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Published online: 09 Aug 2022.

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Pain, discomfort, and functional impairment after extraction of primary teeth in children with palatally displaced canines – a randomized control trial comparing extraction of the primary canine versus extraction of the primary canine and the primary first molar

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ABSTRACT

Objective: To assess pain, discomfort, and functional impairment in children experiencing extraction of primary canine or primary canine and primary first molar as an interceptive treatment for palatally displaced permanent canines.

Material and methods: Twenty-eight children, aged 9.5–14 years with displaced permanent maxillary canines were randomly assigned for extraction of the primary canine only or the primary canine and the primary first molar. Pain and discomfort were rated on visual analogue scales, and influence on daily activities was assessed by a questionnaire that has been previously tested for reliability and validity. Differences between groups were assessed by independent samples *t*-tests, Mann–Whitney *U*-tests or the Fisher's exact test.

Results: Tooth extraction was associated with low levels of pain and discomfort on a group level. Extraction of both the canine and the first molar was associated with significantly more pain and discomfort than was the extraction of the canine only. Extractions were associated with chewing problems among one-third to half of the children, otherwise, few children reported any jaw impairment after extraction.

Conclusion: Primary canines and first molars can be extracted in a way that is associated with relatively low levels of pain and discomfort during and after the procedures. Double extractions induced more pain and discomfort than single extractions, which should be accounted for in the treatment planning.

Introduction

Tooth extractions may be an unpleasant and painful experience for a child [1]; however, very few studies have assessed children's or adolescents' experiences with such treatment. Painful or adverse dental experiences are considered central in the aetiology of dental anxiety, based on findings related to early invasive dental treatment [2]. However, the association is bidirectional, dental anxiety predicts the expectations of pain, pain during treatment, and post-treatment pain [3]. Thus, dental anxiety is important to consider when evaluating pain in the dental setting.

Primary tooth extractions are commonly performed as part of interceptive orthodontic treatment, to improve the eruption path of palatally displaced canine teeth [4]. Ectopic eruption and impaction of the maxillary canine occur in one to three percent of children [5–7]. Left untreated, problems such as dispositioning and retention of the ectopic tooth, external root resorption, migration of neighbouring teeth, dentigerous cyst formation and referred pain may occur [8]. Extraction of the primary maxillary canine (single extraction) is the most common treatment for preventing ectopic

eruption and impaction of PDCs, and the effect has been documented in many studies [9]. Recently, extraction of both the primary canine and the primary first molar (double extraction) has been suggested as an alternative treatment method [10,11]. Double extraction has been reported to have a better effect on PDC eruption than single extraction [10,11], but the results are controversial [12]. To our knowledge, no study has reported patient perceptions of discomfort and pain or effect on daily activities and oral functions of these treatment alternatives. The current study had two main objectives: 1) to compare pain, discomfort, and functional impairment in children experiencing single- and double extractions as treatments for PDCs, and 2) to increase knowledge regarding pain, discomfort, and functional impairment associated with primary tooth extraction.

Materials and methods

Subjects and study design

The children in this study were recruited between 2013 and 2018 among patients referred for orthodontic treatment at a

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public dental specialist clinic in Tromsø, Norway or in a private orthodontic clinic in Bryne, Norway. The inclusion criteria were: (1) chronologic age between 9.5 and 14 years; (2) dental age of 9.5–10.5 years [13]; (3) the presence of both primary maxillary canines and primary maxillary first molars; (4) palatal position of the canine verified by two periapical radiographs; and (5) eruption of the maxillary canine in sectors III and IV according to Lindauer et al. [14] or the maxillary canine in sector II with an angle between the long axis of the canine and the facial midline (Angle C) of at least 25 degrees assessed on panorama radiographs, according to Hadler-Olsen et al. [15]. The exclusion criteria were: (1) agenesis of the maxillary lateral incisor; (2) previous orthodontic treatment; (3) any disease not allowing local anaesthesia or extraction; or (4) the presence of craniofacial syndromes, cleft lip or cleft palate, odontomas or cysts. The treating orthodontist informed patients who fulfilled the inclusion criteria and their legal guardians about the study and invited them to participate.

The outcomes of the present study were secondary outcomes of a larger study, and the sample size was calculated based on the primary outcome measures as previously described [12]. In brief, the sample size was calculated based on the reported mean change in canine angulation after double and single extraction of canines. The sample size was calculated using each PDC as a unit. In the current study, we have done analyses on the subject level as the measures assessed are subjective, and self-reported, whereas those assessed for the primary objectives were based on radiographic and clinical measures.

Thirty-two children were invited to participate in the study, and all accepted the invitaton. The four children who were included in the clinic in Bryne did not receive the questionnaires about discomfort and pain related to the extractions, and they were therefore excluded from the current study. The study thereby encompassed 28 children of whom 15 had bilateral PDCs. In bilateral cases, only the first round of extractions, in one quadrant, was included in the study due to the subjective nature of the outcome measures and the possibility that experiences from the first round of extractions may affect the experience of the second round of extractions. The flow of patients is illustrated in Figure 1. For children with bilateral PDC, extraction on the contralateral side was performed at least one month after the first round of extraction. The study was designed as a parallel assignment, randomised controlled clinical trial with an equal allocation of subjects to either: 1) the double extraction group (DEG) with the extraction of both the primary canine and the primary first molar; or 2) the single extraction group (SEG) with the extraction of the primary canine only. Randomisation was performed prior to the inclusion of patients by the first author of the study using the block randomisation method [16]. Block sizes varied randomly between 2, 4, 6, and 8. Allocation concealment was done by enclosing assignments in sequentially numbered envelopes, using envelopes that had to be torn open. Due to the nature of the intervention, it was impossible to blind the patient, the legal guardian, or the treating orthodontist to the intervention.

The regional ethics committee of Northern Norway approved the study in June 2012 (2012/623/REK Nord). Both the child and a legal guardian gave informed, written consent to participate in the study. We conducted all procedures in accordance with the Declaration of Helsinki. The study is registered on ClinicalTrials.gov (NTC02675036).

Extractions

One orthodontist (S.H.-O.) performed > 85% of the extractions in both the DEG and the SEG, and another orthodontist (J.S.) performed the remaining extractions ($n = 2$ in the DEG and $n = 2$ in the SEG), both following the same extraction procedure. The tell-show-do method [17] was used during anaesthesia and extraction. Before buccal and palatal infiltration anaesthesia with 2% Lidocaine, a topical anaesthetic (18% Benzocaine) was applied at the injection sites. Extraction forceps were used to mobilise and extract the teeth before the extraction wound was tamponed. The canine was extracted before the molar in the DEG. Post-extraction, patients and legal guardians were given postoperative information from the operator performing the extractions and they were recommended to use a nonprescription analgesic at their own discretion. The operators were not blinded to the study aims.

Outcome measures

Outcome measures, pain, discomfort, and impact on daily activities and jaw functions, were assessed by questionnaires that the children answered with the help of a legal guardian. Post-extraction, the children were given one questionnaire to answer on the first evening and one questionnaire to answer one week after the extraction. The children rated the intensity of pain and discomfort on a 100 mm visual analogue scale (VAS), which is a common and well-validated tool for assessing pain among both children and adults [18]. They also answered questions about analgesics consumption and how extractions influenced daily activities and oral functions. These questions have been used in previous studies [19,20], and the validity and reliability of a similar questionnaire have been found to be acceptable [21]. The questionnaire assessing the impact on daily activities and jaw function was originally in Swedish and was translated to Norwegian with the help of the fourth authors, who is Swedish. Due to the strong similarity between Norwegian and Swedish, we did not do validity and reliability testing of the Norwegian version. We categorised the VAS-recordings as follows: 0–4 mm, no pain/discomfort; 5–44 mm, mild pain/discomfort; 45–74 mm, moderate pain/discomfort and 75–100 mm, severe pain/discomfort [22]. Additionally, the children could, in their own words, describe any part of the extraction procedure in an open text section.

Control variables

Dental anxiety may affect an individual's perception of pain. Thus, we used the modified dental anxiety scale (MDAS) [23] to assess dental anxiety prior to the first extraction for all

included patients. MDAS comprises five questions assessing anxiety in relation to dental examination and treatment, with five ordinal options (1–5) for each question. The data are presented as the sum score of all questions (range 5–25). A sum score of $\geq$ 19 indicates dental phobia, whereas MDAS < 11 indicates low dental anxiety [23]. Due to a low number of highly anxious participants, anxiety was dichotomised into low (MDAS <11) and moderate to high (MDAS $\geq$ 11). The children answered the questionnaire with the help of a legal guardian.

Information about the age at extraction, gender, and any previous experience of invasive dental treatment (i.e. anaesthetic injection, tooth drilling/filling, and/or extraction), was collected from dental records. For statistical analyses, we dichotomised chronological age into younger than 11 years and 11 years or older, close to the median.

Statistical methods

We used descriptive statistics (mean, ± standard error (SE)) to report the data. The independent samples t-test was used to assess differences between SEG and DEG for normally distributed continuous variables, whereas the Mann-Whitney U-test was used to assess differences between SEG and DEG in non-normally distributed, continuous variables. For categorical variables, we used Fisher's exact test to assess the differences between the SEG and the DEG. The significance level was set at $p < .05$. We assessed correlations by use of the Spearman bivariate correlation analyses. Statistical analyses were performed using version 26.0 of the SPSS software package (SPSS Inc., Chicago, IL, USA).

Results

Study sample characteristics

The study sample included 28 children, 15 girls and 13 boys, with a mean chronological age of 10.9 ± 0.2 years (range $9.5 - 14.0$). There were no statistically significant differences

in gender, age, number of canines, uni/bilateralism of PDCs, previous experience of invasive dental treatment, or mean MDAS sum score between the SEG and the DEG (Table 1). The MDAS sum score ranged from five to 20, with only one child reporting high dental anxiety ($\geq$19). The mean MDAS sum score for the whole cohort was 10.8 ± 0.7. There was no significant gender difference in dental anxiety (mean 10.7 ± 1.1 and 10.8 ± 0.8 for girls and boys respectively, $p = .928$). Dental anxiety scores did not differ significantly between children with or without previous experience of invasive dental treatment prior to the extractions (MDAS sum score 10.4 ± 1.0 vs 11.0 ± 1.0, respectively, $p = .683$).

Pain and discomfort

Extraction procedures generally induced more discomfort than pain, both being highest during injection of anaesthesia. The discomfort decreased gradually from the injection of anaesthesia until one-week post-extraction, whereas pain was lower during extraction than on the evening of the extraction day. The mean level of pain and discomfort reported by the children never exceeded mild (VAS <45 mm) for any of the procedures or time points (Table 2). However, at the individual level, one child reported severe pain (in the DEG) and two children had moderate pain (in the SEG) during injection of anaesthesia. Two children reported moderate pain during extraction (both in the DEG) and two reported moderate or severe pain in the evening of the extraction day

Table 1. Study sample characteristics in the single- and double extractions groups.

	SEG ($n = 15$)	DEG ($n = 13$)	p
Girls	8 (53%)	7 (54%)	1.000[B]
Age[C]	11.0 ± 0.3	10.8 ± 0.2	.654[A]
Bilateral PDC	7 (47%)	8 (62%)	.476[B]
Previous treatment[D]	6 (43%)	6 (46%)	1.000[B]
MDAS[C]	9.7 ± 0.5	11.9 ± 1.3	.235

SEG = Single extraction group, DEG = Double extraction group, [A] = Independent samples t-test, [B] = Fisher's exact test (2-sided), [C] = Mean ± SE, [D] = Injection, drilling and/or extraction, PDC = palatally displaced canine.
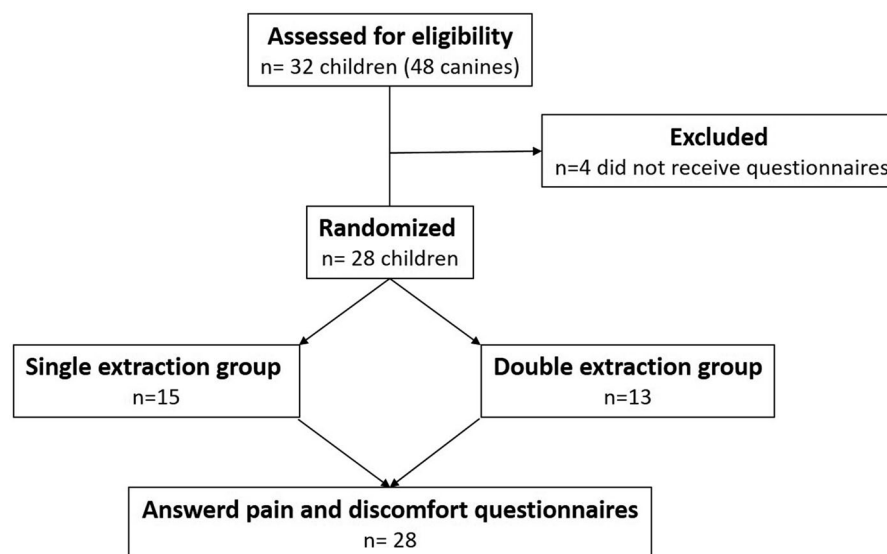

Figure 1. Illustrates the flow of patients in this study.

(both in the DEG). Compared to children in the SEG, children in the DEG reported significantly higher levels of pain and discomfort during injection and extraction as well as on the evening of the extraction day (Table 2).

There were no significant differences in the level of reported pain or discomfort between extractions performed by the two operators (data not shown). Neither were there any significant differences in the level of pain or discomfort reported between children with no-low and children with moderate-high dental anxiety at any time point ($p \geq .378$ for all), between girls and boys ($p \geq .142$ for all time points) or between older or younger children ($p \geq .280$ for all time points). Levels of reported pain during anaesthetic injection, extraction, and on the first evening were significantly correlated (Table 3).

Ten children commented on parts of the extraction that they found particularly uncomfortable. The most common complaint was an unpleasant feeling when the tooth was rotated ($n = 4$, all in the DEG) and unpleasant sounds ($n = 2$

both in the DEG). In the DEG one child mentioned the anaesthetic injection, one the taste of the anaesthetics, and another the extraction of the second tooth. One child in the SEG found the bleeding associated with the extraction particularly unpleasant.

Analgesics

No children used analgesics prior to extractions, but on the evening of the extraction day, 13% of the children in the SEG and 42% of children in the DEG had used analgesics ($p = .096$). Children using analgesics the same day as the extraction reported a higher level of pain from the extraction site the first evening compared to children using no analgesics (mean VAS: 2.3 ± 1.1 and 0.7 ± 0.3, respectively, $p = .009$).

Daily activities and jaw impairment

More children refrained from recreational activities in the DEG compared to the SEG (0 vs. 5 (39%), respectively, $p = .046$) (Table 4). Chewing large and hard pieces was problematic for several children after the extractions, but with no significant differences between the SEG and the DEG. Otherwise, the children reported few problems with jaw functions. There were no significant gender differences in the impact on daily activities or jaw function (data not shown).

Discussion

Few studies have assessed self-reported pain and discomfort associated with tooth extractions in children and adolescents. Tooth extractions are common in orthodontic treatment, both in cases of tooth crowding and as an interceptive treatment for PDCs, and it is therefore important to increase the knowledge of how this treatment is experienced by children. We found that extraction of primary canines and first molars was associated with low levels of pain and discomfort for the children on a group level, and the extractions had a limited impact on their daily activities. Therefore, primary tooth extractions as an interceptive treatment may be regarded as a relatively atraumatic procedure for most children when performed according to the procedures in this study.

Table 2. Pain and discomfort recorded on a 100 mm Visual Analogue Scale in the single- and double extraction groups post extraction.

	SEG ($n = 15$) Mean ± SE	DEG ($n = 13$) Mean ± SE	ΔDEG-SEG	p^*
Pain				
Injection	16 ± 5	32 ± 5	16	.017
Extraction	4 ± 2	21 ± 6	17	.004
Evening	4 ± 3	21 ± 7	17	.033
Week	0 ± 0	8 ± 4	8	.254
Discomfort				
Injection	18 ± 5	39 ± 6	21	.011
Extraction	12 ± 4	35 ± 6	23	.004
Evening	9 ± 3	33 ± 9	24	.041
Week	2 ± 1	10 ± 4	8	.201

SEG = Single Extraction Group, DEG = Double Extraction Group, Δ DEG-SEG = pain/discomfort DEG – pain/discomfort DEG, as assessed on visual analogue scales, SE = standard error of mean, *statistical significance analysed by the Mann Whitney U-test.

Table 3. Correlation between levels of pain at different time points as assessed on Visual Analogue Scales.

Pain	Extraction rho/p	Evening rho/p	Week rho/p
Anaesthesia	**.525/.004**	**.515/.005**	.202/.302
Extraction		**.664/<.001**	.188/.339
Evening			**.445/.018**

Evening = evening of extraction day, Week = one week after extraction, rho = Spearman's rho coefficient, p = statistical significance assessed by Spearman's correlation analyses. Numbers in bold indicate statistically significant correlations.

Table 4. Primary tooth extractions' influence on daily activities and jaw impairment.

	SEG ($n = 15$)			DEG ($n = 13$)			
Home from school	1 (6 %)			3 (23 %)			.311
Refrained from recreational activity	0 (0 %)			5 (39 %)			.013
Sleep disturbances	0			0			
	No problems	Some problems	Large problems	No problems	Some problems	Large problems	p
Speech	14 (93 %)	1 (7 %)	0	11 (85 %)	2 (15 %)	0	.444
Chewing large pieces	9 (60 %)	5 (33 %)	1 (7 %)	5 (39 %)	7 (54%)	1 (8 %)	.512
Chewing hard food	7 (47 %)	6 (40%)	2 (13 %)	3 (23 %)	6 (46 %)	4 (31 %)	.344
Chewing soft food	12 (80 %)	3 (20 %)	0	10 (77 %)	3 (23%)	0	.600
School/ homework	15 (100 %)	0	0	12 (92 %)	1 (8%)	0	.464
Drinking	15 (100 %)	0	0	13 (100 %)	0	0	.488
Laughing	15 (100 %)	0	0	12 (92 %)	1 (8)	0	.464
Yawning	15 (100%)	0	0	13 (100 %)	0	0	

SEG = Single extraction group, DEG = Double extraction group, p = Significance according to Fisher's exact test.

We found that the mean level of pain and discomfort was higher in the DEG than in the SEG group at most time points assessed. There is no general agreement on the minimum clinically significant difference in VAS pain scores, but a previous study found a difference of 9 mm to be the minimum for acute pain, irrespective of age, gender, and cause of pain [24], and another study suggests that a difference of 33% is meaningful from the patients' perspective [22]. The difference in reported pain between the SEG and the DEG exceeded 33% at all time points and was larger than 9 mm on the VAS scale during anaesthesia, extraction, and on the evening of the extraction day. Primary canines have a single, pointed root and can usually be extracted with little handling and use of force. Contrary, the primary first molar in the upper jaw has three strongly diverging roots, and usually requires more handling and use of force to be extracted. It will also leave a larger wound in the jaw after extraction than the canine. This is reflected in the children's comments in their own words from the present study, where rotation/handling of the tooth was highlighted as especially uncomfortable by several children in the DEG. The clinical benefit of extracting both the primary canine and first molar instead of just the primary canine to enhance the eruption of PDC is controversial [10–12]. Therefore, our findings support choosing the least traumatic and best-validated procedure, namely extraction of the primary canine only.

Some of the children reported moderate or severe levels of pain and discomfort during anaesthesia, extraction or on the evening of the extraction day. Many studies have found an association between painful dental treatment and dental anxiety [25–27], and there is an apparent risk that extractions can trigger and increase dental anxiety in susceptible children. Thus, it would be useful to find characteristics of the children who reported high levels of pain or discomfort that could help identify predisposed individuals. Pain perception is subjective and can be modulated by learned responses, expectations, and previous experiences [28]. We did not find any significant difference in the level of reported pain or discomfort between children with or without previous experience with invasive dental treatment at any time point. Neither were there any significant differences in reported pain or discomfort between children with a low level of dental anxiety and children with moderate to high dental anxiety, which is somewhat surprising as previous studies have found that dental anxiety is associated with reporting higher levels of pain [25,29]. However, only three of the children included in the study had an MDAS score above 15, so the number of children with severe dental anxiety was probably too low to detect any associations in this study.

Previous research stresses the importance of procedural information and giving patients the feeling of being in control during dental treatment to lower the level of fear and anxiety [30]. Psychological techniques are essential in pain management; this study used the tell-show-do method successfully in most cases. However, our findings suggest that some children may benefit from additional support to manage pain during primary tooth extractions. Dental procedures might not always be free of pain and discomfort, but dental personnel should facilitate coping on an individual level [31]. In addition to psychological techniques, there are studies showing reduced perioperative and postoperative pain after preoperative administration of non-steroidal anti-inflammatory drugs (NSAID) in children, although the evidence is weak [32,33]. Due to the low risk of complications associated with these drugs in healthy children, preoperative use of NSAIDs could be more widely encouraged to reduce pain associated with tooth extractions.

We found that level of reported pain during anaesthetic injection, extraction, and in the evening of the extraction day correlated. This could reflect individual differences in how pain is experienced and expressed, but may also suggest that experiences at the start of the treatment may influence how the rest of the treatment is perceived. This is in accordance with a previous study, which found that pain during the extraction procedure was the strongest predictor of postoperative pain [29]. However, the correlation between pain levels at the various time points may also be affected by recollection bias, as pain during anaesthesia and extraction was reported in the evening of the extraction day and could therefore be influenced by the postoperative pain in the evening. Thus, ideally, pain and discomfort during anaesthesia and extraction should have been assessed directly after these procedures. Another risk of bias in this study is that the operators were not blinded to the aims of the study. However, the study assesses the children's self-reported experiences and no clinical measures, which may reduce the risk of bias inflicted by operators who were not blinded. Finally, the questionnaire assessing the impact on daily activities and jaw function had been tested for validity and reliability in Swedish, but not in the translated Norwegian version. This is also a possible risk of bias, but the similarity of the languages along with the simplicity of the questions suggests that they are comparable in Norwegian and Swedish.

To conclude, our findings support that primary tooth extractions as an interceptive treatment should be regarded as relatively atraumatic for most children following the procedures described in this study. However, some children report moderate to high levels of pain and discomfort associated with primary tooth extraction, indicating that current practice is not sufficient for pain management in all children. Extraction of both the primary canine and the primary first molar as an interceptive treatment for PDCs is associated with significantly more pain and discomfort than the extraction of the primary canine only, and should thus be avoided as the clinical benefit is controversial.

Ethics approval statement

The regional ethics committee of Northern-Norway approved the study (2012/623/REK Nord). All procedures were conducted in accordance with the Declaration of Helsinki.

Patient consent statement

Informed, written consent was obtained from both the child and a legal guardian.

Clinical trial registration

Author contributions

S.H.-O. and A.S. conceived the ideas; S.H.-O. and J.S. collected the data; S.H.-O. and E.H.-O. analysed the data; and S.H.-O. and E.H.-O. led the writing; A.S., J.S and H.N. critically revised the manuscript.

Disclosure statement

Funding

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Data availability statement

The data that support the findings of this study are not publicly available due to privacy and ethical regulations but are available from the corresponding author on reasonable request.

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