Forty-year review of extraction frequencies at a university orthodontic clinic

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Extraction for orthodontic reasons was commonplace in the late 19th century, when treatment usually consisted only of extraction of severely malaligned teeth. To Edward Angle and his followers in the early 20th century, extraction was anathema. In their concept, extraction destroyed the possibility of ideal occlusion or ideal esthetics, both of which required the presence of all the teeth; in any case, extractions were unnecessary because modern orthodontic treatment, done correctly, would allow function to stabilize the teeth in their new positions.[1]

As it became clear that arches could and did collapse after expansion despite efforts to produce ideal function, extraction was reintroduced in the 1930s in an attempt to overcome relapse problems. By mid-century it had become commonplace among orthodontists using Tweed's modifications of the edgewise appliance. At that time only the edgewise technique provided enough control of root position to allow straightforward management of extraction spaces, so extraction was used infrequently with the other appliances of that era, for example, labiolingual, twin wire, Crozat and other removable appliances. When the Begg technique was introduced into the United States in the 1960s, many orthodontists who had not used edgewise adopted the Begg ap-

Abstract

In a review of consecutive charts at 5-year intervals from the orthodontic clinic at the University of North Carolina, the number of patients with extraction of all four first premolars increased from 10% in 1953 to 50% in 1963, remained at 35% to 45% until the early 1980s, then declined sharply to the 1950s level by 1993. Extraction for camouflage of Class II malocclusion (maxillary first premolars alone or maxillary first–mandibular second premolars) reached 16% in 1968, then declined, but not as dramatically, and presently is as frequent as the extraction of four first premolars. The rate of extraction of other teeth, done for a variety of individual reasons, has remained almost constant at about 15% for the past 40 years. Thus the total extraction percentage was 30% in 1953, peaked at 76% in 1968, and declined again to 28% in 1993, with almost all the change in the percentage of four first premolar extractions. The increase in first premolar extractions occurred primarily in a search for greater long-term stability; the recent decline seems due to a number of factors. Greater concern about the impact of extraction on facial esthetics, data to suggest that extraction does not guarantee stability, concern about temporomandibular dysfunction, and changes in technique all seem to have played a role. With appropriate orthodontic mechanics, many patients with Class I crowding can be treated satisfactorily with or without premolar extraction.

Key words

Orthodontic treatment • Extraction • Stability • Esthetics

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proach and began to extract more frequently and the percentage of orthodontic patients with extraction reached a peak. Since then, extraction percentages have declined noticeably.

Although this brief outline of an important aspect of orthodontic history represents a consensus judgment, it is based on remarkably little data. Particularly, the changes in extraction patterns in recent years have not been documented. In 1979, Peck and Peck reviewed previous reports of extraction percentages, noting a large range with more than 80% extractions in some settings. They reported 42% with extractions in their private practice.[2] In a 1989 telephone survey of orthodontists in Michigan, extraction percentages of 5% to 87% were reported. A review of records from selected practices at the extreme of the range showed actual extraction percentages of 25% to 85%, which differed considerably from the clinicians' subjective estimates.[3] We recently surveyed consecutive charts in a university clinic staffed by a number of attending faculty, to document more clearly the experience relative to extractions since mid-century.

Material and methods

The graduate orthodontic clinic at the University of North Carolina began operation in 1953. Approximately 6000 patients have been treated in the clinic since that time. From its inception, the program was operated on an attending-resident model, with both full- and part-time faculty serving as clinical attendings responsible for individual patients. Treatment decisions including extraction, therefore, were made at all times by multiple faculty who represented the practicing community in the area, with perhaps a bias toward the most recent treatment methods. Orthodontists now treat more young children and more adults than they did many years ago, and to some extent this change in the orthodontic treatment population has been reflected in the graduate clinic. But patients always have been screened to select a balanced group for each resident, so the distribution of malocclusion types in the clinic population has not changed much over the years.

To document the experience with orthodontic extraction, a review of clinic charts was undertaken, examining 50 consecutive charts from 1953 and another series of 50 consecutive charts at every fifth year up to 1993. The presence or absence of extractions of permanent teeth, and which teeth were extracted, were noted. Third molar extractions, which if performed almost always occurred after orthodontic treatment was completed, were excluded. Chi-square analysis was used to test for statistical significance of changes in extraction rates over time.

Results

The percentage of patients with extraction of all four first premolars, an approach used in the treatment of all types of malocclusion but particularly for severe dental crowding, is shown in Figure 1. The rate of four first premolar extractions was 10% in 1953, increased to half the patients in 1963, declined slowly over the next 20 years, and then dropped sharply, to the point that the percentage in 1993 was similar to that of the 1950s. The changes over time were highly significant statistically ($p<.001$).

The percentage of patients with extraction of either maxillary first premolars alone or maxillary first and mandibular second premolars is shown in Figure 2. This extraction pattern indicates camouflage treatment of Class II malocclusions, retracting the maxillary incisors to compensate for an underlying skeletal Class II pattern. The change over time was much less dramatic than the change for four first premolar extraction and was not statistically significant ($p = 0.46$). Its peak prevalence was 16% in 1968 and 1973 and, at 8% in 1993, was as frequent as the extraction of four first premolars.

The percentage of patients with extraction of other teeth (a malformed or severely carious tooth, an impossibly impacted canine, one mandibular incisor, a single premolar, one second and three first premolars, etc.) is shown in Figure 3. Such extractions are done for a variety of specific reasons, often to compensate for dental problems, tooth size discrepancy or asymmetry. For this category, there has been little change since the inception of the program—about one patient in six consistently fell into this category, with no statistically significant differences over time. It is interesting, however, that extraction of one mandibular incisor occurred in 6% of the patients in the 1950s, and was used only rarely thereafter.

The total extraction percentage, the sum of the three categories described separately above, was 30% in 1953, peaked at 73% in 1963 and 76% in 1968, and at 28% was essentially the same in 1993 as in 1953.

Discussion

These data indicate that changes in extraction over the past 40 years are almost entirely due to an increase and then a decrease in the extraction of four first premolars, with less change in other premolar extraction patterns and no change in the prevalence of extraction of other teeth. The changes in four first premolar extraction percentages, from the 1950s low to the peak a decade or so later to the current low level, reflect striking changes in orthodontic practice in the clinic at UNC. The clinic population has changed somewhat over the years, primarily in the age distribution of the patients, but residents always have received a group of patients chosen to represent the total spectrum of malocclusions, so the change in extraction percentages cannot be explained by a change in the type of patients being treated. There have always been enough different attending faculty to prevent eccentric decisions by one or two individuals from heavily skewing the data. Because there have been minimal changes in the clinical faculty over the last decade, the decrease in extractions quite recently is because individual attendings changed their policy, not because faculty personnel changed. The clinic obviously does not perfectly reflect what happened regionally or nationally, but the patient population in the clinic reasonably reflects the population treated in orthodontic practice, and it seems likely that the trends in the clinic were similar to those in orthodontic practice more generally.

It is interesting to reflect on what led to the changes in the number of extractions, both the increase and the decrease. There is no doubt that, in the treatment of Class I crowding problems, the increase in premolar extraction was driven almost entirely by a search for greater stability. The experience of the early nonextraction orthodontists was that many cases collapsed into crowding after a few years. Early in the century, Calvin Case's strong criticism of Angle's nonextraction dogma focused on facial esthetics,[4] and undoubtedly there was some criticism from patients of excessive dental protrusion after extreme arch expansion. But relapse, not esthetics, was the major reason both Tweed and Begg abandoned the nonextraction treatment they had been taught by Angle. Tweed felt that Angle had not understood the genetic determination of tooth size-jaw size relationships, for which extraction could compensate.[5] Begg felt that his predecessors had not understood the effect of lack of attrition in the modern diet, for which extraction would compensate.[6] Both techniques tended to supplant older orthodontic methods that made it difficult to manage extraction treatment.

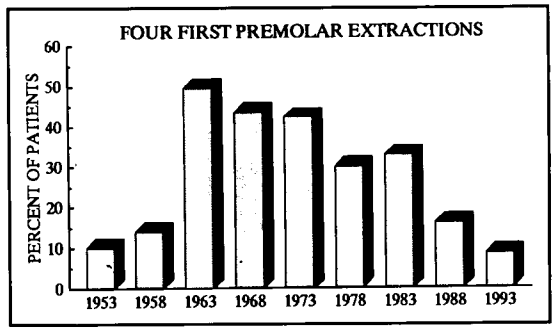

Figure 1

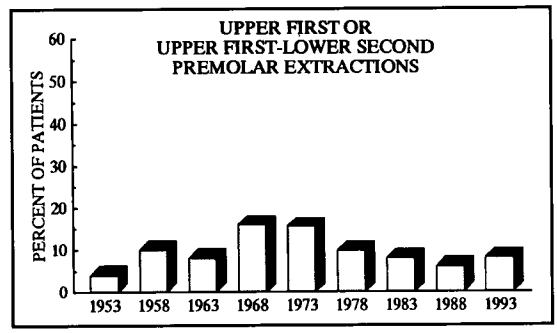

Figure 2

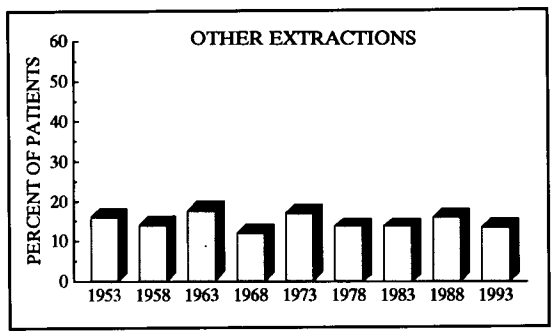

Figure 3

Although the goal of changing technique was largely to improve stability, changes in technique definitely affected extraction percentages. The increase in extraction in the UNC clinic in the 1960s clearly reflects the replacement of labiolingual and twin-wire appliances as edgewise became more popular and Begg technique was introduced. At its inception, the UNC orthodontic department primarily taught labiolingual and twin-wire, with one-third or fewer of the patients being treated with the edgewise appliance. By the mid-1960s, labiolingual and twin-wire had disappeared. Three-fourths of the patients had edgewise appliances, and about one-fourth were treated

Figure 1
The percentage of extraction of all four first premolars. This extraction pattern is used most frequently to treat crowding within the dental arches, but also can be employed in Class II treatment.

Figure 2
The percentage of extraction of only upper first premolars or upper first plus lower second premolars. These extraction patterns indicate camouflage treatment of Class II malocclusions.

Figure 3
The percentage of patients with any other extraction(s) for orthodontic purposes except the premolar patterns shown in Figures 1 and 2 (third molar extraction excluded). For any year, the total extraction percentage is the sum of the values shown in Figures 1, 2 and 3.

with Begg. When fully banded appliances replace partial bands, band space is an issue and this technical factor contributed to the increase in extractions.

Why did the first premolar extraction percentages decline so dramatically, especially in the last decade? Several factors contributed to the decline. One important influence was a change in esthetic guidelines. Riedel's 1957 evaluation of the Seattle Seafair princesses was the first demonstration that orthodontists had come to see profiles differently from the general public: some of the beauty queens were judged by the Tweed-oriented cephalometric standards of that time to be too protrusive and in need of orthodontic treatment with extractions to reduce their dental protrusion.[7] By the 1970s, orthodontists were being criticized by dental colleagues and some elements of the general public for flattening profiles too much with extraction treatment. If the public preferred fuller profiles than the orthodontic ideal of midcentury, reducing the number of extraction cases was an obvious response.

At least four other major factors influenced the decline: (1) studies of long-term stability showed relapse into dental crowding even after extraction treatment, (2) both Tweed's and Begg's rationales for extraction lost some of their validity, (3) concern was expressed about temporomandibular dysfunction related to extraction of premolars, and (4) technique changes made it easier to manage nonextraction treatment and clinicians noted that the average treatment time for nonextraction cases was shorter than for extraction treatment.

The well-known series of studies of long-term outcomes of orthodontic treatment carried out by Little and co-workers at the University of Washington provide the clearest data for stability after extraction treatment.[8,9] The results can be summarized as discouraging: when teeth were severely irregular prior to treatment, a majority of the patients had irregularity long-term, despite premolar extractions. This is not to say that the results would not have been even worse if the patients had been treated without extraction—there are no comparable data for nonextraction patients.

How much can dental arch dimensions be permanently changed by orthodontic treatment? If the limits are tightly set by genetic control, long-term expansion is unlikely to be successful, as Tweed suggested, and tooth size-jaw size ratios would be a major diagnostic criterion. If arch dimensions are greatly influenced by the environment, as Angle believed, major changes should be possible. This view has reappeared in recent years, supported by studies that show little genetic determination of occlusal variations.[10] Begg's assumption that crowding is inevitable in the absence of dental attrition can no longer be supported.[11] It is difficult to know how much a change in basic ideas impacts on clinical decisions, but a different view of what is possible with arch expansion certainly encourages attempts at nonextraction treatment.

Charges that extraction of premolars, particularly first premolars, predisposes to temporomandibular dysfunction were widely circulated in the 1980s. These prompted a series of studies, all of which fail to show any impact of extraction on TMD.[12] Since there is no logical reason to suspect a relationship between the presence or absence of premolars and TMD, and since the data confirm the lack of a relationship, fears about premolar extraction on these grounds can be dismissed. But the threat of lawsuits and "expert" witnesses to testify to the relationship undoubtedly had some effect on reducing the number of extractions.

In addition, continuing changes in orthodontic techniques have had an impact. These include the introduction of functional appliances, the virtual disappearance of Begg technique, bonded rather than banded appliances, and increased use of interproximal enamel reduction to gain space. At UNC, functional appliances came into use in the late 1970s. Begg technique was eliminated from the teaching program about the same time, not because it was no longer a useful method but because there were no longer practitioners using it who could serve as clinical attendings. The decline in extractions at that time probably was not coincidence. In the 1980s the use of bonds rather than bands, by eliminating the interproximal band material that took up significant space during treatment, made it easier to manage borderline patients without extraction. For some patients (though only a few at UNC), interproximal enamel reduction is now used instead of extraction to obtain additional space.[13,14] Vig and co-workers, using data from practitioners in Michigan, showed that the average duration of nonextraction treatment averaged 3 to 6 months less than extraction treatment.[15] This would mean that in borderline cases, nonextraction treatment is more efficient, a further incentive to treat in that way

if feasible.

In perspective, it seems clear that the criticism of premolar extraction that led to its decline in Class I crowding problems was largely criticism of too much retraction of incisor teeth coupled with a reluctance to extract teeth if it was not necessary. The amount of retraction of incisors is only partially a function of the extraction-nonextraction decision. To create an extraction space is one thing; to close it with uncontrolled retraction of the incisors (or excessive anterior movement of the posterior teeth), is quite another. A competent orthodontist should be able to determine what the posttreatment position of the teeth should be and manipulate an orthodontic appliance to put the teeth there. Establishing the final position of the incisors is a major treatment planning decision.

That viewpoint allows the development of three "theoretical extraction percentage" charts (Figures 4 to 6) showing the impact of premolar extraction in Class I crowding on dentofacial esthetics (dental prominence), stability of result (tendency to relapse into crowding), and jaw function (occlusal quality, tendency toward TMD). There are no data at present to allow precise numbers to be placed on such charts, that is, the number of patients who require extraction or nonextraction for a satisfactory outcome and the number who could be treated satisfactorily either way, is not known. The suggestion is, however, that with regard to dentofacial esthetics (Figure 4), approximately 25% of Class I patients are clear-cut extraction cases because of their degree of dental protrusion, approximately 25% must be treated nonextraction to avoid flattening the profile too much, and the remaining 50% could be treated either way to a satisfactory esthetic outcome. Similarly (Figure 5), for stability, about 25% require extraction for a reasonably stable result, about 25% would be at least as stable treated without extraction, and in the remaining 50%, the extraction decision is irrelevant to stability.

One answer to the question, "What makes you think that with nonextraction treatment you won't run into the same problems with stability and esthetics that they did years ago?" is that much arch expansion now is being done in the mixed dentition, as opposed to the permanent dentition treatment employed in the previous nonextraction era. It remains to be seen whether the soft tissues will adapt more successfully and whether early expansion will

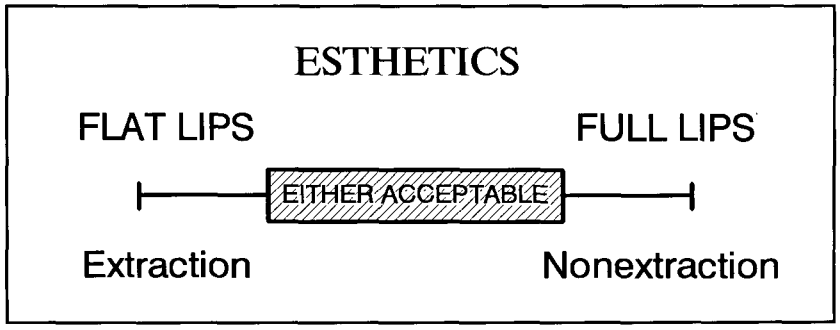

Figure 4

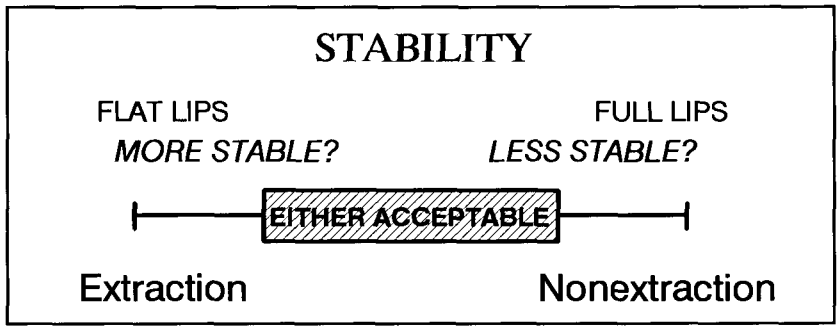

Figure 5

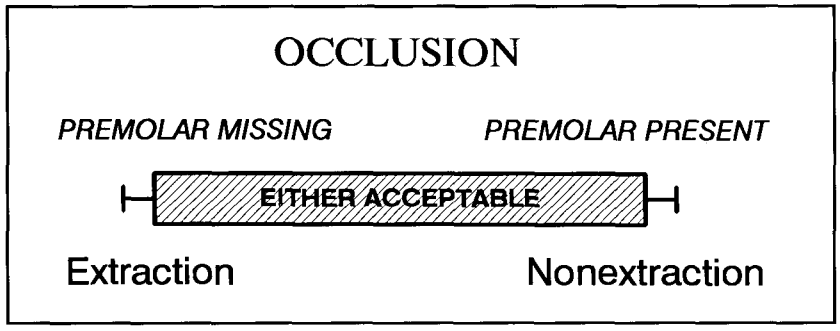

Figure 6

Figure 4
In Class I crowding cases, nonextraction treatment increases the prominence of the lips, extraction decreases it. For satisfactory esthetics, some patients require extraction, some require nonextraction treatment, and a considerable group in the middle could have acceptable esthetics with either approach.

Figure 5
In the treatment of Class I crowding, stability probably is greater with extraction than nonextraction treatment, but the difference is not as great as was believed at the height of enthusiasm for premolar extraction. As with esthetics, some patients require extraction for reasons of stability, some require nonextraction, and a large group in the middle could have satisfactory outcomes with either approach.

Figure 6
Satisfactory occlusal function for the great majority of patients, including consideration of TMD, has little to do with the presence or absence of premolars. A few patients would require extraction or nonextraction treatment for occlusal reasons, but for almost all, either approach is satisfactory from an occlusion point of view.

prove more stable than later expansion. The best U.S. study of early expansion indicates good initial results but contains no really long-term data.[16] Although early expansion has been done for a longer time in Europe, there are no well-characterized samples with good data. My judgment that about 25% of Class I crowded patients would be better treated with premolar extraction is independent of whether treatment starts in the mixed dentition. Successful expansion in the mixed dentition, if indeed it makes a difference, can be viewed as simply improving the outcome of the approximately 75% who can be treated without extraction.

The relationship of dental occlusion to jaw function and TMD has been reviewed in depth in recent years because of the claims of some dentists that premolar extraction predisposes patients to TMD. No data support those claims. It is clear from a number of studies that details of the dental occlusion are at most a minor factor in whether TMD is present or absent for any individual patient.[17] The best guess is that, in terms of the occlusion and jaw function, the extraction-nonextraction decision is important for only a minority of patients, most of whom could be treated either way from this point of view (Figure 6). Only in 10% or so of patients is the impact of extraction on dental function likely to be a valid concern, and in these, the degree of incisor retraction is the primary focus.

There are other indications for extraction than dental arch crowding and the UNC clinical data illustrate two other points about extractions as part of orthodontic treatment. First, an important secondary reason for extraction is to camouflage the skeletal malocclusion, particularly skeletal Class II. Prior to the mid-1960s, there was little or no option for nongrowing skeletal Class II patients. Either they had premolars extracted for camouflage, or they went untreated. The development of modern orthognathic surgery would have been expected to reduce the number of patients treated with orthodontic camouflage, and the data indicate that this happened in the UNC clinic. The limits of camouflage are now much better understood than they were even a decade ago.[18] It is interesting that there was a small increase in camouflage extractions in 1993, which may reflect greater confidence in this approach based on better data for outcomes.

Second, the number of other extractions, in contrast to the number of premolar extractions, has hardly changed over the last 40 years. This relative stability while other extraction percentages were changing undoubtedly reflects

the special circumstances that, for instance, would lead orthodontists to extract three first premolars and a carious second premolar instead of the more usual four first premolar extraction, or to remove peg lateral incisors that were not good candidates for crowns, whether or not the spaces were closed orthodontically. The indications for extraction of one mandibular incisor are rare, principally to compensate for tooth-size discrepancy or to compensate for a tendency toward reverse overjet in mild skeletal Class III patients, and it is interesting that this extraction was used much more in the 1950s than more recently. Second molar extraction rarely is indicated and appears only occasionally in the UNC sample. Diagnostic criteria probably are sharper now than a few years ago, but unlike the situation for premolar extractions, the same rules seem to apply now as previously for other extractions.

It is fair to say that at the peak of first premolar extraction, orthodontists overdid it. Has the pendulum swung too far in the other direction? If 25% of the Class I crowded patients need extraction to obtain a satisfactorily esthetic and stable outcome, the extraction percentage claimed at present by some prominent clinicians is too low. If 25% of patients should be treated nonextraction to achieve the best outcome, some practitioners, primarily those who still employ the classic Begg technique, have too high an extraction percentage. For the 50% of patients in the middle, it comes down to a question of orthodontic skill in producing the desired outcome in terms of incisor position. If you can close extraction spaces without retracting the incisors too much, your extraction percentage can be higher; if you can expand arches without proclining the incisors too much, your extraction percentage can be lower. And fortunately, whichever the choice, TMD is largely irrelevant.

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