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Use of teeth as a compensatory strategy in unilateral upper limb amputation: a global descriptive case study

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ABSTRACT

Introduction: Individuals with upper limb amputation or limb difference commonly adopt compensatory strategies to perform activities of daily living (ADLs). One under-recognised strategy is the use of teeth as functional tools, which increases oral health risks. The prevalence, nature, and impact of compensatory teeth use in this population are poorly described in the literature.

Methods: A global descriptive case study was conducted using an online e-survey of individuals of any age with unilateral upper limb amputation or limb difference. Data included limb difference characteristics, use of teeth for ADLs, dental injury, oral hygiene challenges, and oral health advice. Quantitative data were analysed descriptively and using chi-square testing, and free-text responses were analysed thematically.

Results: One hundred and thirty-one responses were analysed (77% adults, 23% children). Most adults (86.1%) and over half of children (58.1%) reported using their teeth for ADLs. Adults were significantly more likely than children to report tooth damage related to compensatory teeth use (42.6% vs 9.7%, $p < .001$). Almost all participants reported never receiving limb-difference-specific oral health advice.

Conclusion: Compensatory tooth use is common and associated with substantial oral health risk. Rehabilitation professionals should proactively address prevention, hygiene adaptation, and patient education for this underserved population.

➤ IMPLICATIONS FOR REHABILITATION

1. The implications for rehabilitation of individuals with upper limb loss (LL) or limb difference (LD) are substantial and critical due to the currently overlooked area of teeth and oral health care.
2. Nearly all participants had never received oral health advice specific to their limb difference, showing a clear patient education gap.
3. Findings support the integration of dental professionals into multidisciplinary rehabilitation teams to provide tailored advice and preventive strategies.
4. Development of formal guidelines and professional training for upper limb rehabilitation professionals is recommended to recognise and advise against risky compensatory strategies.

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Introduction

Limb amputation affects millions of individuals worldwide, with an estimated 57.7 million people living with limb loss or limb difference globally [1–3]. Limb loss refers to the permanent removal of a limb after birth, whereas limb difference describes congenital variation in limb formation [4]. Major causes of acquired limb loss include vascular disease, trauma, and tumour-related surgery, while congenital limb difference arises from disruption to foetal limb development due to genetic, vascular, or environmental factors [5–8]. As global populations age and chronic disease prevalence increases, the number of individuals living with limb amputation is expected to rise, highlighting the need for comprehensive rehabilitation and long-term health support [2,6].

For individuals with unilateral upper limb amputation, the impact on physical function and independence is immediate. Many experience difficulty performing ADLs such as eating, dressing, grooming, and household tasks [9]. To maintain independence, individuals commonly adopt compensatory strategies,

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relying heavily on the intact limb, trunk, or shoulder. Such strategies are associated with overuse injuries and chronic musculoskeletal pain affecting the contralateral arm, neck, and back [10–13].

One under-recognised area of compensatory overuse involves the mouth. Individuals with upper limb amputation may use their teeth as a functional "third hand" to stabilise, hold, or manipulate objects. This behaviour has evolutionary precedent; archaeological evidence suggests that Neanderthals used their teeth as tools in a similar manner [14]. Very few contemporary reports describe teeth use among individuals with limb absence or difference.

Using teeth for non-masticatory activities exposes them to parafunctional forces [15–18]. While mild parafunctional activity may be tolerated, repeated or excessive loading can result in tooth wear, fractures, periodontal breakdown, temporomandibular joint dysfunction, and oral pain [17–19]. The American Dental Association estimates that approximately 10% of adults experience chipped teeth during their lifetime [16], suggesting that individuals who routinely use their teeth as tools may be at substantially higher risk.

Maintaining oral hygiene may also be challenging for individuals with upper limb differences [20]. Brushing and flossing require grip strength, dexterity, and sustained use of the intact limb, which may already be affected by overuse symptoms [16,21]. Previous research also suggests that people with disabilities may give lower priority to oral healthcare and may be reluctant to access dental services, particularly when disability-related healthcare demands dominate [22].

Despite these plausible risks, little is known about how frequently individuals with upper limb amputation use their teeth for ADLs, the types of tasks involved, or the oral health consequences. This descriptive case study aims to address this gap.

Study aim

To describe the prevalence and nature of compensatory teeth use in individuals with unilateral upper limb amputation or limb difference, associated oral health impacts, and receipt of oral health advice.

Methods

Study design

A mixed-methods descriptive case study design was employed, using a global online e-survey.

Participants and recruitment

Individuals of any age with unilateral upper limb amputation or limb difference were eligible to participate. English-speaking adults aged ≥18 years, young people aged 16–17 years able to consent independently, and children aged ≤15 years with parental consent were included. Both congenital limb difference and acquired limb loss were eligible.

Participants were recruited internationally via limb loss and limb difference social media groups, advocacy organisations, and charities. Recruitment was conducted exclusively online. The total number of upper limb amputees is unknown; estimates suggest 55,000–60,000 [23] in England and ~250,000 in the United States [24]. Using the upper estimate (250,000), a 95% confidence interval, and a 5% margin of error, the required sample size was 384. Given an average online survey response rate of 44.1%, the target response was 169 participants.

Data collection

The survey was hosted on Qualtrics and collected information on participant demographics, limb difference characteristics, prosthesis use, use of teeth for ADLs, types of tasks performed using teeth, dental injury, oral hygiene challenges, and receipt of oral health advice. Free-text responses allowed participants to elaborate on experiences and concerns. The survey was distributed in written English only, piloted on a subset of upper-limb amputees and revised. Survey questions are provided in Table 1.

Table 1. Survey questions.

e-Survey questions
1. Is your/or your child's limb difference congenital (you/or they were born with the limb difference) or was it acquired (you/or they have lost fingers/hand/arm since birth)?
o Yes
o No
2. At what age did the **acquired** limb difference happen (in years, e.g. aged 25): *free text*
3. What best describes your/or your child's limb difference?
o Partial finger or digit
o Partial hand
o Fullhand
o Between hand and elbow
o At the elbow
o Between elbow and shoulder
o Full arm
o Other
4. Please give your/or your child's age in years: *free text*
5. Please give your/or your child's gender?
o Male
o Female
o Non-binary/third gender
o Prefer not to say
6. Please give your/or your child's ethnicity - these are based on the National Institute of health (NIH) racial and ethnic categories (2015):
o American Indian or Alaska Native (A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment)
o Asian (A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent, including Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam)
o Black or African American (A person having origins in any of the black racial groups of Africa. Terms such as "Haitian" can be used in addition to "Black or African American.")
o Hispanic or Latino (A person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin, regardless of race. The term "Spanish origin" can be used in addition to "Hispanic or Latino.")
o Native Hawaiian or Other Pacific Islander (A person having origins in any of the original peoples of Hawaii, Guam, Samoa, of other Pacific Islands)
o White (A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.)
7. Which country do you live in (e.g. UK/USA): *free text*
8. Please give your occupation (for children, please tick 'in school' or other answer)In School or Education
o Retired
o Unemployed
o Full time
o Part time
o Please give your actual occupation:
o Other:
9. Do you/or your child use your teeth to undertake everyday activities like opening packets, tying shoelaces or simply for holding things?
o Yes
o No
10. What kinds of things do you/or your child do with your teeth? *free text*
11. Do you think you/or your child use your teeth more than other people because of your limb difference?
o No
o Yes
12. Have you/or your child ever chipped your teeth, or caused any damage to your teeth or mouth because you are using your teeth for daily tasks?
o Yes
o No
13. Have you/or your child received any information as a person with limb difference in regard to how to look after your teeth?
o No
o Yes
14. Do you/or your child feel able to brush your teeth properly for two minutes?
o Yes
o No
15. Is there anything you/or your child would like to add regarding using your teeth/cleaning your teeth? This can be anything you like: *free text*
16. Do you/your child wear a prosthesis?
o No
o Yes
17. How many days a week do you/your child wear the prosthesis? *free text*
18. Have you/your child worn your prosthesis since birth?
o No—If no how long have you worn it for?
o Yes
19. Were you/your child shown how to use the prosthesis?
o No
o Yes
20. Were you/your child given any advice on using a prosthesis to prevent wear and tear on the unaffected arm? If yes, please describe the advice given below.
o No
o Yes – *free text*

Ethics

Ethical approval was granted by the Kent and Medway Medical School Research Ethics Advisory Group (REAG2410021-110). Implied consent was obtained electronically. For child participants, parental consent and assent procedures followed NSPCC guidance [25].

Data analysis

Quantitative data were analysed descriptively. Associations between age group (adult vs child) and key outcomes were assessed using Pearson's chi-square test with Cramer's V. Free-text responses were analysed thematically.

Results

From 167 survey responses, 131 complete responses were analysed after removing incomplete answers. 77% ($n=101$) were adults and 23% ($n=30$) were children (<18 years old). Mean(SD) adult age was 42.7(13.2) years and mean(SD) child age was 10.0(5.3) years; 85% ($n=111$) had a congenital (from birth) limb difference and 15% ($n=20$) had an acquired limb loss. The most common limb difference was between hand and elbow. 76.3% ($n=100$) respondents were female, 23.7% ($n=31$) male. 90.0% ($n=118$) were white, 4.6% ($n=6$) Hispanic or Latino, 3.0% ($n=4$) Asian, 1.5% ($n=2$) black and 0.9% ($n=1$) Native American or Alaskan. No responders were from Hawaiian or pacific island backgrounds. Respondents came from Canada, Estonia, France, Italy, Netherlands, Pakistan, Switzerland, with majority from USA (63%, $n=83$), UK (20.6%, $n=27$) and Australia (8.4%, $n=11$).

Using teeth for everyday activities

Participants were asked if they use their teeth for everyday activities like opening packets, tying shoelaces or holding things. 86.1% ($n=87$) adults and 58.1% ($n=18$) children use their teeth for such activities. Four children were aged 0–2 years, so answers were blank, likely due to young age/incomplete teeth. When asked to list examples, 95.4% ($n=125$) reported using their teeth for one or more everyday tasks. Participant answers were thematically grouped (Table 2).

Using teeth more because of limb difference

83.2% ($n=84$) of adults and 60% ($n=18$) of children reported using their teeth more due to their limb difference. There is a significant association between adults and children who use their teeth more (Figure 1) ($p=.007$, Cramer's V .234)), with adults using teeth significantly more, likely due to some children being too young to have teeth or needing parent/carer support.

Chipped or damaged teeth

In adults, 42.6% ($n=43$) reported damaging their teeth as a compensatory mechanism for daily tasks. For children, 9.7% ($n=3$) reported the same. A statistically significant association exists between adults and children who damaged teeth through daily activities (Figure 2) ($p =< .001$, Cramer's V .287)), with adults showing significantly more damage. Acquired amputees had a higher percentage of chipped teeth, but this difference was not statistically significant. Compared to the general population [16], adults with upper limb amputation are 4.26 times (326%) more at risk of teeth damage.

Table 2. List of daily tasks performed using teeth.

Task	% (*n*)
Opening packets, bottles or jars/unpackaging items	70% (91)
Holding objects (door and car keys/bags/toys/tools)	20% (27)
Using teeth for assistance (putting on jewellery/tying bows/peeling veg/opening envelopes/untie knots/closing doors/swipe cards)	24% (32)
Dressing/Personal care (pulling up sleeves/braiding hair/doing up buttons/hold clothing/tying shoes/getting dressed/bathroom needs/wetsuit/velcro)	22% (30)
Cleaning and Organisation (folding sheets/opening bathroom items/cleaning cloths/tidying up and carrying things)	10% (15)
Only for eating	3% (4)

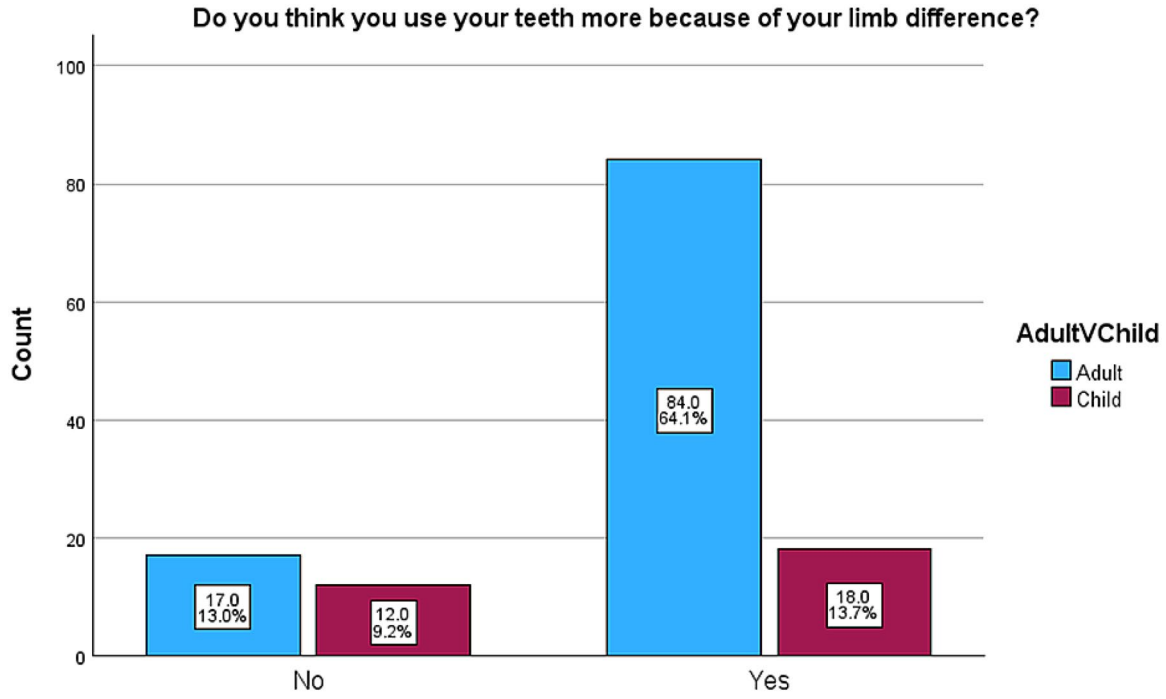

Figure 1. Using teeth due to a limb difference.

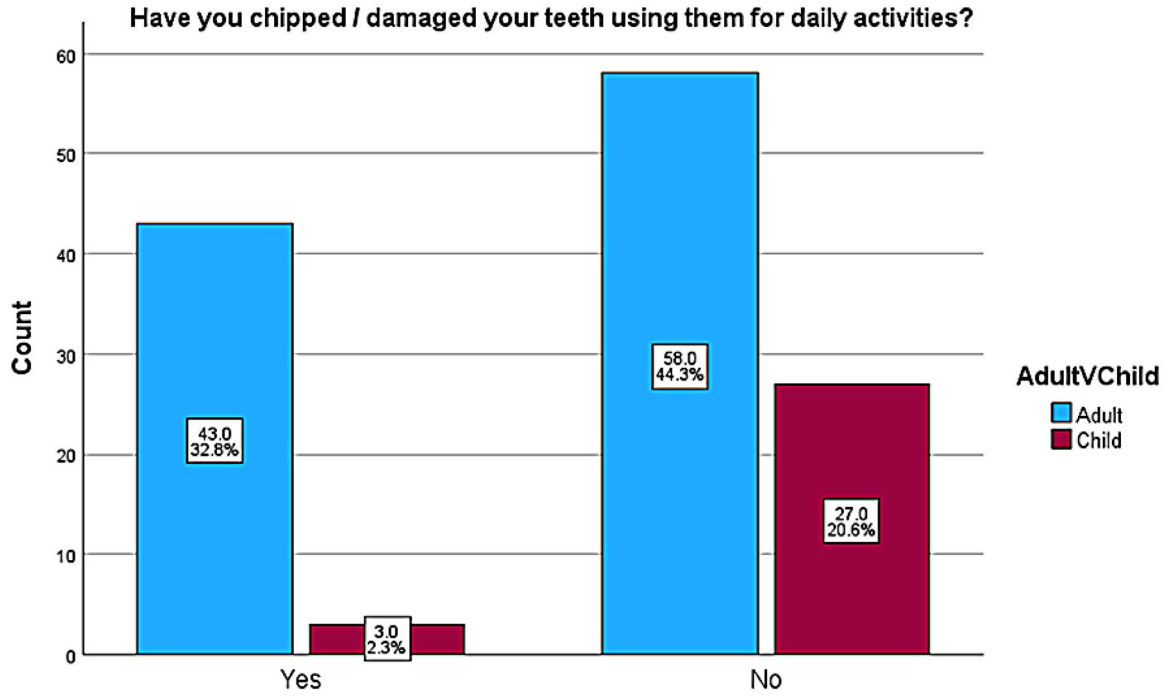

Figure 2. Tooth chips or damage from compensatory teeth use due to limb amputation.

Receipt of information regarding to how to look after your teeth

97.0% ($n = 98$) of adults and 87% ($n = 27$) of children have never received information on dental care as a limb different person. There is no significant difference between adults and children regarding teeth care advice ($p = .106$). Almost all participants have never received oral health care advice.

Able to brush teeth properly for 2 min

93.1% ($n = 94$) of adults and 84% ($n = 26$) of children can brush their teeth for two minutes. There is no significant difference between adults and children in teeth brushing ability ($p = .276$), however many find it difficult due to overuse symptoms in their remaining arm. Respondents reported pain or cramp in their remaining arm when brushing, struggle to apply toothpaste, floss or hold the toothbrush properly and find it difficult to position their arm correctly to brush their teeth. Many mentioned their fillings or gum problems, or that their dentist noted one side of their mouth needs better brushing.

Oral health concerns from using teeth for ADLs (activities of daily living). Participants reported overuse led to sensitivity, grinding, cavities, wear, or damage. They stated their teeth weakened from overuse, causing injury or cracking. They were concerned about soreness or brittleness and had difficulty flossing due to hand limitations and other health conditions. Many reported their dentists had said they must grind their teeth. Others worried about infection risk: "I have health concerns that using my teeth places items in/near my mouth that are not intended to be there" ($Adult_{25}$); "My teeth are chipped and suffer wear similar to bruxism due to overuse." ($Adult_{58}$); "I have had times where my teeth are sore from using them for tasks." ($Adult_{83}$); "I believe using my teeth for activities has weakened them." ($Adult_{84}$); "I have worn my teeth down after using them for so many things" ($Adult_{94}$).

Brushing and flossing

Patients reported difficulty maintaining oral health and using a toothbrush. Many noted that flossing can be more difficult and that only premade flossers are usable, which do not allow for as thorough cleaning around the teeth. One adult expressed difficulty holding floss with their limb-different hand but remained conscientious about dental hygiene. Pain in the arm and struggling to hold a toothbrush for extended periods were also reported by many. Electric toothbrushes were described as heavy and awkward, with the manual brushing motion causing wrist pain, while others use an electric toothbrush with their "normal" hand but wished for accommodations to use it with their limb-different hand. Shoulder and wrist pain due to overuse during flossing was also mentioned. Children reported challenges such as difficulty using a flossing string, reliance on feet for assistance, and difficulty applying toothpaste.

Describing non-dental tasks performed with teeth

Respondents described using their teeth for various daily tasks such as opening packages, holding items, and pulling on clothes. Common activities included peeling vegetables, tying shoelaces, and opening doors. Many expressed concerns about overusing their teeth in these ways. Some acknowledged using their teeth despite being aware of the risks involved. Most said they use their teeth to open food packages, hold items, and pull clothes about. Others mentioned opening cans and bottles and holding hair in their mouth while braiding. Some reported folding and hanging clothes, twisting small jars or pill vials, putting on or removing rings and watches, and unbuttoning shorts. One noted their child's frequent use of teeth to open marker pens, while other parents mentioned them opening cheese strings and yoghurt pouches. Many respondents reflected on the automatic nature of these habits and the infection risk of putting things (e.g., car keys) in the mouth.

Dental visits and professional advice

Very few respondents mentioned visiting the dentist or dental hygienists regularly, though some dental concerns had been addressed during these visits. A few reported receiving professional advice, while others expressed concern about the cost of dental care. One respondent shared that although their damage wasn't visible, their dentist suggested they must be grinding their teeth at night, but they now believe the dentist was seeing the effects of overusing their teeth. Another said they attend dental hygiene and dentist appointments regularly and brush extensively. Some mentioned being advised by health professionals to use their teeth for tasks despite the damage incurred, noting that this practice is sometimes viewed as legitimate by some healthcare providers but can lead to additional issues such as

exposure to germs, neck injuries, and temporomandibular joint damage or difficulty. "My dentist said I need to brush better on the left side of my mouth." ($Adult_{28}$); "I have been encouraged by health to professionals to use my teeth for tasks despite the damage I have incurred by doing so, using teeth is seen as a legitimate strategy for many treating health professionals and also exposes the person to other issues like germs in the mouth, injured neck, TMI damage/difficulty" ($Adult_{96}$).

Prosthesis wear

From the participants who answered this question ($n = 88$), 27% ($n = 20/74$) congenital amputees, and 35.7% ($n = 5/14$) of acquired amputees wore a prosthesis. There was no statistically significant difference in prosthesis use between congenital and acquired respondents ($p = .528$). There was no meaningful age-group difference in prosthesis use. Overall, of prosthesis wearers, 52% ($n = 13/25$) have chipped their teeth, compared to 31.7% ($n = 20/63$) non-prosthesis wearers. In this dataset, wearing a prosthesis is not protective of the teeth in avoiding chips or damage. If anything, prosthesis wearers had a higher rate of chipped teeth, but the association was not statistically significant ($p = .09$, Cramer's V .189). Of the prosthesis wearers, 80% ($n = 4/5$) of acquired amputees had chipped their teeth using them for daily activities, compared to 45% ($n = 9/20$) of congenital amputees ($p = .30$, Cramer's V 0.26).

Discussion

This study highlights that teeth use, as a compensatory strategy, is very common among individuals with upper limb amputation and is associated with increased dental and oral health risks. This is a significant, yet under-recognised, area of concern in the daily lives of these individuals: the compensatory use of teeth as functional tools. Findings demonstrate that the majority of individuals with upper limb amputation (86.1% of adults, 58.1% of children) routinely use their teeth to assist with ADLs, such as opening packets and bottles, dressing or holding objects. Consequently, over 40% of adults reported sustaining dental damage from such practises, yet nearly all individuals with upper limb amputation reported having never received any oral health guidance tailored to their limb difference. The participants in this study do not routinely initiate conversations regarding their teeth, in keeping with evidence that people with disabilities are reluctant to seek support in regard to oral health [26]. The most frequently mentioned activities were opening/unpackaging items (53.3%), using teeth for assistance, e.g., tying knots, untangling things (23.7%); and holding objects, with 83.2% of adults and 60.0% of children believing they use their teeth more because of their limb difference. Although this study did not compare directly to a group with no limb difference, it is reasonable to suggest that those with upper limb amputation most likely use their teeth more often than able-bodied individuals. It is also of note that there was a statistically significant difference between adults and children ($p < .007$) in terms of using their teeth due to their limb amputation. This is likely because adults had a greater load of daily tasks, hence using their teeth more to complete these and because 4 of the child participants were aged between 0 and 2, many with no or incomplete sets of teeth. There was a high proportion of adult respondents (42.6%) who reported having chipped or damaged their teeth from using them for daily tasks. This is much greater than the American Dental Association's estimate that almost 10% of the whole adult population have sustained chipped teeth in their lifetime [16], putting adult individuals with upper limb amputation at 4.26 times more risk of developing chips and damage to their teeth than the rest of the population. The proportion of adult respondents who reported having chipped or damaged teeth (42.6%) was also significantly higher than children (9.7%, $p < .001$). This suggests that there is increasing risk as a person ages, from the cumulative effect of using teeth for everyday tasks over many years. Overall, there is no statistically significant difference in prosthesis use by congenital versus acquired amputees; however, acquired amputees had a higher rate of chipped teeth from using them for everyday activities. This study suggests that prosthesis use is not protective for the prevention of chipped or damaged teeth. These findings may be suggestive of longer-term adaptation patterns in congenital amputees, putting them at lower risk of teeth damage than acquired amputees, regardless of prosthesis use. Moreover, this finding may be indicative of the limitations of conventional prosthetic hands.

Furthermore, in this study many participants struggled to maintain adequate oral hygiene due to their struggles with limb loss and overuse symptoms causing pain and discomfort, in keeping with previous findings [21]. In addition to this, the majority of adults (97%) and children (87%) have never received specific information on how to take care of their teeth in relation to their limb difference. There was no statistical significance between adults and children ($p = .106$) suggesting that the lack of advice is a systemic issue that affects all ages, again congruent with previous findings [21]. Despite the obvious challenges many respondents face in achieving adequate dental health, many reported using effective adaptive methods such as floss picks over traditional floss and highlighted the importance of electric toothbrushes to help relieve pressure on their overused contralateral arm. This demonstrates that adaptive methods can be effective and lead to satisfactory results when it comes to dental care. The results necessitate the requirement for integrated, interdisciplinary approaches to care, that explicitly consider the oral health of individuals with upper limb amputation. Specifically, this study supports the development of targeted oral health education, preventative strategies, development of formal clinical guidelines within amputee rehabilitation pathways. Raising awareness among clinicians and individuals living with limb amputation, as well as exploring and implementing alternative strategies to ADLs, may significantly improve oral health outcomes and overall quality of life in this underserved group.

Limitations

The main limitation of the study was the e-survey response rate. Predicted sample size was 169, and the initial number of responses almost reached this target with 167 submissions (44.1% response rate). However, incomplete responses reduced the final analysed sample to 131 (34% response rate). The sample size calculation was based on widely varying prevalence estimates, making the target number (169) inherently approximate rather than fixed. Since compensatory teeth use and related oral health impacts in upper limb amputees lack well-established prevalence data, this figure serves as a guideline, not a strict threshold for power. The achieved sample offers valuable insight but results in an underpowered study. Thus, sample size should be interpreted cautiously, reflecting prevalence variability and the exploratory nature of the research rather than as an absolute measure of statistical validity. A further limitation is the self-determined nature of the survey and requiring respondents to recall information, and therefore maybe subject to recall bias.

Recommendations

The implications for rehabilitation are substantial and critical due to the overlooked area of teeth use and oral health care for individuals with upper-limb amputation. Recommendations include:

- Oral health should be formally recognised in functional rehabilitation for individuals with upper limb difference and embedded into care pathways
- Integration of dental professionals into multidisciplinary teams to provide tailored advice and preventative strategies
- Development of clinical guidelines on oral health risk management in upper limb amputees
- Development of assessment tools to identify teeth use in daily task
- Training for rehabilitation professionals to recognise and advise against risky compensatory strategies
- Proactively exploring alternative strategies such as adaptive tools, environmental modifications, and one-handed techniques
- Develop patient-facing materials to raise awareness of oral health risks, encourage routine dental care, and provide guidance on safe task completion.

Summary

This research establishes that teeth are widely used as functional tools by individuals with upper limb amputation, especially for tasks related to activities of daily living. This behaviour poses significant dental

risks (e.g., tooth damage, wear and tear, and infection risk), which are not currently addressed in standard rehabilitation care in the UK. This represents a serious and unaddressed intersection between functional rehabilitation and oral health in upper limb amputees. Addressing it will require a shift in rehabilitation practice towards an interdisciplinary model that prioritises oral health care support and preventative care as an integral component of upper limb amputee rehabilitation.

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Ethics approval

Kent and Medway Medical School Research Ethics Advisory Group approval, registration number: **REAG2410021-110**

Author contributions

CRediT: **Claire Parkin**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing; **Lewis Courtnage**: Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

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Use of AI

Paperpal by Editage AI was used to assist with reducing wordage only.

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