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The Extensively Restored Posterior Tooth has a High Incidence of Tooth Fracture

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Abstract - *A multicentred practice based study was established to test the hypothesis that the extensively restored tooth has a high incidence of posterior tooth fracture (PTF). All patients who presented with PTF in 23 general dental practices over a period of 14 weeks were included in the study. 764 PTF restorations were placed out of a total of 7551, an incidence of 10%. A novel classification proposing increased severity of fracture from I – IV was used. Class I = 19%, II = 54%, III = 22% and IV = 5%. Primary PTFs accounted for 67%, secondary 33%. 92% of fractured teeth had a Class 2 restoration in situ. The heavily restored tooth has been shown to have a high incidence of PTF and it is suggested that this is a major restorative problem in general dental practice in the UK.*

KEY WORDS: posterior tooth fracture, fracture classification, multi-centre study.

INTRODUCTION

In the extensively restored dentitions of the middle aged and elderly there is increased risk of fracture of the weakened tooth[1]. In previous studies other factors have been suggested for the high prevalence of posterior tooth fracture (PTFs) (Table 1)[2-9]. Braly and Maxwell [1] suggested in a review of the literature that tooth loss due to tooth fracture affects dentitions which have been well cared for and maintained. The flexing of the non functional cusps (lingual/mandibular) could be the reason why these cusps have a higher incidence of fracture[2]. Khera *et al* [3] suggested that the anatomic configuration of the occlusal surfaces and the occlusal relationships could play a part in weakening the tooth. The incomplete tooth fracture[4] or cracked cusp syndrome is often the first sign of an impending fracture. Bell *et al* [8] demonstrated using finite element analysis that a mathematical model of a tooth when subjected to tensile stress over a long period of time produced a similar fracture as is seen *in vivo*. Ellis *et al* [9] concluded that, complete fractures can occur at any age. In a recent study[10], tooth fracture was the most common reason for the provision of initial placement crowns.

As a consequence of previous work in a study on the placement and replacement of restorations in a dental practice[11] it was therefore found that PTFs were a significant reason for the placement of restorations. It was decided to perform a pilot study for six months to see how significant a problem PTFs were in general dental practice. A PTF classification was devised (Fig. 1) and was used to record primary and secondary fractures. The results of this pilot study recorded an incidence of 19% for both primary and secondary fractures. The consistency of results in the two studies[11,12] on the incidence of PTFs prompted the current nation wide study, the aim of which was to record the number and type of restoration for PTFs in a multi - centre practice based study.

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MATERIALS AND METHOD

Design

The design was a multi-centre prospective study in general dental practice treating patients under both private contract and National Health Service provision over a period of 14 weeks. It was thought that a significant number of PTFs could be recorded in three months in an average general dental practice, a longer period would make compliance difficult. Advertisements were placed in the BDA News, Faculty of General Dental Practitioner (UK) newsletter *First Hand*, asking for GDPs who were interested in a practice based research project on PTFs to contact the authors. Similar recruitment took place using GRID (Glasgow Research Initiative in Dental Practice) and locally at dental meetings.

A previously used classification[11] recorded the types of PTFs as they presented and the type of restorations used to restore the fractures (Fig 1 & Table 3). Two types of restoration were identified : a) the restoration restoring the primary fracture, b) the restoration restoring a secondary fracture or a previously restored fracture which had failed. The numbers of primary and secondary fractures in posterior teeth were recorded as a percentage of all restorations placed. The restorations already *in situ* in fractured teeth were recorded. This was to determine whether the presence of a restoration was a factor with regard to the tooth fracture. Lastly, the types of PTF restorations were recorded to assess the percentage of adhesive resin restorations placed to restore posterior tooth fractures.

Organisation

The study design, data collection and instruction sheets were presented to a statistician and four consultants in Restorative Dentistry and Dental Public Health.

Modifications were made to these and they were further modified after a focus group meeting of six practitioners who were already recruited into the study. Details of

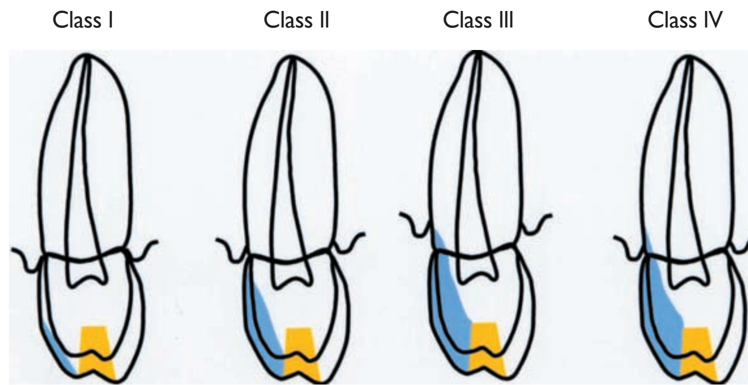

Figure 1. *Schematic diagram of the four classes of posterior tooth fracture.*

Table 1. *Reasons for the high incidence of posterior tooth fractures*

a)	The weakening effect of large intra-coronal restorations[2]
b)	The occlusion (as in group function and the loss of anterior guidance)[3]
c)	The occlusal morphology (steep cusps and deep fissures)[4]
d)	A history of fracturing restorations and teeth[5]
e)	An incomplete tooth fracture[6]
f)	Post endodontic treatment (suggested and supported by *in vivo* studies[7])
g)	Persons age[8,9]

Table 2. *Posterior tooth fracture research information pack*

1)	Introduction sheet : the reasons and background to the study
2)	Instructions: sheet 1
3)	Instructions sheet 2
4)	Posterior tooth fracture classification: Figure 1
5)	Tooth fracture data collection sheet, seventeen categories to record tooth fracture and eleven categories describing treatment options
6)	Totals of all other restorations placed during the study period, not PTF restorations

whether the practitioners practised privately or with the NHS and how many sessions a week they worked were recorded. Sixty five general dental practitioners volunteered for the study, and 46% were sent the study papers (6 pages) and the remainder retrieved them from the co-ordinators' web-site. Before starting the study they had to notify the co-ordinator by email or telephone to say that they fully understood the instructions, thus ensuring agreement. An enquiry telephone number was available during the period of the study. Six sheets of A4 paper were in the research study pack (Tables 2 & 3). The division between the epidemiology and description of the PTF with the treatment options was an important distinction for the statistical analysis. It was important that the "other restorations" were recorded so that the incidence could be calculated. Totals of all other restorations were divided into 14 weeks and further subdivided into days worked. Daily and weekly figures were combined into a running total for ease of the final calculations. On the completion of the 14 week study period the participants returned the data to the co-ordinator for data processing and statistical analysis.

RESULTS

Sixty five GDPs received the PTF study pack and 23 returned the data sheets, an uptake of 35% (Table 4). In general, the interpretation of the study design was good. The average age of the patients was 52 years (Fig 2) and 53% were female. The total non PTF restorations placed was 6787 and the total PTFs was 764 (Table 5) which is an incidence of 10%. (95% confidence intervals (CI=9-11%)). The number of each PTF classification was Class l=19%, ll=54%, lll=22% and lV=5%. 67% (Cl= 63-70%) were primary PTFs and 33% (Cl= 30-37%) secondary. 92% of the fractured teeth had 2 - 3 surface restorations in situ. The materials subsequently used to restore the fractured teeth were amalgam (32%), GIC (28%), composite/compomer (24%) and cast crown restorations (16%). Two thirds of the PTFs were primary (Cl = 63% - 70%). The majority of restorations *in situ* involved three surfaces (68%) and two surface restorations accounted for 26%. The vertical surface of the restoration *in situ* was amalgam in 63%, enamel and dentine in 28% and composite and GIC in 8% of the

Table 3. *Data recording instructions (2) sent out in laminated covers*

TOOTH FRACTURE DATA

Enter number, abbreviations, or tick box. It will not always be possible to fill in all relevant boxes. eg fracture cause or occlusion.

DENTIST'S NAME

CASE NUMBER
Consecutive numbering

GENDER

AGE
At last birthday

POSTCODE
To assist socio-economic information

ETHNICITY
European white - W
Afro-Caribbean - AC
Chinese - C
Indian - In
Other - O

TOOTH NUMBER & CUSP
Maxillary tooth number in upper half of the box, mandibular in lower half
Buccal cusp - written next to tooth number - B
Lingual cusp - written next to tooth number - L
or rarely in a buccal lingual fracture - BL

FRACTURE INDEX
Class l - enamel fracture
Class ll - enamel and dentine fracture
Class lll - enamel and dentine extending below the amelo - cemental junction
Class lV - fracture extending below the gingival margin
A - one fractured cusp
B - two fractured cusps
C - three or more fractured cusps

RESTORATION IN SITU
MOD, DO and MO

VERTICAL INNER SURFACE
Enamel / dentine - ED
Dentine - D
Amalgam - AMAL
Composite or compomer - COMP
Glass ionomer - GI

VITALITY
Non - vital tooth - N / V

FRACTURE CAUSE
Hard object - H
Trauma - T
Other - O

OCCLUSION
Canine protected - C
Group function - GF
Bruxing - B

TREATMENT OPTIONS

NONE OR SMOOTH
No treatment is an option

PART REMOVE
Preparation of adjacent restoration / tooth substance

TYPE OF MATERIAL
Use of abbreviations for amalgam, composite / compomer and glass ionomer

CAST
Full / partial coverage cast restoration - C
Resin bonded porcelain inlay - P

ENAMEL BONDING

DENTINE BONDING

ROOT FILLING
As a result of the fracture

EXTRACTION
As a result of the fracture - E
Of cusp and part of root - C

NEW RESTORATION
Tick for new restoration
If a replacement for a lost restoration - L

TIME
Length of time the previous restoration was in place

If there is any difficulty in interpretation please ring the HELPLINE ………………………..

situations. The practitioners who practised under private contract provided 20% (CI =15-27%) cast restorations and 48% (CI = 40-56%) composite/compomer restorations, however, under NHS provision the figures were 14% (Cl = 11-17%) and 20% (17 = 24%) respectively. Figure 3 shows the incidence of individual cusp fractures in percentages in both dental arches and Table 6 the collective figures. 13% of the PTF teeth were non-vital.

The main treatments provided were restorations (91%), extractions (6%) smoothing or no treatment (3%). Treatment procedures were part removal of the restoration *in situ* or tooth substance (45%), enamel /dentine bonding (32%), pin (17%) and endodontic treatment (5%). 45% of patients reported the causes of PTF due to a hard object, and 55% other causes. 54% had occlusal group function, 39% canine protected occlusion and 6% were considered to be bruxists. The average time a primary PTF restoration was in place before renewal was 2 years. The number of PTFs by age group is shown in Figure 2. White Europeans comprised 98% of the sample and Afro - Caribbean, Indian and others 2%.

DISCUSSION

In this multi-centre study it was found that a high proportion of PTFs were in heavily restored teeth and that a classification for PTFs was proposed and used by the GDPs successfully in their data collection.

The graph showing PTFs by age group (Fig 2) mirrors a similar distribution to a previous placement and replacement study in general dental practice[11]. Other studies that have recorded PTFs [11,12,13] indicate an incidence of PTF from

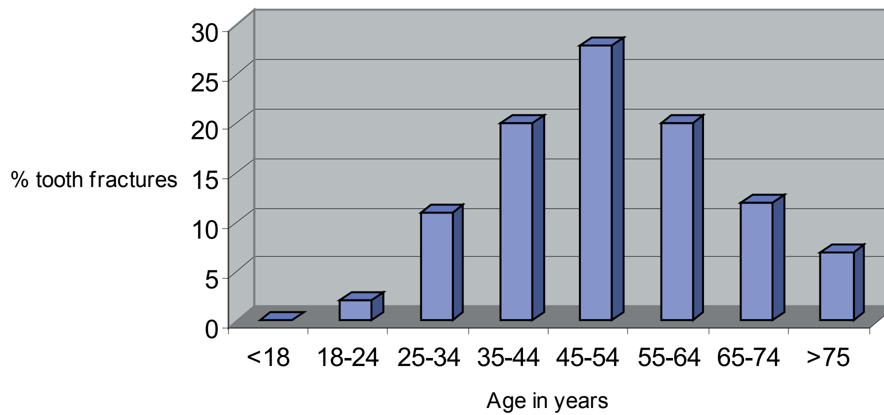

Figure 2. *Graph showing the number of posterior tooth fractures by age group.*

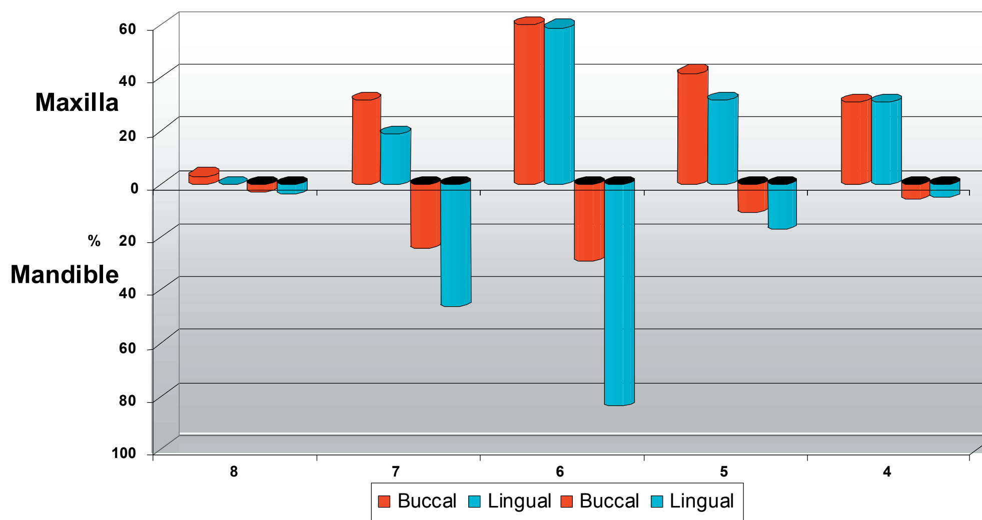

Figure 3. *Graph showing the percentages of cusp fractures in both dental arches.*

6% to 19%. The type of cusp fractures recorded is similar to other published studies[2,7,12,14] with one difference in that the maxilla, had more fractured cusps than the mandible (Table 5) although the tooth with the most fractures was the mandibular 1st molar (22%) (Fig 3). Bader *et al* [15] recorded 543 cusp fractures in a period of 105 days. Out of 16,674 patients they recorded 465 complete root fractures. The percentages of each tooth fracture in both dental arches were similar to the incidence in this study apart from the mandibular molars which were greater than the maxillary molars. The majority of cusp fractures (Table 6), occur in maxillary buccal and mandibular lingual cusps. No cause of PTF due to the occlusal relationships could be attributed. It appears that intact teeth which fracture when something hard is bitten on tend to fracture vertically through the naturally weaker part of the tooth which coincides with occlusal fissure patterns and the root furcation[7]. This contrasts with our study where 95% of the fracture lines are oblique (PTF classes l,ll and lll) and are restricted to the crown of the tooth. The presence of the restoration in situ suggests an influence on this oblique fracture.

Thirteen per cent of the teeth were non-vital, whereas lower figures have been reported [12]. It is often recommended that after endodontic treatment, the tooth is crowned to prevent fracture[16]. The present study shows that extensively restored posterior teeth have an increased incidence of PTFs. Amalgam comprised nearly a third of the PTF restorations, this is probably the preferred intra coronal restoration but it relies on the integrity of the restoration *in situ* [17]. Other materials were 52% adhesive resin and 16% crowns. It would appear from our results that adhesive techniques are used routinely as an alternative to crowns in restoring PTFs. In 17% of restorations a pin was placed although pins have been criticised for causing crazing of the tooth substance and a weakening of the physical properties of amalgam[18].

A primary fracture restoration lasted a short time (two years) but it seems that although these restorations were placed in challenging positions it is often the expedient option.

Table 4. *Table showing information on participants (GDPs).*

Numbers of GDPs sent study pack	65
Number of data returns	23
Response: % of GDPs practices who provided returns	35%
The number of sessions (1/2 day) worked per week according to method of payment.	
Private	65 36%
NHS (GDS, 97. PDS, 9. Body corporate, 10)	116 64%
Geographical spread of the GDP's	
Scotland 7, Wales 1, England, North 2, Midlands 1, Southwest 6, Southeast 6.	
Average number of restorations placed per GDP	357
Average number of PTF's per GDP	36
Average number of sessions worked per week	8 4 days
Average number of restorations placed per session	3

Table 5. *Table showing posterior tooth fracture totals*

Total restorations placed, not fractures			6787
Total Posterior Tooth Fractures (PTF)			764
Incidence of PTF.			10%
Primary PTF	67%	Secondary PTF	33%
Class l	19%	Subdivision A One cusp	78%
Class ll	54%	Subdivision B Two cusps	22%
Class lll	22%	Subdivision C Three or more	_
Class lV	5%		

Table 6. *Table showing the collective incidence of cusp fractures in percentages*

Maxillary cusps (U)	54%
Mandibular cusps (L)	46%
Individual cusps	
(L) Lingual cusps	66%
(L) Buccal cusps	34%
(U) Lingual cusps	43%
(U) Buccal cusps	57%

The present study may be criticised due to the small sample size, however the data collected is on a far larger scale than comparable studies[2,12] and it has a geographical variation as well as private/NHS mix. The private practitioners provided slightly more cast restorations and double the number of composite restorations. As a NHS item of service restoration composite resin was not allowed further posterior than the premolars when this study took place. Even with resources beyond the reach of this investigator the data collected in this type of study is often disappointing[19]. The enthusiasm of our colleagues who completed the data collection is to be admired and many requested that they be kept informed of further primary care research.

CONCLUSION

A new PTF classification was proposed[12] and successfully used in general dental practice research. The incidence of primary and secondary PTF teeth at 10% is significant (95% confidence intervals (CI =9 -11%). Forecasting treatment

need is an important part of health care provision and it would appear that the restoration of PTF is a common item of treatment that is very demanding. Sixty eight per cent of fractured teeth had a three surface or more restoration in situ and 26% a two surface restoration in situ. To restore 16% of PTF, crowns were used and amalgam, composite or glass ionomer resin were used in equal proportions for the remaining PTF restorations.

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