissue and pathogenic microorganisms in the root canal system through

mechanical preparation and chemical disinfection, followed by meticulous three-dimensional obturation with biocompatible materials to block the pathway of bacterial proliferation toward periapical tissues[7, 8]. This treatment can effectively eliminate clinical symptoms such as spontaneous pain and cold/heat stimulation pain, promote the healing of periapical lesions, preserve natural dentition, and restore normal masticatory function. To prevent tooth fracture and restore complete oral function, timely coronal restoration is required after treatment to block the progression of oral frailty caused by tooth defects[9–11]. However, existing studies on pulpitis are mostly limited to biomedical outcomes such as clinical cure rate and pain relief, and lack a dynamic perspective to examine its long-term impact on oral function decline.

According to chronic stress theory, continuously inflammation and pain caused by pulpitis act as long-term physiological and psychological stressors that overactivate the hypothalamic-pituitary-adrenal axis, leading to a sustained increase in cortisol levels. This in turn triggers systemic low-grade inflammation and muscle catabolism, accelerating the development of sarcopenia[12], which is the core pathological basis of oral frailty. Rogers' behavioral change theory holds that a patient's health recovery is not linear; instead, it presents multiple heterogeneous evolutionary trajectories during treatment and rehabilitation[13]. Under standard root canal therapy intervention, the symptom burden trajectories of different patients may differ significantly due to variations in host immune response, pain threshold, and disease coping styles, forming distinct subgroups. The heterogeneity of symptom burden trajectories determines the prognosis of oral function: continuously inflammatory stress may lead to sarcopenia and reduced physical performance, thereby increasing the risk of oral frailty.

Based on this, this study proposes the following research hypotheses:

**Hypothesis 1**

The evolutionary trajectory of oral symptom burden in patients with pulpitis after endodontic treatment is not homogeneous, but shows significant temporal heterogeneity.

**Hypothesis 2**

A continuously high-level oral symptom burden trajectory after root canal treatment is an independent risk factor for oral frailty.

**Hypothesis 3**

A dynamically worsening trajectory of oral symptom burden is a better predictor of oral frailty than a high baseline burden alone.

**Hypothesis 4**

The effect of oral symptom burden on oral frailty remains independent after controlling for demographic characteristics, disease severity, and baseline functional status.

By testing the above hypotheses, this study aims to provide clinical early warning indicators based on dynamic trajectories, so as to realize a paradigm shift from passive treatment to active prevention of oral function decline.

# Participants and Methods

# Participants

This prospective cohort study consecutively enrolled patients diagnosed with pulpitis and scheduled for root canal treatment at the School and Hospital of Stomatology, Wenzhou Medical University between August - September 2026.

## Inclusion criteria:

Clinically confirmed pulpitis, presenting with clinical symptoms (including spontaneous pain, cold and heat stimulation pain, and bite pain;

Radiographic findings (periapical membrane widening or sparse areas observed via X-ray or CBCT);

Abnormal pulp vitality test results;

Aged 18 years or older;

Planned to complete standardized root canal treatment;

Able to cooperate with clinical examinations and scale evaluations at baseline and 2 months after treatment;

Have basic communication skills and provided signed informed consent.

**Exclusion criteria**:
Patients with severe cardiovascular and cerebrovascular diseases, liver and kidney insufficiency, malignant tumors, hematological diseases or other systemic diseases that may affect oral health assessment or follow-up compliance;

The affected tooth had previously received root canal treatment or endodontic retreatment;

Presence of maxillofacial tumors, a history of radiotherapy, jaw osteonecrosis or other diseases that affect oral function and symptom judgment;

Patients planning to receive other major oral treatments such as orthodontics, implantation, and complex prosthodontics that may confound the assessment of symptom burden;

Treatment failure or interruption may occur during root canal treatment, such as instrument separation, perforation, or failure to complete root filling;

Severe complications after root canal treatment, such as acute cellulitis and maxillofacial space infection, that require additional surgical intervention.

# Ethical Principles

This study strictly follows the Declaration of Helsinki and the relevant ethical review norms for biomedical research involving human subjects in China. The study protocol has been submitted to the Medical Ethics Committee of SCHOOL & HOSPITAL OF STOMATOLOGY WENZHOU MEDICAL UNIVERSITY, and ethical review approval has been

obtained (approval number: Wenzhou Medical University Dental Medicine Review No. 067, 2026, 2nd Edition/ acceptance number: 260810085511).

## Sample size calculation

Based on the statistical requirements of Latent Transition Analysis (LTA) and referring to the rule of thumb for model stability [14]proposed by Nylund-Gibson et al., this study aims to accurately identify 3–4 latent categories of symptom burden and estimate their transition probabilities. Each category was set to include at least 50 patients, meaning 150 patients were required for the initial baseline assessment. Combined with the results from G*Power software for repeated measures design (α = 0.05, Power = 0.80, effect size w = 0.25), and after adjusting for 20% treatment dropout and loss to follow-up[15], we finally determined that 250 patients with pulpitis planning to receive root canal treatment should be included in the study. This provides sufficient statistical power to explore the association between oral frailty and the dynamic evolution of symptom burden.

# Survey Instruments

# General Information Questionnaire

Sociodemographic, clinical and behavioural data were collected with a General Information Questionnaire that was developed for this study (i.e., not previously published); it is provided as an English-language version in Supplementary File 1. The item pool was generated from a structured review of determinants of post-endodontic oral-health-related quality of life and oral frailty, reviewed in two rounds by an expert panel (2 endodontists, 2 gerontological nurse specialists, 1 clinical epidemiologist), and pilot-tested in 30 patients undergoing root canal treatment, which led to wording and sequencing revisions (mean completion time ≈ 5 min). The questionnaire comprises four modules: (i) sociodemographics — sex, age (18–44, 45–59, 60–74, ≥ 75 y; 60 y being the threshold used for oral-frailty stratification), educational attainment (≤ junior high / senior high or vocational / ≥college) and monthly personal income (tertiles); (ii) disease- and treatment-related characteristics — treated tooth, symptom duration (months from first spontaneous pain to presentation), preoperative pain intensity measured on a 0–10 cm visual analogue scale (VAS; 0 = no pain, 10 = worst imaginable pain) and completed before local anaesthesia, number of treatment visits (abstracted from clinical records rather than self-reported), pulp/periapical diagnosis, and single- versus multi-visit completion; (iii) lifestyle and health behaviour — smoking (never / former, quit ≥ 6 mo / current) and alcohol use (same categories), toothbrushing frequency (dichotomised at < 2 vs ≥ 2 times/day to match item 7 of the OFI-8), and use of floss or interdental brushes; (iv) systemic health and frailty-related factors — BMI computed from objectively measured height and weight (calibrated stadiometer and scale, not self-reported), comorbidity count verified against medical records (hypertension, diabetes, coronary heart disease, stroke, COPD, osteoporosis).

## Results

# Basic Participant Information

A total of 252 pulpitis patients participated in this study, and their baseline information is presented in Table 1.

Table 1
General information of the subjects (*n* = 252)

| Items | Categories | n | Percentage (%) |
|---|---|---|---|
| Age (years) | < 45 | 146 | 57.94 |
| | 45 ~ 59 | 73 | 28.97 |
| | ≥ 60 | 33 | 13.09 |
| Gender | male | 104 | 41.27 |
| | female | 148 | 58.73 |
| Level of education | Junior high school and below | 71 | 28.17 |
| | High school | 58 | 23.02 |
| | Junior college and above | 123 | 48.81 |
| Income level | Poor | 25 | 9.92 |
| | Average | 156 | 61.90 |
| | Good | 71 | 28.17 |
| Duration of illness (weeks) | < 2 | 146 | 57.94 |
| | ≥ 2 | 106 | 42.06 |
| Pain score (points) | 0 ~ 3 | 5 | 1.98 |
| | 4 ~ 6 | 193 | 76.59 |
| | ≥ 7 | 54 | 21.43 |
| Number of root canal treatments (number) | 1 | 196 | 77.78 |
| | ≥ 2 | 56 | 22.22 |
| History of smoking | yes | 97 | 38.49 |
| | no | 155 | 61.51 |
| Drinking history | yes | 105 | 41.67 |
| | no | 147 | 58.33 |
| Brushing frequency | ≤ 1 times/day | 92 | 36.51 |
| | ≥ 2 times/day | 160 | 63.49 |
| BMI | < 18.5 | 23 | 9.13 |
| | 18.5 ~ 23.9 | 116 | 46.03 |
| | ≥ 24 | 113 | 44.84 |
| Medical history | hypertension | 44 | 17.46 |
| | diabetes | 38 | 15.08 |
| | Coronary heart disease | 27 | 10.71 |

**Scores of each scale in pulpitis patients before and after root canal treatment and their correlation**

The scores of symptom burden (F = 1850.070, P < 0.001) and oral frailty (F = 485.635, P < 0.001) of pulpitis patients before and after root canal treatment showed a statistically significant downward trend, as shown in Table 2. There was a significant positive correlation between symptom burden scores and oral frailty scores at different time points (r > 0), and the specific correlation coefficients are shown in Table 3.

Table 2
Scores of different scales before and after root canal treatment in patients with pulpitis (*n* = 252)

| Time | Symptom burden score | Oral Frailty Score |
|---|---|---|
| T1 | 41.95 ± 5.64 | 5.24 ± 1.60 |
| T2 | 23.14 ± 3.95 | 3.12 ± 1.12 |
| T3 | 16.33 ± 3.27 | 2.73 ± 0.83 |
| *F* | 1850.070 | 485.635 |
| *P* | < 0.001 | < 0.001 |

Table 3
Correlation analysis of the scales before and after root canal treatment (*r*, *n* = 252)

| Scales | □ | □ | □ | □ | □ | □ |
|---|---|---|---|---|---|---|
| □ Symptom burden score T1 | 1 | | | | | |
| □ Symptom burden score at T2 | 0.514 * * | 1 | | | | |
| □ Symptom burden score at T3 | 0.405 * * | 0.469 * * | 1 | | | |
| □ Oral frailty score T1 | 0.385 * * | 0.356 * * | 0.423 * * | 1 | | |
| □ Oral frailty score T2 | 0.333 * * | 0.392 * * | 0.396 * * | 0.425 * * | 1 | |
| □ Oral frailty score T3 | 0.275 * * | 0.314 * * | 0.427 * * | 0.367 * * | 0.412 * * | 1 |

Note: ** indicates P < 0.001 and * indicates P < 0.01

# Latent profile analysis of symptom burden in patients with pulpitis

The average scores of the seven domains of OHIP-14 were used as the observation indicators for symptom burden. In latent profile analysis (LPA), model fitting started with a baseline 1-class model, and the number of classes was gradually increased to 4. The fit indices of each model are shown in Table 4. Model selection followed these criteria: on the premise that both the LRT and BLRT tests were statistically significant (P < 0.05), smaller AIC, BIC, and aBIC values were prioritized, and Entropy values greater than 0.8 indicate high classification accuracy. Based on the above criteria, the optimal model for T1 was a two-class model, which was divided into a moderate burden group (C1) and a severe burden group (C2) according to score characteristics. For T2 and T3, the three-class model was preferred to further include the low-burden group (C3). The distribution of score characteristics of the three groups is shown in Fig. 1.

Table 4
Comparison of fitting parameter indexes of different latent profile models (*n* = 252)

| Time | Model | AIC | BIC | aBIC | Entropy | LRT | BLRT | Class probability |
|---|---|---|---|---|---|---|---|---|
| T1 | 1 | 35735.751 | 35765.773 | 35742.490 | | | | |
| | **2** | **33672.864** | **33750.785** | **33693.283** | **0.852** | **0.010** | **< 0.001** | **0.28/0.72** |
| | 3 | 34602.362 | 34628.289 | 34616.296 | 0.876 | 0.085 | < 0.001 | 0.25/0.47/0.28 |
| | 4 | 36526.153 | 36589.331 | 36548.364 | 0.895 | 0.157 | 0.128 | 0.21/0.17/0.13/0.49 |
| T2 | 1 | 26743.376 | 26782.337 | 26756.757 | | | | |
| | 2 | 25627.852 | 25668.284 | 25633.463 | 0.875 | 0.000 | < 0.001 | 0.44/0.56 |
| | **3** | **24531.728** | **24558.560** | **24538.580** | **0.883** | **0.010** | **< 0.001** | **0.34/0.28/0.38** |
| | 4 | 27421.276 | 27527.564 | 27434.707 | 0.905 | 0.163 | < 0.001 | 0.25/0.17/0.26/0.32 |
| T3 | 1 | 34407.158 | 34986.773 | 34825.335 | | | | |
| | 2 | 33457.857 | 33792.590 | 33556.379 | 0.904 | 0.000 | < 0.001 | 0.35/0.65 |
| | **3** | **31660.289** | **31693.378** | **31783.625** | **0.911** | **0.005** | **< 0.001** | **0.22/0.16/0.62** |
| | 4 | 35429.346 | 35727.252 | 35712.447 | 0.936 | 0.158 | < 0.001 | 0.20/0.21/0.28/0.31 |

# Analysis of Latent Changes in Oral Symptom Burden in Patients with Pulpitis

Since latent transition analysis requires that the number and nature of subgroups at different time points are basically consistent, only changes in subgroup membership of participants between T2 and T3 were analyzed. The results showed that 63.10% of pulpitis patients remained in their original latent state. Among them, 34.92% of pulpitis patients stayed continuously in the low-burden group, which was therefore named the continuous low burden group; 15.87% remained continuously in the moderate-burden group, which was named the continuous moderate burden group; and 12.30% stayed continuously in the severe-burden group, which was named the continuous severe burden group.

For patients with changed subgroup membership, 2.38% of pulpitis patients transitioned from the moderate-burden group to the severe burden group (Symptom worsening Group), 1.19% moved from the low-burden group to the severe burden group, and 1.98% transitioned from the low-burden group to the moderate-burden group. 31.36% of pulpitis patients showed an improving trend: specifically (Symptom Improvement Group), 15.87% transitioned from the moderate burden group to the low burden group, 3.97% moved from the severe burden group to the moderate burden group, and 11.51% transitioned from the severe burden group to the low burden group, as shown in Table 5.

Table 5
Transition probability of oral symptom burden in patients with pulpitis at T2-T3 time points (*n* = 252)

| Items | | T3 | | |
|---|---|---|---|---|
| | | C1: moderate burden group | C2: severe burden group | C3: low burden group |
| T2 | C1: moderate burden group | 0.465 | 0.070 | 0.465 |
| | C2: severe burden group | 0.143 | 0.443 | 0.414 |
| | C3: low burden group | 0.052 | 0.031 | 0.917 |

**Exploring the Effect of Changing Patterns of Oral Symptom Burden on Oral Frailty in Patients with Pulpitis**

We further analyzed the effect of changing patterns of oral symptom burden on oral frailty in patients with pulpitis, with univariate and multivariate regression analyses performed using the continuous low burden group as the reference.

Taking the changing pattern of oral symptom burden in patients with pulpitis as the independent variable, and the occurrence of oral frailty (≥ 4) at T3 as the dependent variable, Logistic regression analysis showed that compared with the continuous low burden group, patients with pulpitis in the continuously severe burden group (OR = 14.614), continuously moderate burden group (OR = 4.043), symptom deterioration group (OR = 7.523) and symptom improvement group (OR = 3.52) all had an increased risk of oral frailty (all $P < 0.05$), as shown in Table 6.

Table 6
Association between oral symptom burden and oral frailty in patients with pulpitis

| Transition patterns | *B* | *SE* | OR | 95%CI | P |
|---|---|---|---|---|---|
| Model 1 | | | | | |
| Continuous low burden group | - | - | - | - | - |
| Continuous moderate burden group | 1.537 | 0.422 | 4.651 | 2.034 ~ 10.635 | < 0.001 |
| Continuous severe burden group | 2.855 | 0.514 | 17.374 | 6.344 ~ 47.581 | < 0.001 |
| Symptom worsening group | 2.204 | 0.389 | 9.061 | 4.227 ~ 19.423 | < 0.001 |
| Symptom improvement group | 1.424 | 0.472 | 4.154 | 1.647 ~ 10.476 | < 0.001 |
| Model 2 | | | | | |
| Continuous low burden group | - | - | - | - | - |
| Continuous moderate burden group | 1.458 | 0.385 | 4.297 | 2.021 ~ 9.139 | < 0.001 |
| Continuous severe burden group | 2.790 | 0.524 | 16.281 | 5.830 ~ 45.469 | < 0.001 |
| Symptom worsening group | 2.112 | 0.356 | 8.265 | 4.113 ~ 16.606 | < 0.001 |
| Symptom improvement group | 1.338 | 0.478 | 3.811 | 1.493 ~ 9.727 | < 0.001 |
| Model 3 | | | | | |
| Continuous low burden group | - | - | - | - | - |
| Continuous moderate burden group | 1.397 | 0.360 | 4.043 | 1.997 ~ 8.187 | < 0.001 |
| Continuous severe burden group | 2.682 | 0.433 | 14.614 | 6.255 ~ 34.147 | < 0.001 |
| Symptom worsening group | 2.018 | 0.379 | 7.523 | 3.579 ~ 15.813 | 0.001 |
| Symptom improvement group | 1.259 | 0.325 | 3.522 | 1.863 ~ 6.659 | < 0.001 |

Note: Model 1: Logistic regression; Model 2: controlling for gender, age, education level, income level, disease duration, pain score, number of root canal treatments, smoking and drinking history, brushing frequency, BMI, past medical history and other confounding factors. Model 3: controlling for gender, age, education level, income level, disease duration, pain score, number of root canal treatments, smoking and drinking history, tooth brushing frequency, BMI, past medical history and oral frailty at T1 and T2.

# Discussion

The results of this study showed that patients with pulp disease exhibited a downward trend in both symptom burden score ($F = 1850.070$, $P < 0.001$) and oral frailty score ($F = 485.635$, $P < 0.001$) before and after root canal treatment. This significant downward trend is first attributed to root canal therapy directly reducing symptom burden, and relieving oral intake restriction and muscle disuse degeneration caused by toothache[18, 19]. This is achieved by completely removing infected and necrotic pulp and periapical inflammatory mediators, thereby blocking pain transmission and dysfunction originating from the pathological site.

Symptom burden scores at different time points were significantly correlated with oral frailty scores. Severe oral pain forces patients to reduce chewing movements and social activities, accelerating the loss of oral muscle strength and functional decline. In turn, frailty weakens tissue inflammation repair capacity and lowers the pain threshold[20, 21]. In addition, the correlation of post-treatment scores suggests that with the removal of pathological stimuli, patients' physical function and psychological state recover synergistically: the restoration of masticatory function promotes nutritional intake and social participation, which further reduces frailty symptoms[22, 23].

Therefore, this strong correlation confirms that endodontic therapy is not only an anti-infection treatment, but also a key intervention node to break the cycle of pain and frailty and restore oral homeostasis.

AccordingAccording to latent profile analysis, there were two groups of pulpitis patients before root canal treatment: the moderate burden group (C1) and the severe burden group (C2). At 1 month and 2 months after root canal treatment, a three-category model was established, and the low burden group (C3) was further subdivided from the original groups.

Before treatment, only the moderate and severe burden groups existed, with no low burden group. This indicates that the pain, masticatory dysfunction and psychological stress triggered by pulpitis have already developed into substantial functional damage, which is difficult for patients to relieve spontaneously. The emergence of the low burden group (C3) after root canal treatment confirms that root canal treatment effectively blocks pain pathways and restores oral physiological homeostasis by completely removing the source of infection and periapical inflammatory mediators that stimulate nerve endings, enabling some patients to transition from a pathological state to health[24, 25].

However, the moderate and severe burden groups still account for a certain proportion after treatment. The persistence of these two groups may be related to temporary postoperative inflammatory responses caused by large pre-treatment periapical lesions, incomplete cleaning of the root canal system, or individual differences in central sensitization. This suggests that biological cure alone does not equate to simultaneous relief of patients' subjective symptom burden[26, 27]. ThisHeterogeneity suggests that clinical medical staff should abandon the traditional concept of only focusing on imaging healing, and instead establish a precise management pathway based on symptom burden stratification.

For patients in the high burden group before surgery, it is recommended to strengthen the sequential use of non-steroidal anti-inflammatory drugs and implement psychological and cognitive intervention during the perioperative period of root canal treatment, to reduce the risk of central sensitization. For patients who remain in the medium-high burden group after root canal treatment, it is necessary to be alert to the latent risk of oral frailty and provide timely intervention including occlusal adjustment, physical therapy, or multidisciplinary consultation, so as to extend the clinical endpoint from successful root canal filling to the substantial improvement of patients' subjective oral health-related quality of life.

According to latent transition analysis, 34.92% of the patients remained stable in the low-burden group and 31.36% showed an improving trend. It has been confirmed that by completely removing the source of infection in the root canal system and eliminating the chemical stimulation of periapical inflammatory mediators on nerve endings, the pain transmission pathway can be effectively blocked and oral physiological homeostasis can be reconstructed. Thus, the cycle of masticatory avoidance and functional disuse caused by toothache can be interrupted[28, 29]. However, itIt cannot be ignored that 28.17% of the patients continue to anchor in the moderate to severe burden

range, and 5.55% of the patients have worsening symptoms. This suggests that simple biological debridement does not equal simultaneous resolution of symptom burden.

The root cause may lie in differences between primary and secondary hyperalgesia induced by long-term chronic inflammation before surgery, as well as individual differences in central sensitization mechanisms. Another potential root cause is unrecognized pathological factors such as occlusal trauma, residual root canals, and periodontal synergistic destruction, which lead to irreversible functional remodeling of the pain regulation system in some patients[30, 31]. The continuous presence of bacterial biofilms after treatment failure or in refractory pulp disease leads to periapical tissue destruction and nerve sensitization triggered by the release of inflammatory mediators.

At the same time, such patients are often accompanied by significant dental anxiety, catastrophic pain cognition, and limited social support and financial capacity[32], which drive their repeated willingness to seek medical treatment. The proportion of the worsening group is relatively small, but this group reflects severe inflammatory reactions during the transition from acute pulpitis to periapical periodontitis, or treatment complications such as instrument separation and chemical periapical periodontitis, which cause sudden pain aggravation and an abrupt decline in quality of life.e. The proportion of the improvement group was second only to that of the continuous low-burden group. This proves that modern endodontic diagnosis and treatment technology can effectively block disease progression through thorough debridement and tight obturation. Furthermore, the improvement in patients' self-efficacy and oral hygiene maintenance behaviors leads to a significant reduction in most patients' symptom burden over time[33, 34]. This finding emphasizes that clinical decision-making should go beyond traditional cross-sectional assessment, and instead focus on early identification of risk trajectories and individualized intervention to block transition to a high-burden state.

The results of this study showed that compared with the continuous low-burden group, the risk of oral frailty increased among pulpitis patients in the continuous severe burden group (OR = 14.614), continuous moderate burden group (OR = 4.043), symptom deterioration group (OR = 7.523) and symptom improvement group (OR = 3.52) (all $P < 0.05$). These results suggest that persistent high levels and dynamic deterioration of pulpitis symptom burden can significantly increase patients' risk of oral frailty. This association is independent of single disease severity, and shows cumulative and trajectory-dependent characteristics. The underlying mechanism is that long-term or progressive pulpitis directly limits patients' oral masticatory ability and nutrient intake efficiePersistently occurring pain and masticatory dysfunction lead to muscle loss and a decline in physical performance[35, 36]. Meanwhile, low-grade systemic inflammation triggered by chronic inflammation can accelerate skeletal muscle wasting and immune dysfunction.

Patients in the severe or worsening symptom groups are more likely to develop avoidant eating due to long-term pain and experience impaired oral health-related quality of life. This in turn reduces their social engagement and physical exercise, forming a vicious cycle of activity limitation and physiological function degradation[37, 38].

In addition, a sustained high burden of dental pain is often accompanied by higher levels of dental anxiety and delayed treatment. This leaves oral problems unresolved in a timely manner, further reducing oral motor function and self-care ability[39].

Even after symptoms subside from their peak, cumulative functional impairment and altered behavioral patterns in the improved symptom group still leave the risk of oral health burden significantly higher than that in the group with

a consistently low burden. This reflects that the impact of symptom burden trajectories on oral frailty has a lagged effect and path dependence, which cannot be completely reversed by short-term symptom relief[40].

In clinical practice, attention should be paid to early screening and dynamic monitoring of oral frailty risk in patients with pulpitis, especially those with a high symptom burden trajectory. Equal priority should be given to functional assessment and symptom management.Attention should be paid to multidisciplinary collaborative intervention to block the pathological chain leading from chronic oral diseases to general functional decline.

## Conclusion

Symptom burden and oral frailty in patients with pulpitis improved significantly after root canal treatment, but significant heterogeneity remained across the study population. Latent transition analysis identified 5 distinct trajectories: the persistently low-burden group accounted for the largest proportion, while the persistently moderate-to-severe burden group and the symptom-worsening group, despite their small proportions, faced a very high risk of oral frailty.

Compared with the persistently low burden group, the persistently severe burden group had the highest risk of oral frailty, followed by the symptom-worsening group and the persistently moderate burden group. Even the symptom improvement group had a significantly higher risk than the persistently low burden group.

In clinical practice, monitoring of symptom burden trajectories should be integrated into the management of high-risk populations, rather than being limited to single efficacy evaluation. Through early identification and prevention of progression from high symptom burden to oral frailty, coordinated maintenance of oral and overall bodily function can be achieved.

## Declarations

**Ethics approval:**

This study was conducted in accordance with the Declaration of Helsinki and the ethical guidelines for biomedical research involving human subjects in China. Ethical approval was granted by the Medical Ethics Committee of the School & Hospital of Stomatology, Wenzhou Medical University (approval No. Wenzhou Medical University Dental Medicine Review No. 067, 2026, 2nd Edition; acceptance number: 260810085511).

**Consent to participate:**

Written informed consent was obtained from all participants before enrolment. Participants were informed of the study objectives, procedures, and their right to withdraw at any time without affecting their clinical care.

**Consent for publication:**

Not Applicable.

# Competing interests:

The authors have no relevant financial or non-financial interests to disclose.

# Note

** indicates P < 0.001 and * indicates P < 0.01


# Funding:

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.


# Author Contribution

Liping Hu：Conceptualization；Data curation；Formal analysis；Methodology；Software；Writing – original draftYao Jin：Data curation；Investigation；Methodology；Writing – review & editingHaibin Bai：Investigation；Resources；Project administration；Writing – review & editingQiaoqiao Liu：Conceptualization；Supervision；Funding acquisition；Writing – review & editing


# Acknowledgements:

Not applicable.


# Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

## References

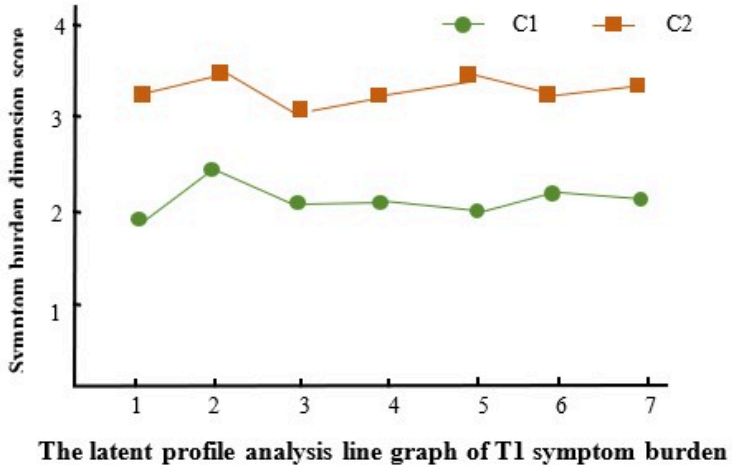

1. Slade GD, Spencer AJ. Development and evaluation of the Oral Health Impact Profile[J]. Community Dent Health. 1994;11(1):3–11.
2. Dibello V, Zupo R, Sardone R, et al. Oral frailty and its determinants in older age: a systematic review. lancet Healthy Longev. 2021;2(8):e507–20.
3. de Sire A, Ferrillo M, Lippi L, et al. Sarcopenic Dysphagia, Malnutrition, and Oral Frailty in Elderly: A Comprehensive Review[J]. Nutrients. 2021;14(5):982.
4. Hanan SA, Cohen-Carneiro F, Herkrath FJ, et al. Validation of the brazilian version of the oral health impact profile - Aesthetic questionnaire[J]. Braz Dent J. 2021;33(1):77–86.
5. Karrar RN, Craig SG, Duncan HF, et al. Clinical validation of a proposed diagnostic classification for pulpitis[J]. Int Endod J. 2025;58(8):1158–71.
6. Yong D, Cathro P. Conservative pulp therapy in the management of reversible and irreversible pulpitis[J]. Australian Dent J Australian Dentistry. 2021;66(Suppl 1):S4–14.
7. Huang H, Okamoto M, Watanabe M et al. Development of Rat Caries-Induced Pulpitis Model for Vital Pulp Therapy[J]. J Dent Res, 2023102(5): 574–82.
8. Donnermeyer D, Dammaschke T, Lipski M, et al. Effectiveness of diagnosing pulpitis: A systematic review[J]. Int Endod J. 2023;56(Suppl 3):296–325.

9. Zhang L, Lin C, Chen Z, et al. Expert consensus on pulpotomy in the management of mature permanent teeth with pulpitis[J]. Int J J oral Sci. 2020;17(1):4.
10. Wang B, Li W, Huang W, et al. Multiple cell death modalities and immune response in pulpitis[J]. Int Endod J. 2025;58(1):111–27.
11. Wei X, Ran S, Yan X, et al. Pyroptosis in Pulpitis[J]. J Inflamm Res. 2020;18:5867–79.
12. Cohen S, Janicq-Deverts D, Miller GE. Psychological stress and disease[J]. JAMA. 2007;298(14):1685–7.
13. Decker AM, Kapila YL, Wang H. The psychobiological links between chronic stress-related diseases. Periodontol 2000. 2021;87(1):94–106. (in Chinese).
14. Nylund KL, Asparouhov T, Muthen BO. Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study[J]. Struct Equation Model Multidisciplinary J. 2007;14(4):535–69.
15. Faul F, Erdfelder E, Lang A, et al. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences[J]. Behav Res Methods. 2007;39(2):175–91.
16. Wei-ni XIN. LING Jun-chi. A validation study on oral health impact scale [J]. Chin J Stomatology. 2006;41(4):4. (in Chinese).
17. Chen Zong-mei, Ying T, Yuan-jun LIANG, et al. Chinesization and reliability and validity test of Oral frailty screening scale for the elderly [J]. Nurs Res. 2023;37(21):3808–12. (in Chinese with English abstract).
18. Taha NA, Abuzaid AM, Khader YS. A Randomized Controlled Clinical Trial of Pulpotomy versus Root Canal Therapy in Mature Teeth with Irreversible Pulpitis: Outcome, Quality of Life, and Patients' Satisfaction[J]. J Endod. 2023;49(6):624–31.
19. Anagha CS, Koshy M, Varghese R, et al. Comparison of postoperative pain following single-visit and two-visit root canal therapy in controlled diabetic patients with irreversible pulpitis: A randomized control trial[J]. J conservative dentistry: JCD. 2021;25(4):392–7.
20. Sarı M, Yılmaz K, Özyürek T. Postoperative pain after total pulpotomy and root canal treatment in mature molars according to the new and traditional classifications of pulpitis: a prospective, randomized controlled trial[J]. BMC Oral Health. 2024;24(1):1075. 10.1186/s12903-024-04836-z.
21. Singh S, Bolla N. Reevaluating irreversible pulpitis: Is root canal treatment always necessary? [J]. J conservative dentistry endodontics. 2020;28(11):1067–8.
22. Dibello V, Lozupone M, Manfredini D et al. Oral frailty and neurodegeneration in Alzheimer's disease[J]. Neural regeneration Res, 2021(11): 2149–53.
23. Yang C, Gao Y, An R, et al. Oral frailty: A concept analysis[J]. J Adv Nurs. 2024;80(8):3134–45.
24. Tomson PL, Vilela Bastos J, Jacimovic J, et al. Effectiveness of pulpotomy compared with root canal treatment in managing non-traumatic pulpitis associated with spontaneous pain: A systematic review and meta-analysis[J]. Int Endod J. 2023;56(Suppl 3):355–69.
25. Patel N, Khan I, Jarad F, et al. The short-term postoperative pain and impact upon quality of life of pulpotomy and root canal treatment, in teeth with symptoms of irreversible pulpitis: A randomized controlled clinical trial[J]. Int Endod J. 2020;58(1):55–70.
26. Shen M, Yan Y. Clinical Impact of Root Canal Treatment Combined with Eugenol Cement on Acute Pulpitis and its Influence on Inflammatory Factor Levels[J]. Altern Ther Health Med. 2024;30(9):426–31.
27. Manteca-Fernandez L, Meniz-Garcia C, Fernandez-Caliz F, et al. Influence of Premedication and Dental Anxiety on Anesthetic Efficacy in Patients Undergoing Root Canal for Symptomatic Irreversible Pulpitis in Upper and

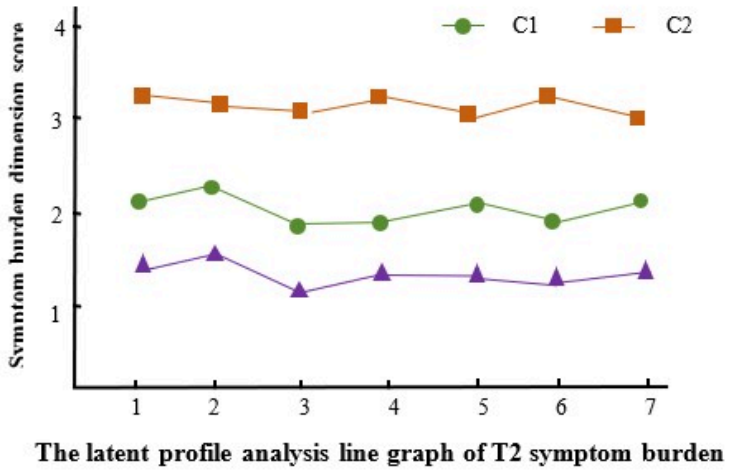
Lower Molars: A Comparative Study of Articaine and Bupivacaine[J]. J Dent. 2020;13(5):199.

28. El Karim IA, Duncan HF, Fouad AF, et al. Effectiveness of full Pulpotomy compared with Root canal treatment in managing teeth with signs and symptOms indicative of irreversible pulpitis: a protocol for prospectiVE meta-analysis of individual participant data of linked randomised clinical trials (PROVE)[J]. Trials. 2023;24(1):807.
29. SarıM YılmazK, Ozyurek T. Postoperative pain after total pulpotomy and root canal treatment in mature conditions according to the new and traditional classifications of pulpitis: a prospective, randomized controlled trial[J]. BMC Oral Health. 2024;24(1):1075.
30. Kumar G, Sangwan P, Tewari S. Effect of premedication on postoperative pain after root canal therapy in patients with irreversible pulpitis: a systematic review and meta-analysis[J]. J Dent Anesth pain Med. 2021;21(5):397–411.
31. Razumova S, Brago A, Serebrov D et al. The Application of Nano Silver Argitos as a Final Root Canal Irrigation for the Treatment of Pulpitis and Apical In Vitro Study of Periodontitis. [J]. Nanomaterials (Basel, Switzerland), 2021,12(2):248.
32. Shirobe M, Watanabe Y, Tanaka T, et al. Effect of an Oral Frailty Measures Program on Community-Dwelling Elderly People: A Cluster-Randomized Controlled Trial[J]. Gerontology. 2021;68(4):377–86.
33. Leong DJX, de Souza NN, Sultana R, Yap AU. Outcomes of endodontically treated cracked teeth: a systematic review and meta-analysis[J]. Clin Oral Investig. 2020;24(1):465–73. 10.1007/s00784-019-03139-w.
34. Suneelkumar C, Subha A, Gogala D. Effect of Preoperative Corticosteroids in Patients with Symptomatic Pulpitis on Postoperative Pain after Single-visit Root Canal Treatment: A Systematic Review and Meta-analysis of root canal treatment [J]. J Endod. 2018;44(9):1347–54.
35. Ke J, Cai Q, Zhang C, et al. Analysis of the Efficacy and Safety of Pulpitis Treated with Different Root Canal Flushing Fluids Based on VAS and Temporomandibular Joint Function[J]. Volume 202. Contrast media & molecular imaging; 2021. p. 1470389.
36. Lu Y, Liu Z, Huang J, et al. Therapeutic effect of one-time root canal treatment for irreversible pulpitis[J]. J Int Med Res. 2020;48(2):1219678839.
37. Nagatani M, Tanaka T, Son B, et al. Oral frailty as a risk factor for mild cognitive impairment in community-dwelling older adults: Kashiwa study[J]. Exp Gerontol. 2023;172:112075.
38. Dibello V, Lobbezoo F, Lozupone M et al. Oral frailty indicators to target major adverse health-related outcomes in older age: GeroScience, 2023,45(2):663–706.
39. Tanaka T, Hirano H, Ikebe K, et al. Oral frailty five-item checklist to predict adverse health outcomes in community-dwelling older adults: A Kashiwa cohort study[J]. Geriatr Gerontol Int. 2023;23(9):651–9.
40. Wang H, Ji X, Yan H et al. Development and validation of a risk-predicting model for oral frailty in older patients with chronic pulpitis[J]. BMC Oral Health, 2026:10–1186.

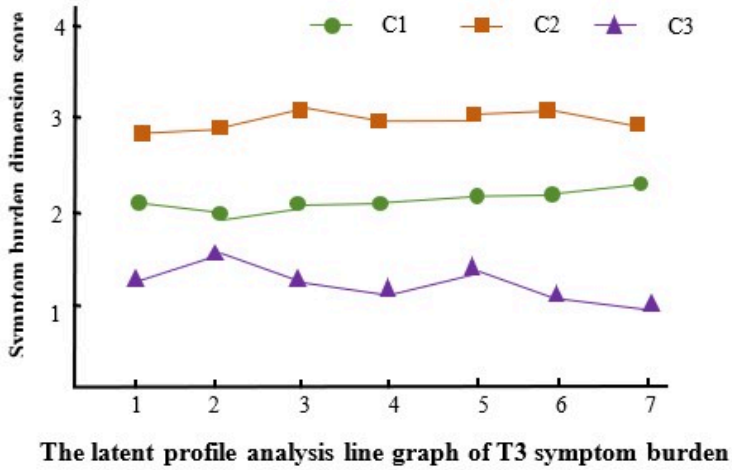
## Figures



The latent profile analysis line graph of T1 symptom burden



The latent profile analysis line graph of T2 symptom burden



The latent profile analysis line graph of T3 symptom burden

**Figure 1**

Latent profile analysis line graph of symptom burden during root canal treatment for patients with pulpitis

## Supplementary Files

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