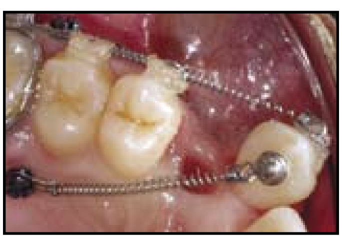
JOURNAL OF CLINICAL ORTHODONTICS

VOLUME XLIII NUMBER 1 JANUARY 2009

The Cover

Mechanics described in the article on mandibular incisor extraction by Drs. Uribe and Nanda are illustrated.

34 Elastics Attachment



39 Mini-Implant Placement

45 Incisor Extraction

DEPARTMENTS

 Journal of Clinical Orthodontics (USPS 802-120, ISSN 0022-3875) is published monthly for $220 per year (U.S. individual rate) by JCO, Inc., 1828 Pearl St., Boulder, CO 80302-5519. Periodicals postage paid at Boulder, CO, and additional mailing office. POSTMASTER: Send address changes to JCO, 1828 Pearl St., Boulder, CO 80302-5519. Phone: (303) 443-1720; e-mail: info@jco-online.com.

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THE EDITOR'S CORNER

The State of the Profession

In this issue, we conclude our three-part presentation of the 2008 JCO Study of Orthodontic Diagnosis and Treatment Procedures. Along with Parts 1 and 2, which appeared in the November and December issues, this segment confirms the impressions that many of us have had over the past few years about the direction in which the practice of clinical orthodontics is going. There are a few, but not many, surprises.

One point that stood out to me in the area of diagnosis and treatment planning is the finding that fewer routine diagnostic records are being taken. As recently as 10 years ago, the status quo with respect to pretreatment diagnostic records was panoramic and cephalometric radiographs, facial and intraoral photographs, and study models. Few orthodontists now take that full battery, with the panorex now the only record obtained in the vast majority of cases. Digital imaging and computerized analysis are taking over—film cameras having virtually disappeared—but in general, we are noticing a trend toward fewer pre- and post-treatment diagnostic records. This could have a far-reaching impact on what is considered the "usual and customary" standard of care and, consequently, what records are required for board certification and publication.

On the treatment side, we found that esthetic brackets and titanium-alloy archwires are continuing to gain in popularity. Stainless steel has served the specialty well for three generations, but newer materials that are both more patient-friendly and more doctor-friendly are slowly but surely replacing the old workhorse. If and when stainless steel goes into retirement, it will be in good company, joining gold and silver as materials that served their purpose well in their day. Bands also appear to be on the way out; given the further changes in orthodontic procedures noted in the Study, perhaps the only remaining need for bands is for the application of headgear to the upper arch—and that treatment modality is also declining dramatically. As for bonding, the two-paste, pad-mixed composites are still excellent bonding materials, but the convenience of light-cured adhesives seems to be winning over the market. Indirect bonding is on the rise compared to direct bonding, probably because of its accuracy, but has yet to achieve the ease of use that would make it the method of choice.

Minimizing the need for patient compliance seems to be an ongoing concern of clinicians, with fixed functional appliances prescribed more often over removable appliances and routine headgear use (except for reverse-pull headgear) continuing to decline. Colleagues from around the globe report that it is increasingly difficult to get "today's kids" to wear headgear, for whatever social or psychological reason, and the fixed functional obviates that problem.

The Angle-Case debates on extraction occurred almost a century ago. Case won out in the mid-20th century, but Angle may have the last word: we've seen a gradual decline in extraction treatment over the past 20 years, to fewer than 20% of all cases in the current Study. On the other hand, cosmetic finishing procedures are becoming more customary, and clear, removable retainers and lingual fixed retainers are gaining popularity over the old Hawley and spring-type retainers. The overall trend is toward treatment decisions that place an emphasis on patient desires, esthetics, and comfort rather than on any perceived mechanical or biological superiority.

A few of the technological developments that have occurred since our last Treatment Study six years ago have been more sudden than the trends noted above. Self-ligating brackets have caught on dramatically over the past decade. But the one finding that impressed me most was the dramatic correlation of the use of Invisalign with practice income. Although the cause-and-effect nature of this relationship has yet to be explored, it is undeniable that the most monetarily productive offices perform the most Invisalign treatment. I believe this is a manifestation more of a practice attitude than of the effectiveness of a specific treatment modality. Orthodontists who do a lot of Invisalign do so because of patient demand. The rise in nonextraction therapy and in the use of self-ligation are probably manifestations of the same underlying philosophy. Of course, while it's a tempting conclusion to draw, we still need statistical validation.

Regarding another new technology, we note that skeletal anchorage, in only a few years, has become a basic tool in orthodontic treatment. This really comes as no surprise, as I have commented in previous columns, but the Treatment Study gives us data to back up our impressions. Since the use of temporary anchorage devices is now taught in virtually all orthodontic graduate programs, we can see an age-related preference in TAD usage, with younger practitioners much more likely to place their own miniscrews.

This editorial overview of the survey is merely intended to whet your appetite. The more subtle nuances to be gleaned from the 2008 JCO Study of Orthodontic Diagnosis and Treatment Procedures reside in the details of the three articles and their accompanying tables. I hope you find them as interesting as I did, and I look forward to exploring the implications of these findings in future surveys. Finally, I'd like to thank the hundreds of practitioners who took the time to fill out their questionnaires and allow us to take the pulse of the profession. Their efforts help keep all of us better informed on the current state of orthodontic treatment.

Happy New Year! RGK

2008 JCO Study of Orthodontic Diagnosis and Treatment Procedures
Part 3 More Breakdowns of Selected Variables

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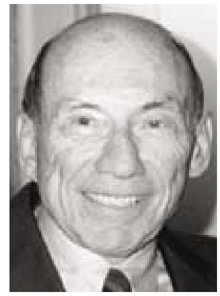
Our three-part series of articles on the 2008 JCO Study of Orthodontic Diagnosis and Treatment Procedures concludes this month with more breakdowns of the most important diagnostic and treatment techniques by number of years in practice, geographic region, and gross income level. A description of the survey methodology can be found in the first article (JCO, November 2008), which also covered the basic results and trends in orthodontics since the first Study in 1986. The second article (JCO, December 2008) contains the remainder of selected breakdowns.

TABLE 38
ROUTINE USE OF REMOVABLE AND FUNCTIONAL APPLIANCES BY YEARS IN PRACTICE

	1-5	6-10	11-15	16-20	21-25	26+
Activator	1.1%	0.0%	0.0%	0.0%	0.0%	0.4%
Bionator	0.0	0.0	1.2	3.8	1.0	1.5
Bite plates	6.8	15.5	10.8	15.1	10.8	12.7
Class II Corrector	4.5	15.5	4.8	0.9	4.9	2.2
Distal Jet	3.4	2.4	6.0	1.9	2.9	1.9
Dynamax	1.1	0.0	1.2	0.0	0.0	0.4
Forsus	28.4	33.3	16.9	16.0	19.6	8.2
Fränkel	1.1	0.0	1.2	4.7	0.0	2.2
Herbst						
Banded	6.8	20.2	8.4	12.3	8.8	6.4
Bonded	0.0	1.2	0.0	1.9	1.0	0.7
Crowns	14.8	22.6	21.7	21.7	20.6	18.0
Removable	0.0	1.2	1.2	0.9	0.0	0.4
Fixed-removable	0.0	1.2	3.6	0.0	2.9	0.7
Hilgers Pendulum	2.3	8.3	3.6	8.5	7.8	6.0
Invisalign	30.7	28.6	24.1	17.9	15.7	16.1
Jasper Jumper	1.1	0.0	1.2	0.9	2.0	1.5
Jones Jig	0.0	0.0	0.0	0.9	0.0	0.0
Magnets	0.0	0.0	0.0	0.0	0.0	0.0
Mandibular Corrector	0.0	0.0	0.0	0.0	0.0	0.0
Mandibular Protrusion	0.0	0.0	0.0	0.0	1.0	0.0
MARA	6.8	9.5	3.6	3.8	5.9	5.2
Sagittal	1.1	2.4	3.6	0.9	2.9	2.6
Schwarz plates	2.3	6.0	6.0	8.5	3.9	4.5
Twin Block	3.4	3.6	3.6	3.8	3.9	3.4

Dr. Keim is Editor, Dr. Gottlieb is Senior Editor, and Mr. Vogels is Managing Editor of the *Journal of Clinical Orthodontics,* 1828 Pearl St., Boulder, CO 80302. Dr. Nelson is Director and Research Consultant, Nelson Associates, Nederland, CO.

Dr. Keim



Dr. Gottlieb

Dr. Nelson

Mr. Vogels

Removable and Functional Appliances

There was little apparent relationship between number of years in practice and routine use of removable and functional appliances (Table 38). Newer practices were more likely than older practices, however, to use the Forsus appliance and Invisalign.

When respondents were broken down by region, the most routine users of bite plates, fixed-removable Herbst appliances, and Invisalign systems were in New England; of the banded Herbst, in the South Atlantic region; of the Jones Jig and Mandibular Protrusion Appliance, in the Middle Atlantic region; of the bionator, Class II Corrector, Forsus appliance, Jasper

TABLE 39
ROUTINE USE OF REMOVABLE AND FUNCTIONAL APPLIANCES BY GEOGRAPHIC REGION

	NE	MA	SA	ESC	ENC	WNC	MTN	WSC	PAC
Activator	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%
Bionator	2.4	0.0	0.7	2.9	2.0	2.2	0.0	0.0	2.4
Bite plates	19.0	12.2	11.2	17.6	11.8	10.9	5.2	7.6	16.3
Class II Corrector	7.1	7.1	4.5	8.8	2.0	0.0	1.7	3.8	5.7
Distal Jet	2.4	5.1	0.7	2.9	4.9	2.2	0.0	0.0	5.7
Dynamax	2.4	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
Forsus	9.5	11.2	16.4	32.4	18.6	6.5	24.1	22.8	19.5
Fränkel	0.0	3.1	0.7	0.0	3.9	2.2	0.0	3.8	0.8
Herbst									
Banded	7.1	6.1	14.2	8.8	12.7	8.7	5.2	11.4	4.9
Bonded	2.4	1.0	0.0	0.0	1.0	0.0	0.0	2.5	0.8
Crowns	9.5	13.3	17.9	14.7	24.5	13.0	27.6	21.5	22.0
Removable	0.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0	0.8
Fixed-removable	2.4	1.0	1.5	0.0	2.0	0.0	0.0	1.3	1.6
Hilgers Pendulum	4.8	3.1	4.5	8.8	9.8	4.3	3.4	5.1	8.9
Invisalign	28.6	20.4	18.7	17.6	13.7	17.4	19.0	21.5	26.0
Jasper Jumper	0.0	1.0	0.7	2.9	1.0	0.0	0.0	0.0	2.4
Jones Jig	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Magnets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mandibular Corrector	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mandibular Protrusion	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MARA	7.1	1.0	0.7	2.9	9.8	10.9	8.6	3.8	9.8
Sagittal	0.0	3.1	3.7	2.9	3.9	2.2	0.0	0.0	2.4
Schwarz plates	2.4	9.2	5.2	0.0	9.8	2.2	1.7	3.8	4.9
Twin Block	2.4	4.1	3.7	5.9	3.9	4.3	1.7	1.3	4.9

TABLE 40
ROUTINE USE OF REMOVABLE AND FUNCTIONAL APPLIANCES BY GROSS INCOME LEVEL

	Less than $200,000	$201,000-400,000	$401,000-600,000	$601,000-850,000	$851,000-1,100,000	More than $1,100,000
Activator	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%
Bionator	0.0	1.4	0.0	0.0	3.6	1.5
Bite plates	8.8	10.1	18.9	11.8	8.0	12.6
Class II Corrector	0.0	2.9	0.0	5.9	5.4	5.5
Distal Jet	2.9	5.8	0.0	3.4	3.6	2.5
Dynamax	0.0	0.0	1.4	0.0	1.8	0.0
Forsus	14.7	8.7	18.9	16.8	15.2	20.6
Fränkel	5.9	0.0	0.0	0.8	1.8	2.5
Herbst						
Banded	5.9	7.2	8.1	8.4	11.6	10.2
Bonded	0.0	0.0	1.4	0.8	0.0	1.2
Crowns	5.9	11.6	6.8	14.3	17.0	28.3
Removable	0.0	0.0	0.0	0.8	0.9	0.6
Fixed-removable	0.0	1.4	0.0	3.4	0.0	1.2
Hilgers Pendulum	2.9	10.1	2.7	2.5	9.8	6.5
Invisalign	8.8	10.1	13.5	19.3	15.2	27.7
Jasper Jumper	2.9	0.0	1.4	3.4	0.9	0.6
Jones Jig	0.0	0.0	1.4	0.0	0.0	0.0
Magnets	0.0	0.0	0.0	0.0	0.0	0.0
Mandibular Corrector	0.0	0.0	0.0	0.0	0.0	0.0
Mandibular Protrusion	0.0	0.0	0.0	0.8	0.0	0.0
MARA	0.0	4.3	4.1	5.0	7.1	7.1
Sagittal	0.0	1.4	1.4	3.4	1.8	2.8
Schwarz plates	0.0	4.3	4.1	9.2	3.6	5.2
Twin Block	0.0	1.4	0.0	5.0	3.6	4.9

TABLE 41
ROUTINE USE OF HEADGEAR BY YEARS IN PRACTICE

	1-5	6-10	11-15	16-20	21-25	26+
Kloehn facebow	3.9%	5.3%	5.1%	17.7%	19.5%	16.9%
J-hook	0.0	0.0	1.3	0.0	0.0	3.4
Cervical-pull	11.8	26.7	20.3	28.1	31.0	21.1
Straight-pull	0.0	5.3	0.0	3.1	1.1	4.6
Variable straight-pull	0.0	0.0	0.0	1.0	1.1	1.3
High-pull	9.2	16.0	10.1	11.5	14.9	14.8
Combi	0.0	4.0	2.5	4.2	3.4	3.8
Reverse	6.6	20.0	10.1	15.6	8.0	10.1
Chin cup	0.0	1.3	2.5	1.0	2.3	2.5
Facial mask	3.9	22.7	16.5	14.6	12.6	9.7
Safety or breakaway	36.8	30.7	29.5	46.3	43.7	34.3

Jumper, and Twin Block, in the East South Central region; of the activator, Fränkel, removable Herbst, Hilgers Pendulum, and sagittal appliances and Schwarz plates, in the East North Central region; of the MARA system, in the West North Central region; of the Dynamax and Herbst with crowns, in the Mountain region; of the bonded Herbst, in the West South Central region; and of the Distal Jet, in the Pacific region (Table 39).

As in past surveys, routine use of removable and functional appliances tended to increase with gross income (Table 40). This pattern was especially noticeable for the Herbst with crowns, Invisalign, and MARA.

Headgear

The types of headgear used for Class II treatment were prescribed more routinely by

TABLE 42
ROUTINE USE OF HEADGEAR BY GEOGRAPHIC REGION

	NE	MA	SA	ESC	ENC	WNC	MTN	WSC	PAC
Kloehn facebow	10.5%	13.8%	8.2%	7.1%	15.7%	16.2%	21.8%	7.8%	15.0%
J-hook	2.6	0.0	0.0	7.1	2.2	0.0	1.8	2.6	0.0
Cervical-pull	26.3	28.7	21.8	17.9	21.3	27.0	32.7	16.9	20.4
Straight-pull	0.0	2.3	1.8	7.1	1.1	5.4	3.6	3.9	3.5
Variable straight-pull	0.0	1.1	0.9	3.6	0.0	2.7	1.8	1.3	0.0
High-pull	13.2	5.7	11.8	21.4	11.2	24.3	21.8	10.4	14.2
Combi	2.6	4.6	3.6	3.6	0.0	5.4	1.8	2.6	5.3
Reverse	21.1	6.9	13.6	10.7	9.0	5.4	16.4	9.1	12.4
Chin cup	0.0	3.4	1.8	0.0	1.1	5.4	1.8	1.3	0.9
Facial mask	7.9	16.1	8.2	10.7	14.6	8.1	12.7	9.1	15.0
Safety or breakaway	44.7	39.1	32.1	17.9	38.2	42.9	36.4	41.6	32.7

TABLE 43
ROUTINE USE OF HEADGEAR BY GROSS INCOME LEVEL

	Less than $200,000	$201,000-400,000	$401,000-600,000	$601,000-850,000	$851,000-1,100,000	More than $1,100,000
Kloehn facebow	10.7%	10.6%	16.9%	16.7%	6.4%	14.1%
J-hook	0.0	6.1	0.0	0.0	3.2	0.7
Cervical-pull	17.9	16.7	30.8	23.5	19.1	25.5
Straight-pull	0.0	6.1	3.1	2.9	1.1	3.1
Variable straight-pull	0.0	0.0	3.1	0.0	1.1	1.0
High-pull	10.7	13.6	16.9	10.8	12.8	14.5
Combi	0.0	6.1	4.6	2.0	2.1	3.4
Reverse	3.6	3.0	12.3	9.8	11.7	14.5
Chin cup	0.0	0.0	4.6	1.0	1.1	2.1
Facial mask	7.1	3.0	7.7	12.7	10.6	16.6
Safety or breakaway	28.6	40.9	33.8	43.1	35.1	35.4

orthodontists who had been in practice longer (Table 41). On the other hand, Class III devices such as reverse headgear and facial masks were more popular in newer practices.

Kloehn facebows and cervical-pull headgear were used most routinely in the Mountain region, while J-hook, straight-pull, and variable straight-pull devices were used most commonly by East South Central orthodontists (Table 42). High-pull and combi headgear and chin cups were used most routinely in the West North Central region, reverse headgear in New England, and facial masks in the Middle Atlantic region. Safety or breakaway devices were most frequently employed by New England orthodontists and least frequently by East South Central respondents.

In general, Class II headgears and safety or breakaway devices were used more routinely by middle-income practices, and Class III appliances by high-income practices (Table 43).

Finishing Procedures

There was no obvious correlation between number of years in practice and the use of cosmetic finishing procedures (Table 44). Younger practices were slightly more likely than older practices to use hand instruments for stripping, compared to power instruments. Middle-age practices were the most routine users of laser procedures, but none of these was used by more than 14% of any group. The oldest practices were somewhat more likely than others to routinely prescribe fiberotomies and positioners. Hawley and spring retainers were used almost equally across the board, but Essix and Invisalign retainers and fixed bonded retainers were used more routinely by younger practitioners.

The most routine use of cosmetic procedures appeared to be in the West South Central and Mountain regions (Table 45). No geographic pattern emerged among other finishing techniques, except that laser procedures were most commonly used in the East South Central region, and zig-zag elastics and equilibration in the West South Central region. Hawley retainers were used most routinely in the Pacific region; spring retainers in the South Atlantic region; modified spring retainers in the Middle Atlantic region; clear slipover and Invisalign retainers in the East South Central region; and Essix retainers in the Mountain region. Fixed bonded retainers seemed to be most popular among West South Central orthodontists.

Routine use of finishing procedures tended to increase with gross income, but not as sharply as in past surveys (Table 46). Practices with the highest income were also the most likely to use clear slipover, Invisalign, and fixed bonded retainers.

KEY TO GEOGRAPHIC REGIONS

NE = New England (CT, ME, MA, NH, RI, VT)
MA = Middle Atlantic (NJ, NY, PA)
SA = South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA, WV)
ESC = East South Central (AL, KY, MS, TN)
ENC = East North Central (IL, IN, MI, OH, WI)
WNC = West North Central (IA, KS, MN, MO, NE, ND, SD)
MTN = Mountain (AZ, CO, ID, MT, NV, NM, UT, WY)
WSC = West South Central (AR, LA, OK, TX)
PAC = Pacific (AK, CA, HI, OR, WA)

Invisalign

Respondents who had been in practice the longest treated space-closure and Class I cases with severe crowding more routinely with the Invisalign system than other respondents did (Table 47). Otherwise, there was not much difference in the types of cases treated with Invisalign by years in practice. (Tables on Invisalign and skeletal anchorage include only respondents who reported treating at least one case.)

Orthodontists in the East North Central region used Invisalign most routinely for treatment of moderate Class I and space-closure cases (Table 48). New England respondents were the most routine users for severely crowded Class I

TABLE 44
ROUTINE USE OF FINISHING PROCEDURES BY YEARS IN PRACTICE

	1-5	6-10	11-15	16-20	21-25	26+
Cosmetics						
Incisal adjustment	70.0%	83.7%	77.4%	76.6%	66.7%	68.0%
Shaping labial/lingual surface	31.1	43.0	39.3	35.5	33.3	29.6
Porcelain laminate veneers	1.1	3.5	3.6	0.9	3.7	3.4
Composite resin build-up	8.9	7.0	9.5	6.5	11.1	8.6
Anterior stripping (slenderizing)						
With hand instruments	40.0	30.2	42.9	40.2	38.0	39.2
With handpiece	31.1	38.4	35.7	31.8	27.8	32.3
With air turbine	14.4	23.3	10.7	18.7	13.0	14.4
Posterior stripping						
With hand instruments	21.1	14.0	17.9	12.1	10.2	13.4
With handpiece	17.8	26.7	15.5	13.1	11.1	17.2
With air turbine	6.7	17.4	3.6	12.1	10.2	14.1
Fiberotomy	0.0	0.0	4.8	1.9	6.5	7.6
Gingivectomy	2.2	9.3	3.6	3.7	5.6	2.1
Frenulotomy	6.7	3.5	4.8	4.7	9.3	6.9
Laser procedures						
Exposure of impacted teeth	6.7	14.0	13.1	8.4	9.3	7.2
Removal of opercula	1.1	7.0	2.4	2.8	1.9	2.7
Frenectomy	1.1	7.0	4.8	1.9	6.5	4.1
Gingivectomy	3.3	10.5	4.8	2.8	4.6	4.5
Ankyloglossia	0.0	1.2	0.0	1.9	0.9	1.0
Zig-zag (up-and-down) elastics	36.7	36.0	33.3	30.8	35.2	31.3
Equilibration	8.9	22.1	16.7	13.1	19.4	18.2
Positioner	2.2	1.2	1.2	1.9	2.8	6.9
Retention						
Removable						
Hawley	59.1	61.2	45.9	56.4	54.9	56.9
Spring retainer	13.6	12.9	9.4	14.9	10.8	10.6
Modified spring retainer	8.0	7.1	7.1	7.9	9.8	6.2
Clear slipover (invisible)	38.6	28.2	40.0	40.6	42.2	35.4
Essix	48.3	47.1	34.1	29.7	31.4	27.4
Invisalign	11.4	10.6	7.1	5.9	4.9	8.4
Fixed banded						
3-3	4.5	7.1	4.7	5.9	12.7	5.5
4-4	0.0	0.0	0.0	0.0	1.0	2.2
5-5	0.0	0.0	0.0	0.0	0.0	0.4
6-6	0.0	0.0	1.2	1.0	1.0	1.5
Fixed bonded						
Maxillary	12.5	15.3	9.4	8.9	13.7	8.4
Mandibular	48.9	49.4	45.9	48.5	37.3	33.9
2-2	5.7	14.1	8.2	8.9	11.8	5.8
3-3	53.4	57.6	48.2	54.5	48.0	39.4
4-4	0.0	0.0	2.4	0.0	1.0	1.5

TABLE 45
ROUTINE USE OF FINISHING PROCEDURES BY GEOGRAPHIC REGION

	NE	MA	SA	ESC	ENC	WNC	MTN	WSC	PAC
Cosmetics									
Incisal adjustment	63.6%	61.2%	68.3%	83.3%	68.8%	63.0%	83.3%	83.3%	73.8%
Shaping labial/lingual surface	27.3	31.1	34.5	38.9	23.9	26.1	41.7	48.8	32.5
Porcelain laminate veneers	0.0	1.9	2.1	0.0	2.8	2.0	1.7	2.4	4.8
Composite resin build-up	6.8	9.7	9.2	2.8	8.3	2.2	11.7	7.1	10.3
Anterior stripping (slenderizing)									
With hand instruments	45.5	35.9	41.5	41.7	35.8	39.1	36.7	40.5	34.9
With handpiece	36.4	21.4	34.5	44.4	26.6	39.1	28.3	32.1	37.3
With air turbine	18.2	12.6	12.7	19.4	14.7	8.7	16.7	26.2	13.5
Posterior stripping									
With hand instruments	13.6	16.5	16.9	8.3	12.8	15.2	16.7	15.5	8.7
With handpiece	25.0	8.7	18.3	22.2	11.9	19.6	13.3	17.9	19.0
With air turbine	9.1	9.7	11.3	13.9	8.3	2.2	13.3	27.4	8.7
Fiberotomy	2.3	1.9	3.5	0.0	3.7	6.5	8.3	6.0	6.3
Gingivectomy	2.3	1.0	7.0	5.6	3.7	2.2	5.0	1.2	2.4
Frenulotomy	6.8	1.9	7.7	8.3	6.4	6.5	8.3	8.3	4.0
Laser procedures									
Exposure of impacted teeth	6.8	2.9	7.7	16.7	8.3	15.2	8.3	14.3	7.9
Removal of opercula	9.1	0.0	3.5	5.6	0.9	4.3	1.7	3.6	2.4
Frenectomy	0.0	1.0	5.6	8.3	5.5	6.5	1.7	2.4	4.8
Gingivectomy	4.5	1.0	4.9	11.1	4.6	8.7	3.3	8.3	3.2
Ankyloglossia	0.0	0.0	0.0	2.8	1.8	0.0	0.0	1.2	0.8
Zig-zag (up-and-down) elastics	34.1	19.4	29.6	41.7	26.6	17.4	41.7	48.8	42.9
Equilibration	20.5	13.6	17.6	16.7	12.8	15.2	15.0	27.4	17.5
Positioner	6.8	4.9	2.8	5.6	5.5	2.2	0.0	1.2	4.0
Retention									
Removable									
Hawley	61.9	52.5	50.7	42.4	49.0	59.1	55.2	62.8	65.8
Spring retainer	9.5	10.9	16.7	9.1	14.4	13.6	10.3	6.4	9.2
Modified spring retainer	2.4	12.9	10.1	12.1	4.8	6.8	0.0	0.0	6.7
Clear slipover (invisible)	38.1	31.7	37.0	48.5	39.4	36.4	37.9	37.2	36.7
Essix	40.5	39.6	33.3	36.4	32.7	22.7	41.4	35.1	30.8
Invisalign	4.8	11.9	6.5	12.1	4.8	6.8	10.3	3.8	10.8
Fixed banded									
3-3	2.4	6.9	6.5	3.0	6.7	6.8	1.7	9.0	8.3
4-4	0.0	2.0	1.4	3.0	1.0	0.0	0.0	1.3	0.0
5-5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
6-6	2.4	1.0	1.4	0.0	1.0	0.0	0.0	0.0	1.7
Fixed bonded									
Maxillary	2.4	6.9	10.9	12.1	22.1	18.2	12.1	7.7	7.5
Mandibular	38.1	33.7	40.6	45.5	51.0	38.6	36.2	59.0	36.7
2-2	4.8	5.0	10.1	6.1	12.5	13.6	10.3	7.7	7.5
3-3	35.7	42.6	44.2	48.5	59.6	45.5	50.0	64.1	44.2
4-4	0.0	1.0	1.4	0.0	0.0	2.3	0.0	0.0	0.0

TABLE 46
ROUTINE USE OF FINISHING PROCEDURES BY GROSS INCOME LEVEL

	Less than $200,000	$201,000-400,000	$401,000-600,000	$601,000-850,000	$851,000-1,100,000	More than $1,100,000
Cosmetics						
Incisal adjustment	60.0%	48.2%	77.0%	73.0%	65.0%	80.2%
Shaping labial/lingual surface	25.7	20.5	35.1	35.2	29.2	37.4
Porcelain laminate veneers	2.9	0.0	1.4	2.5	2.5	3.9
Composite resin build-up	2.9	4.8	5.4	10.7	7.5	10.8
Anterior stripping (slenderizing)						
With hand instruments	42.9	25.3	39.2	42.6	35.8	41.6
With handpiece	25.7	20.5	24.3	31.1	30.0	39.2
With air turbine	5.7	7.2	13.5	16.4	15.0	19.2
Posterior stripping						
With hand instruments	8.6	10.8	21.6	16.4	12.5	13.5
With handpiece	11.4	15.7	14.9	16.4	15.8	18.0
With air turbine	0.0	8.4	12.2	14.8	13.3	11.7
Fiberotomy	5.7	3.6	4.1	5.7	5.8	3.6
Gingivectomy	2.9	1.2	4.1	0.8	5.0	5.1
Frenulotomy	5.7	1.2	4.1	5.7	9.2	6.6
Laser procedures						
Exposure of impacted teeth	0.0	3.6	1.4	6.6	9.2	14.4
Removal of opercula	0.0	2.4	0.0	2.5	0.8	4.8
Frenectomy	0.0	1.2	0.0	4.9	6.7	5.1
Gingivectomy	0.0	1.2	1.4	3.3	4.2	8.1
Ankyloglossia	0.0	2.4	0.0	0.8	0.0	1.2
Zig-zag (up-and-down) elastics	31.4	25.3	36.5	36.1	34.2	34.7
Equilibration	14.3	6.0	16.2	16.4	10.8	22.2
Positioner	0.0	8.4	2.7	1.6	2.5	4.5
Retention						
Removable						
Hawley	54.5	60.0	58.0	59.3	49.6	56.1
Spring retainer	9.1	8.8	17.4	14.4	10.4	10.9
Modified spring retainer	9.1	5.0	11.6	4.2	7.0	7.5
Clear slipover (invisible)	15.2	21.3	27.5	30.5	36.5	47.0
Essix	30.3	27.5	42.6	31.4	35.7	34.3
Invisalign	3.0	5.0	1.4	10.2	6.1	10.6
Fixed banded						
3-3	0.0	1.3	5.8	7.6	7.8	6.9
4-4	9.1	1.3	1.4	0.8	0.9	0.0
5-5	3.0	0.0	0.0	0.0	0.0	0.0
6-6	0.0	1.3	2.9	1.7	0.9	0.3
Fixed bonded						
Maxillary	9.1	2.5	10.1	9.3	8.7	15.0
Mandibular	45.5	15.0	39.1	38.1	42.6	50.2
2-2	6.1	1.3	4.3	5.1	13.0	11.5
3-3	42.4	23.8	44.9	43.2	47.0	57.6
4-4	3.0	0.0	2.9	0.0	0.0	1.2

patients, upper-premolar-extraction patients, and finishing. Pacific orthodontists used Invisalign most routinely for Class II and III and other premolar-extraction cases, although the differences among regions in treatment of Class III and extraction patients were not substantial.

Routine Invisalign usage generally increased with gross income for every type of treatment surveyed (Table 49). Still, only Class I cases with moderate crowding and space-closure cases were treated routinely by as many as 10% of the respondents in any group.

Skeletal Anchorage

Orthodontists who had been in practice for less than six years were clearly more comfortable than others in placing miniscrews themselves, and they had also received more of their training in university graduate and postgraduate programs (Table 50). Nevertheless, only Class II cases were treated more routinely with skeletal anchorage by this group than by any other age group.

There were marked regional differences in the use of temporary anchorage devices (Table 51). New England orthodontists were the most

TABLE 47
CASES TREATED ROUTINELY WITH INVISALIGN BY YEARS IN PRACTICE

	1-5	6-10	11-15	16-20	21-25	26+
Class I, moderate crowding	68.9%	60.3%	68.3%	68.1%	67.8%	63.5%
Class I, severe crowding	5.4	6.3	1.6	5.6	5.1	9.6
Class II	5.4	7.9	6.3	8.3	6.8	7.1
Class III	4.1	1.6	7.9	4.2	0.0	5.1
Space closure	41.9	42.9	49.2	40.3	45.8	54.5
Upper premolar extraction	0.0	4.8	0.0	4.2	1.7	2.6
Lower premolar extraction	0.0	0.0	0.0	1.4	0.0	1.3
Four-premolar extraction	0.0	0.0	0.0	1.4	0.0	1.9
Lower incisor extraction	8.1	4.8	6.3	5.6	3.4	10.9
Finishing/positioner	2.7	1.6	1.6	2.8	5.1	3.2

TABLE 48
CASES TREATED ROUTINELY WITH INVISALIGN BY GEOGRAPHIC REGION

	NE	MA	SA	ESC	ENC	WNC	MTN	WSC	PAC
Class I, moderate crowding	69.0%	67.6%	71.0%	57.1%	72.4%	51.7%	59.0%	54.2%	71.3%
Class I, severe crowding	10.3	5.4	6.5	4.8	8.6	3.4	5.1	8.3	8.0
Class II	6.9	5.4	3.2	4.8	10.3	6.9	0.0	4.2	16.1
Class III	6.9	5.4	1.1	4.8	6.9	6.9	0.0	2.1	6.9
Space closure	37.9	50.0	49.5	23.8	53.4	41.4	46.2	45.8	51.7
Upper premolar extraction	6.9	0.0	1.1	0.0	1.7	3.4	0.0	2.1	4.6
Lower premolar extraction	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	2.3
Four-premolar extraction	0.0	1.4	0.0	0.0	1.7	0.0	0.0	0.0	2.3
Lower incisor extraction	3.4	10.8	10.8	0.0	5.2	10.3	2.6	4.2	6.9
Finishing/positioner	6.9	5.4	5.4	0.0	3.4	0.0	2.6	0.0	0.0

TABLE 49
CASES TREATED ROUTINELY WITH INVISALIGN BY GROSS INCOME LEVEL

	Less than $200,000	$201,000-400,000	$401,000-600,000	$601,000-850,000	$851,000-1,100,000	More than $1,100,000
Class I, moderate crowding	47.4%	68.6%	60.5%	59.0%	62.5%	71.4%
Class I, severe crowding	5.3	0.0	4.7	4.8	9.7	8.3
Class II	5.3	0.0	2.3	4.8	9.7	9.5
Class III	0.0	2.9	0.0	7.2	4.2	4.6
Space closure	21.1	40.0	41.9	43.4	45.8	53.9
Upper premolar extraction	0.0	0.0	0.0	0.0	5.6	2.9
Lower premolar extraction	0.0	0.0	0.0	0.0	1.4	0.8
Four-premolar extraction	0.0	0.0	0.0	1.2	1.4	0.8
Lower incisor extraction	0.0	2.9	7.0	4.8	6.9	9.5
Finishing/positioner	0.0	5.7	4.7	4.8	4.2	1.2

TABLE 50
USE OF SKELETAL ANCHORAGE BY YEARS IN PRACTICE

	1-5	6-10	11-15	16-20	21-25	26+
Who usually places miniscrews?						
Orthodontist	53.3%	41.8%	45.7%	40.3%	36.0%	40.2%
Oral surgeon	33.3	43.6	45.7	46.8	50.0	46.6
Periodontist	13.3	12.7	4.3	11.3	14.0	10.3
General dentist	0.0	1.8	4.3	1.6	0.0	0.9
Training in skeletal anchorage						
University graduate course	34.0	14.5	7.7	6.0	14.6	9.2
Postgraduate course	30.0	24.2	19.2	29.8	14.6	33.8
Proprietary course	44.0	53.2	55.8	56.7	50.9	42.6
Other	6.0	4.9	7.7	7.5	9.1	10.8
Types of cases treated routinely						
Class I, crowding	2.3	1.9	0.0	5.1	2.2	3.6
Class II	15.9	7.4	13.3	15.3	15.2	10.0
Class III	0.0	1.9	0.0	3.4	4.3	3.6
Bimaxillary protrusion	9.1	3.7	8.9	6.8	13.0	5.5
Premolar extraction	6.8	5.6	4.4	6.8	4.3	5.5
Open bite	9.1	18.5	13.3	11.9	10.9	10.0
Molar intrusion	9.1	24.1	15.6	11.9	19.6	11.8
Molar distalization	2.3	3.7	6.7	6.8	10.9	7.3
Molar uprighting	4.5	11.1	8.9	5.1	6.5	6.4
Incisor translation/inclination	0.0	1.9	0.0	1.7	2.2	2.7
Midline correction	2.3	1.9	2.2	1.7	4.3	2.7

likely to refer placement of miniscrews to oral surgeons, and they also reported the least university training. Mountain and West South Central orthodontists appeared to have received the most training in graduate and postgraduate courses, while two-thirds of all Middle Atlantic orthodontists who used skeletal anchorage had been trained in proprietary courses. The most routine miniscrew users were in the East North Central region for Class I and III treatment; in the West North Central region for Class II and molar-distalization cases; in the East South Central region for bimaxillary-protrusion treatment, molar uprighting, incisor translation and inclination, and midline correction; in the Middle Atlantic region for premolar-extraction cases; and in the Mountain region for open-bite and molar-intrusion treatment.

Practices with the lowest income were most likely to place miniscrews themselves and to have had graduate or postgraduate training, which probably reflects the preponderance of younger orthodontists in this category (Table 52). As in Table 50, however, the low-income practices tended not to use skeletal anchorage on a routine basis.

Conclusion

Results of the 2008 JCO Study of Orthodontic Diagnosis and Treatment Procedures demonstrate the continuation of several trends noted in the four previous surveys:

- Fewer routine diagnostic records are being taken.
- The use of esthetic brackets and titanium-alloy archwires is increasing compared to stainless

TABLE 51
USE OF SKELETAL ANCHORAGE BY GEOGRAPHIC REGION

	NE	MA	SA	ESC	ENC	WNC	MTN	WSC	PAC
Who usually places miniscrews?									
Orthodontist	26.7%	39.5%	35.1%	57.1%	25.0%	39.1%	68.0%	41.9%	51.2%
Oral surgeon	66.7	47.4	46.8	21.4	60.4	56.5	24.0	39.5	41.9
Periodontist	6.7	10.5	16.9	21.4	14.6	4.3	8.0	14.0	4.7
General dentist	0.0	2.6	1.3	0.0	0.0	0.0	0.0	4.7	2.3
Training in skeletal anchorage									
University graduate course	0.0	9.5	13.6	21.4	7.8	3.7	17.6	21.3	12.0
Postgraduate course	6.2	26.2	23.9	21.4	21.6	25.9	32.4	29.8	32.6
Proprietary course	43.8	66.7	45.4	57.1	58.8	37.0	52.9	47.8	45.6
Other	18.8	4.8	5.7	14.3	9.8	11.1	8.8	8.5	8.8
Types of cases treated routinely									
Class I, crowding	0.0	2.6	4.3	7.7	8.9	4.8	3.8	2.4	1.2
Class II	6.7	15.8	15.7	7.7	17.8	19.0	7.7	4.8	12.9
Class III	0.0	2.6	0.0	7.7	8.9	0.0	3.8	2.4	1.2
Bimaxillary protrusion	6.7	2.6	7.1	23.1	6.7	9.5	3.8	0.0	10.6
Premolar extraction	6.7	10.5	4.3	7.7	6.7	9.5	0.0	2.4	7.1
Open bite	13.3	10.5	11.4	7.7	15.6	9.5	19.2	4.8	15.3
Molar intrusion	13.3	7.9	18.6	15.4	15.6	9.5	19.2	9.5	21.2
Molar distalization	13.3	7.9	8.6	7.7	6.7	14.3	7.7	2.4	5.9
Molar uprighting	13.3	7.9	4.3	15.4	4.4	9.5	7.7	0.0	11.8
Incisor translation/inclination	0.0	0.0	0.0	7.7	2.2	4.8	0.0	0.0	2.4
Midline correction	0.0	2.6	2.9	7.7	4.4	0.0	0.0	0.0	2.4

steel materials.

• Banding has been almost completely replaced by bonding, increasingly using indirect techniques; light-cured adhesives are gradually replacing chemical composites.

• Fixed functional appliances are gaining popularity compared to removable appliances, and routine headgear use (except for reverse headgear) is declining.

• Extractions are becoming almost rare in orthodontic treatment.

• Cosmetic finishing procedures are becoming fairly routine.

• Clear, removable retention appliances are gaining over Hawley and spring-type retainers, but bonded retainer wires are now almost standard in the mandibular arch.

• Routine TMJ treatment is not being performed by many orthodontists.

Significant new developments in technology, materials, and treatment methods are also apparent since the last Study in 2002:

• Digital imaging and computerized analysis are continuing a rapid growth.

• Self-ligating brackets have shown a dramatic increase compared to standard edgewise systems.

• Most orthodontists now feel they need to offer Invisalign treatment to their adult patients.

• Skeletal anchorage is also becoming a basic tool in the orthodontic armamentarium, especially as university curricula develop and new graduates open their practices. ❑

TABLE 52
USE OF SKELETAL ANCHORAGE BY GROSS INCOME LEVEL

	Less than $200,000	$201,000-400,000	$401,000-600,000	$601,000-850,000	$851,000-1,100,000	More than $1,100,000
Who usually places miniscrews?						
Orthodontist	55.6%	37.0%	38.5%	36.0%	41.9%	45.3%
Oral surgeon	33.3	33.3	34.6	56.0	48.4	43.8
Periodontist	0.0	25.9	23.1	8.0	8.1	9.9
General dentist	11.1	3.7	3.8	0.0	1.6	1.0
Training in skeletal anchorage						
University graduate course	22.2	22.2	20.7	8.6	17.6	9.7
Postgraduate course	55.6	29.6	27.6	22.4	26.5	26.0
Proprietary course	55.6	33.3	34.5	50.0	44.1	55.8
Other	0.0	11.1	17.2	12.1	5.9	7.1
Types of cases treated routinely						
Class I, crowding	0.0	0.0	0.0	1.9	1.7	5.1
Class II	11.1	12.5	4.3	9.6	13.8	13.8
Class III	0.0	0.0	4.3	7.7	0.0	2.1
Bimaxillary protrusion	0.0	8.3	4.3	11.5	5.2	7.2
Premolar extraction	0.0	0.0	8.7	7.7	3.4	6.7
Open bite	0.0	12.5	4.3	11.5	13.8	14.4
Molar intrusion	0.0	12.5	13.0	13.5	20.7	15.9
Molar distalization	0.0	8.3	0.0	9.6	10.3	6.2
Molar uprighting	0.0	4.2	13.0	5.8	5.2	7.7
Incisor translation/inclination	0.0	4.2	4.3	1.9	1.7	1.0
Midline correction	0.0	4.2	0.0	1.9	5.2	1.5

Attachment of Intermaxillary Elastics to Thermoformed Aligners

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Although intermaxillary elastics are most commonly used with fixed orthodontic appliances, they can also be used with removable, thermoformed appliances such as Essix* or Invisalign.** This article describes various methods of attaching intermaxillary elastics to thermoformed aligners.

*Registered trademark of Raintree Essix, Inc., 6448 Parkland Drive, Sarasota, FL 34243; www.essix.com.

**Registered trademark of Align Technology, Inc., 881 Martin Ave., Santa Clara, CA 95050; www.aligntech.com.

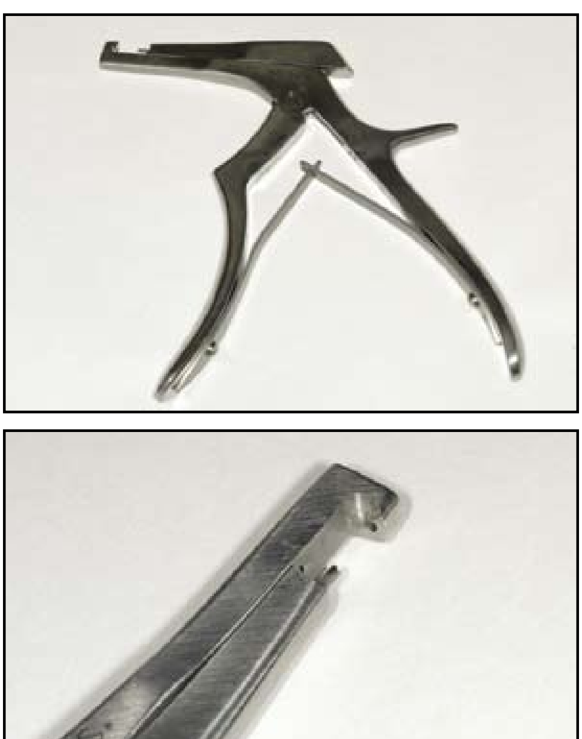

Fig. 1 Commercially available hole-punching pincers, with detail of head.

Rinchuse Slits

Elastic hooks can be made in aligners using specially designed tools such as the Hilliard Thermoplier Elastic Hook-Forming Pliers* or by creating vacuum-formed ball hooks in the aligner material.[1-2] A simpler technique, however, is to create "Rinchuse slits" in the aligners with scissors.[3] If the slits are appropriately angulated, the intermaxillary elastics can be attached directly between an aligner and another removable or fixed orthodontic appliance.

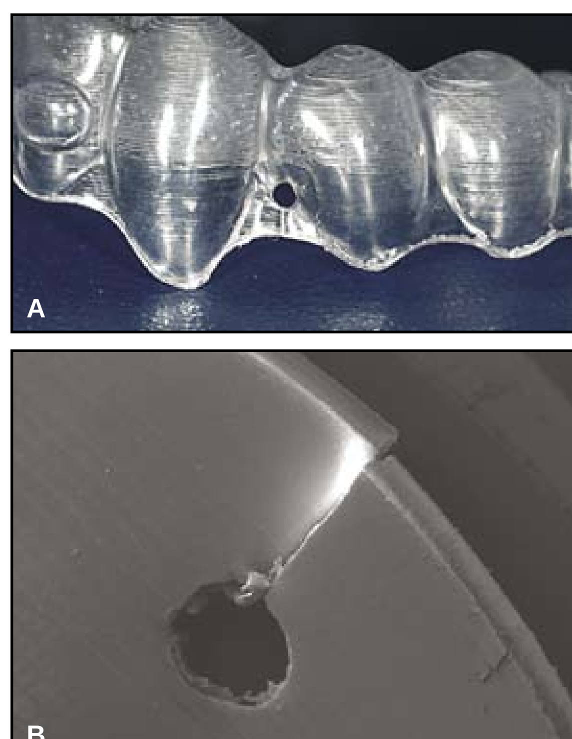

Fig. 2 A. Slit and hole made in aligner with pincers. B. Electron microscopic image.

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The sharp edges of Rinchuse slits can cause patient discomfort if the aligner is dislodged by the force of the elastics. To improve retention of an Essix-type aligner, undercuts can be made on the model or in the aligner itself with Hilliard Thermoplier Undercut Enhancing Pliers.* With the Invisalign system, bonding an appropriate number of attachments to the teeth will prevent dislocation of the aligner.

A disadvantage of Rinchuse slits is that as the aligners loosen with wear, their gingival borders may become ill-fitting, causing patient discomfort and deformation of the aligners by the elastics. Cutting the slits also weakens the aligner material, which, in combination with the forces exerted by the elastics, may lead to aligner breakage.

Bonded Buttons

Another method of attaching elastics to thermoformed aligners is by bonding metallic or composite buttons to the teeth and removing the corresponding sections of the aligners; alternatively, composite buttons can be attached to the aligners themselves.[4] These buttons may become detached from the teeth or aligners, however, and many patients find them esthetically unacceptable. Moreover, the removal of portions of the aligner to accommodate bonded buttons is not only time-consuming, but may create sharp edges that can cause patient discomfort.

Hole-Punching Tool

Problems associated with Rinchuse slits and bonded buttons can be addressed by using a hole-punching tool that produces smooth edges in the aligner material; a commercially available pincer tool*** has been designed specifically for this task (Fig. 1). The instrument is used to make small holes in the aligner that will accommodate either intramaxillary or intermaxillary elastics (Fig. 2). The process is quick and easy, and the holes prevent the elastics from detaching and the aligner from breaking. In addition, the discomfort associated with sharp edges is eliminated. The patient can easily attach intermaxillary elastics to the upper and lower aligners before placing them in the mouth (Fig. 3).

***Hammacher Instrumente, Steinendorfer Str. 27, D-42699 Solingen, Germany; www.hammacher.de.

Fig. 3 A. Elastic inserted in hole. B. Class III elastic attached to upper and lower aligners. C. Aligners with Class III elastic in place.

"Virtual Hooks"

For patients using the Invisalign system, another simple method of attaching elastics is to form "virtual hooks" in the aligners. Attachments are normally designed during the ClinCheck** stage, so that raised bumps will be built into the aligners to accommodate the attachments. To create "virtual hooks", instead of bonding attachments to the teeth, convert the bumps into hooks as follows:

1. During the ClinCheck procedure, specify vertical rectangular attachments (5mm × 2mm × 1mm) on the canines and horizontal rectangular attachments (4mm × 2mm × 1mm) on the molars.
2. When the aligners and template arrive, bond attachments as usual to any teeth that are not involved in the "virtual hooks" arrangement.
3. Using a diamond disk, carefully slice into the bumps in the aligners to form hooks for elastics in the planned locations (Fig. 4). In the example shown, for attachment of Class II elastics, the

**Registered trademark of Align Technology, Inc., 881 Martin Ave., Santa Clara, CA 95050; www.aligntech.com.

Fig. 4 Diamond disk used to slice into raised bumps in upper and lower aligners for attachment of elastics.

Fig. 5 Class II elastics attached to "virtual hooks" on aligners.

bump at the upper canine is sliced from the gingival, and the bump at the lower first molar is sliced from the distal.

4. Show the patient how to insert the intermaxillary elastics while wearing the aligners as prescribed (Fig. 5).

The "virtual hooks" are economical, quick, and easy to produce, with no unexpected effects on the planned biomechanics. They are generally comfortable for the patient, and compliance is good because of the ease of placing the elastics, even on the most posterior teeth. The disadvantages of this method are that it must be planned in advance and that it requires some extra work at the chair each time the aligners are changed.

Conclusion

A hole-punching pincer is an effective tool for overcoming the disadvantages of other methods of attaching elastics to both Essix-type and Invisalign thermoformed aligners. The "virtual hooks" are another effective means of attaching elastics in patients being treated with the Invisalign system. Because any significant modification can eventually weaken the aligners, however, we recommend using them for no longer than one month at a time.

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OVERVIEW

Guidelines for Success in Placement of Orthodontic Mini-Implants

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(Editor's Note: In this quarterly column, JCO provides an overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Various skeletal anchorage devices were introduced in the late 20th century, including prosthodontic implants, zygoma ligatures, palatal onplants and implants, retromolar implants, miniplates, and surgical screws.[1] The latter, which became known as temporary anchorage devices (TADs), have become increasingly popular because they are small and easy to insert and remove, they can be loaded immediately after insertion, and they can provide absolute anchorage for many types of orthodontic treatment, with no need for special patient compliance.[2-5] The use of orthodontic mini-implants is not without risks and complications, however; reports of miniscrew failure rates and causes have been published by numerous authors.[6-16]

Miyawaki and colleagues, in a study of 134 titanium screws of three different types, found that factors related to miniscrew failure included a screw diameter of 1mm or less, inflammation of the peri-implant tissues, and a high mandibular plane angle associated with thin cortical bone.[6] In a prospective study involving 44 patients treated with a total of 140 mini-implants, Cheng and colleagues reported a success rate of 89%; risk factors were identified as reduced bone quality and quantity at the insertion sites, soft-tissue characteristics such as absence of keratinized mucosa, and peri-implant bacterial infection.[7] More recently, Park and colleagues identified the jaw in which the miniscrew is placed, the side of placement relative to individual oral hygiene, and the lack of primary

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TABLE 1
MINISCREW SUCCESS RATES FOR VARIOUS LOADING TIMES

Authors	Year	Sample Size	Time of Loading	% Success
Miyawaki et al.[6]	2003	134	Variable	83.9-85.0
Fritz et al.[15]	2004	36	During first 4 weeks	70.0
Cheng et al.[7]	2004	140	After 2 weeks	89.0
Park et al.[8]	2006	227	Variable	91.6
Chen et al.[9]	2006	59	After 2 weeks	84.7
Motoyoshi et al.[10]	2006	124	Immediate	85.5
Tseng et al.[11]	2006	45	After 2 weeks	91.1
Kuroda et al.[12]	2007	116	Immediate-12 weeks	81.1-88.6
Luzi et al.[13]	2007	140	Immediate	90.7
Wiechmann et al.[14]	2007	133	Immediate	86.8
Chen et al.[16]	2007	273	Delayed	76.4-82.6

stability as additional factors.[8]

In either jaw, anterior implant placement has reportedly been more successful than posterior placement because of the detrimental effects of mastication forces.[8,11,12] Chen and colleagues concluded that screw length is a factor in success or failure after finding a higher success rate for 8mm implants (90.2%) than for 6mm implants (72.2%).[9] Motoyoshi and colleagues suggested that adequate placement torque was important to success,[10] while Luzi and colleagues emphasized the importance of proper insertion technique.[13] Wiechmann and colleagues found a significantly lower success rate for implants inserted in the lingual aspect of the mandible compared to other locations.[14]

The timing of orthodontic force loading—immediate, early, or delayed—has been discussed as a possible factor in TAD failure.[17] A delay before loading was recommended for the first skeletal anchorage systems, but immediate loading is now accepted, as supported by several histological[18-20] and clinical[10,13,14] studies. The success rates found in previous studies do not differ widely according to the time of loading (Table 1).

Despite the considerable research already published on miniscrew failures, most of these studies have been retrospective, have involved a limited number of patients, and do not include detailed descriptions or analyses of the reasons for failure. In this article, we report the results of a prospective clinical study that was conducted to improve our understanding of the factors involved in mini-implant success.

Materials and Methods

The study involved 137 adolescent and adult patients (52 male and 85 female) treated with fixed appliances at the Department of Orthodontics, School of Dentistry, Aarhus University, Denmark. All patients were informed about mini-implant procedures and risks and provided written consent to participate in the study. The indications for skeletal anchorage included insufficient teeth for the application of conventional anchorage, a high risk of adverse side effects on the anchorage units, planned asymmetrical tooth movements, the need for tooth movement to generate bone for prosthodontic implants, and special anchorage requirements to avoid orthognathic surgery. Aarhus Mini-Implants* with a length of 9.6mm or 11.6mm and a diameter of 1.5mm or 2mm were used in all patients.

A total of 211 miniscrews were inserted, 82

*Registered trademark of Medicon, Tuttlingen, Germany; www.medicon.de.

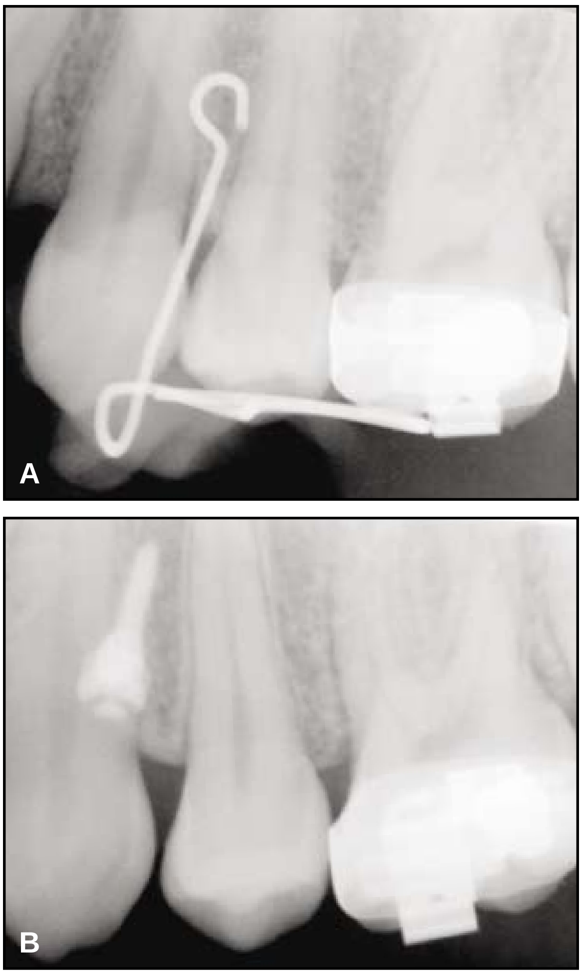

Fig. 1 A. Custom-made orthodontic wire template positioned over desired insertion area. B. After miniscrew insertion.

Fig. 2 Various Aarhus Mini-Implants* used in study.

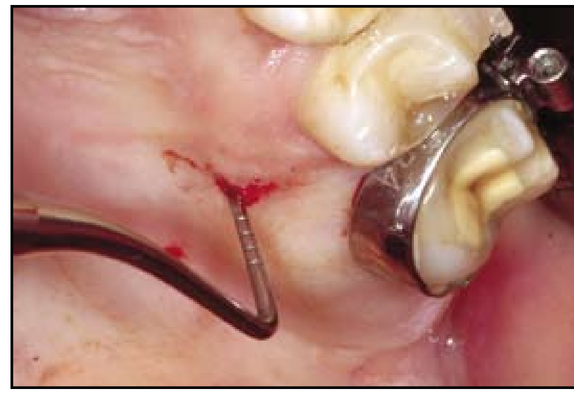

Fig. 3 Measurement of soft-tissue thickness in palatal area with periodontal probe.

in the maxilla and 129 in the mandible. The insertion sites, determined according to the planned dental movements and available bone, included the alveolar processes of both jaws, the palate, the mandibular symphysis, and the upper and lower retromolar areas. To evaluate the anatomical details of each insertion site, a periapical radiograph was taken using a custom-made template (Fig. 1). This radiograph was used to guide the selection of a miniscrew of appropriate size and shape (Fig. 2).

After administration of local anesthesia, the mucosa surrounding the insertion site was rinsed with a .02% chlorhexidine solution for two minutes. The soft-tissue thickness was measured with a periodontal probe or an endodontic file at the same inclination as the desired insertion angle of the miniscrew (Fig. 3). Because the mini-implants were self-drilling and self-tapping, it was not necessary to raise flaps for transmucosal insertion, although in areas of thick cortical bone (the mandibular symphysis and lower retromolar areas), a pilot hole was drilled using a low-speed bur and light pressure under constant irrigation. Each miniscrew was inserted with a manual screwdriver until the entire threaded portion was inside the bone, with only the head visible in the oral cavity.

After insertion, all miniscrews were immediately loaded, either directly or indirectly, using low forces of 50-100g from superelastic closed-coil springs (Fig. 4). In some cases, the skeletal

TABLE 2
MINISCREW FAILURE RATES BY INSERTION SITE

Site	No. Implants	No. Failures	%
Maxillary alveolar process	70	5	7.1
Mandibular alveolar process	100	9	9.0
Mandibular symphysis	19	2	10.5
Palate	12	2	16.7
Retromolar area	10	1	10.0

Fig. 4 Direct loading of miniscrews used as anchorage for canine retraction.

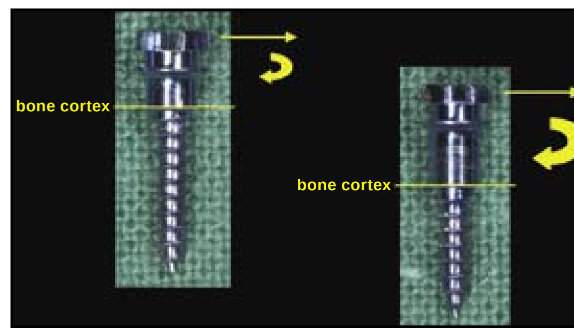

Fig. 5 Increased torsional force and moment generated on miniscrew by increasing distance between point of force application and resistance level (bone cortex).

anchorage was combined with other anchorage methods to achieve dental movements such as incisor intrusion and proclination, incisor retraction, premolar intrusion, midline correction, premolar distal movement, molar intrusion and uprighting, molar uprighting and mesial movement, molar intrusion and mesial movement, and molar mesial movement. Patients were given precise oral hygiene instructions, and all miniscrews were left in place until the desired tooth movements had been achieved. The miniscrew placement was considered successful if the implant withstood continuous mechanical loading for at least 120 days.

Results

Nineteen of the 211 miniscrews (9.0%), placed in 15 different patients, failed and had to be removed (Table 2). Eight of these were in the upper jaw (9.8% of the maxillary miniscrews) and 11 in the lower jaw (8.5% of the mandibular miniscrews). The failures occurred at five different anatomical sites. Because the number of failures was considered low relative to the number of possible causes of failure, the analysis was performed without statistical testing.

Causes of failure were divided into three categories (Table 3): dentist-related (incorrect surgical procedure), patient-related (bone characteristics, soft-tissue thickness, inflammation or poor hygiene, and increased bone metabolism), and implant-related (screw breakage). Each of these factors accounted for between two and five failures, or between 1.0% and 2.4% of the total miniscrews inserted.

Discussion

The overall implant success rate of 91% in our study is slightly higher than the rates reported in most of the previous studies reviewed. Although other authors have reported higher success rates for maxillary implants,[8-11,15,16,21] the mandibular implants in our sample were slightly more successful than the maxillary implants (91.5% vs. 90.2%).

TABLE 3
CAUSES OF MINISCREW FAILURE

Category	Cause	No.	Patient Initials	%
Dentist-related	Incorrect surgical procedure	2	M.M., L.E.	1.0
Patient-related	Bone characteristics	5	B.H.(3), M.N., N.R.	2.4
	Soft-tissue thickness	4	H.O., B.L., R.D., R.M.	1.9
	Inflammation/hygiene	4	Y.S., D.E.(2), R.B.	1.9
	Increased bone metabolism	2	C.W., M.N.	1.0
Implant-related	Screw breakage	2	A.S., C.H.	1.0
TOTAL		19	15 patients	9.0

The higher density of mandibular bone is probably conducive to primary stability, but negative factors such as mastication forces and surgical difficulties related to the anatomical structure of the mandible may outweigh this advantage, especially in the posterior segments.

Incorrect insertion technique has been identified as a primary cause of failure in implant dentistry.[22] For orthodontic miniscrews, transmucosal flapless insertion after decontamination of the site with a chlorhexidine rinse is standard procedure, since flap surgery or mucoperiosteal incisions would cause more pain and discomfort.[12] Inadequate irrigation of the surgical site, excessive drill speed, wiggling movements of the screwdriver, and insufficient placement torque are among the most common mistakes. Operator experience is thus an important factor in reducing failure rates.[13,15]

Patient-related causes of possible failure should be thoroughly evaluated before miniscrew placement. There seems to be general agreement that the sex and age of the patient are unimportant; only Chen and colleagues, in a retrospective study of 129 patients, found that patients younger than 30 had a higher risk of failure than older patients.[16] On the other hand, anatomical issues seem to be highly significant. Insertion sites with extremely thin cortical bone provide less primary stability, but thick soft tissue may reduce the proportion of the miniscrew engaged in the bone and increase the torsional moment on the implant, due to the increased distance between the point of force application and the screw's center of resistance (Fig. 5). As in general implant dentistry, systemic diseases associated with increased bone metabolism or negative bone balance, such as osteoporosis and uncontrolled diabetes, can also reduce the chances of success.

Fig. 6 Screw broken during insertion.

Inflammation of the peri-implant soft tissues is another potential factor[6-8,13] that caused the loosening of four miniscrews in the present study. Strict oral hygiene, including thorough brushing of the miniscrew head with a soft toothbrush after every meal, is needed to minimize the risk of inflammation. Insertion of the device in the attached gingiva is recommended to avoid interference with the functional movements of the soft tissues apical to the mucogingival line. Anti-inflammatory drugs should not need to be routinely prescribed.[17]

Although miniscrews are now designed to withstand standard orthodontic forces of torsion and flexion,[5] improper insertion or removal can cause breakage, as with two screws in our sample (Fig. 6). The advent of self-drilling miniscrews has facilitated insertion, reducing the amount of torsional force required, but it may still be necessary to drill or enlarge a pilot hole if substantial resistance to insertion is encountered.

The risk of injury to dental roots during placement is one of the greatest concerns with orthodontic mini-implants, especially when they are inserted between teeth. Placement of a mini-screw too close to a root can also result in insufficient bone remodeling around the screw and transmission of occlusal forces through the teeth to the screws, which can lead to implant failure.[21] Even though periodontal structures can heal after being injured by TADs,[23] it is important to select insertion sites carefully, using thorough clinical and radiographic evaluation of their anatomical details.

Conclusion

Mini-implant failure can involve factors related to the clinician, the patient, and the screw itself. Large, multicenter studies are needed to shed additional light on the processes involved in skeletal anchorage so that failure rates can be reduced even further.

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Considerations in Mandibular Incisor Extraction Cases

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Tooth-size-arch-length discrepancy, or arch crowding, has traditionally been managed by means of first or second premolar extractions; first or second molar extraction is a less common approach.[1] Incisor extraction is another alternative in the mandibular arch. In 1905, Jackson described a case in which two lower incisors were extracted at different times to relieve mandibular crowding.[2] Since then, a few case series and clinical studies of this treatment modality have been reported.[3-5]

Previous authors have listed specific criteria for mandibular incisor extraction: permanent dentition, minimal growth potential, a Class I molar relationship, a harmonious soft-tissue profile, minimal-to-moderate overbite, little or no crowding in the maxillary arch, an existing Bolton discrepancy, and a tooth-size-arch-length discrepancy of more than 5mm in the anterior region.[3,6] A diagnostic setup is strongly recommended with this treatment approach.[7-9]

Mandibular incisor extraction has several advantages over premolar extractions. First, it may reduce treatment time, especially if crowding is limited to the anterior segment.[7] Second, a more stable result is likely in the anterior region, because expansion is not necessary and intercanine width is minimally altered.[5] Finally, because little retraction is required compared with premolar extraction therapy, the anteroposterior position of the mandibular incisors is not changed, allowing maintenance of a harmonious profile.[6]

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Mandibular incisor extraction therapy has some disadvantages as well. If no Bolton discrepancy exists, closure of the incisor space will result in increased overjet. If the overjet is adequate after the incisor is removed, the result will be a Class III occlusal relationship. Moreover, a midline discrepancy is inevitable, and the extraction site may reopen over the long term.[5,10] Finally, the interproximal papillae may be sacrificed, which may lead to the development of open gingival embrasures or "black triangles".[4,11]

The critical decision of which lower incisor to extract depends on several considerations, including periodontal conditions, the presence of gingival recession, and the location of any restorations, including endodontic treatment. In addition, the mesiodistal width of each incisor should be measured and the anticipated amount of tooth movement determined with the Bolton analysis, keeping in mind that in the mandible, the central incisors tend to be smaller than the lateral ones. Extraction of a lateral incisor is generally preferred because it is less visible from the front,[6] but the incisor that is farthest outside the natural arch and closest to the crowding is usually the best candidate for extraction.

Case Selection

Mandibular incisor extraction therapy is more appropriate for certain types of malocclusion than for others, making proper case selection important. It is especially suitable for patients with Class I (Fig. 1) and mild Class III malocclusions with mild open-bite tendencies.[3,4] Faerovig and

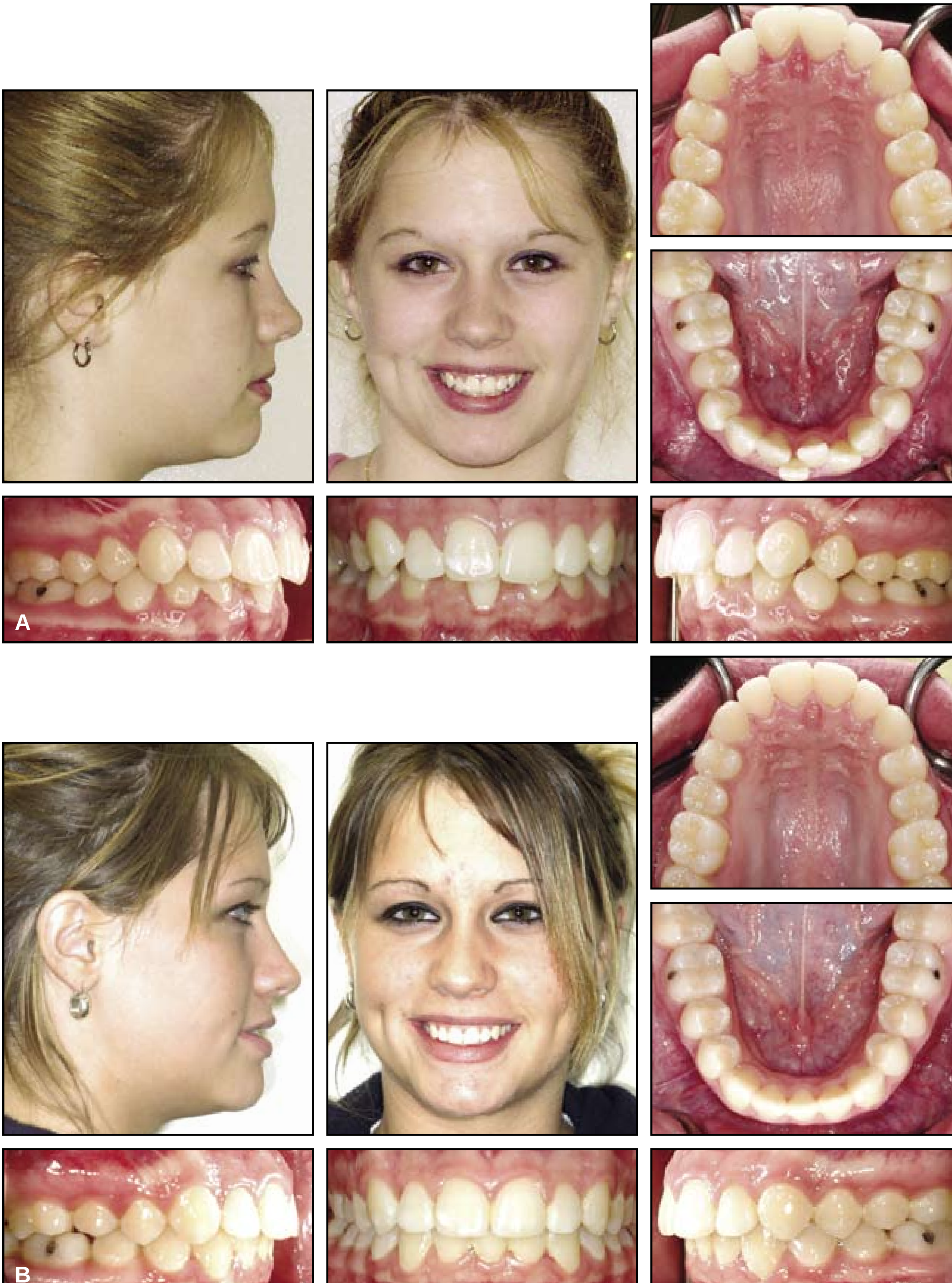

Fig. 1 Case 1. A. 15-year-old female patient with more than 5mm of mandibular anterior crowding, mild maxillary crowding, harmonious profile, Class I molar relationship, and minimal-to-moderate overbite before treatment involving extraction of mandibular right central incisor. B. Patient after 20 months of treatment, showing achievement of proper overjet and overbite and maintenance of buccal anteroposterior relationship. New mandibular midline is at midpoint of left central incisor.

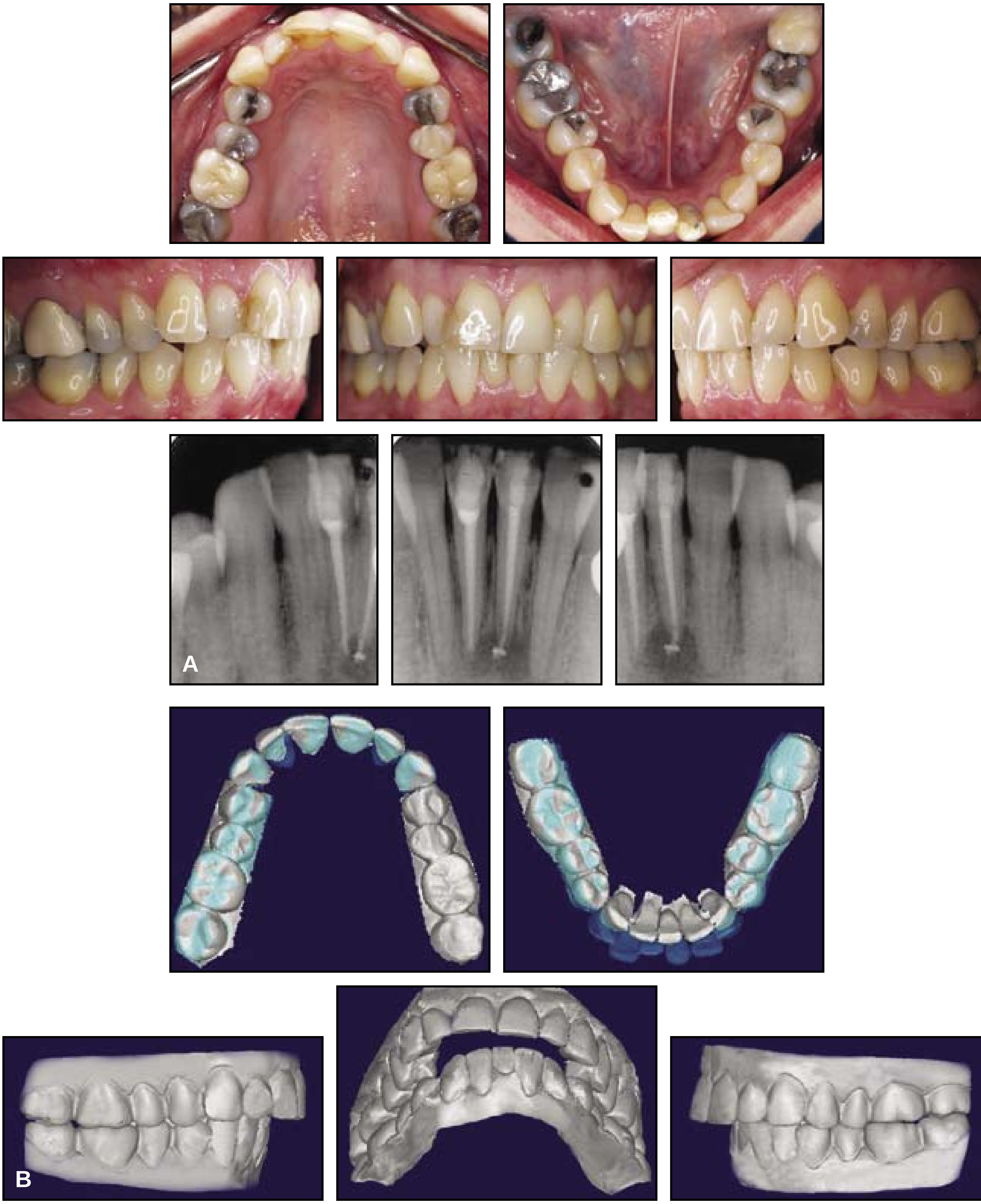

Fig. 2 Case 2. A. Adult patient with convex profile, mild Class II tendency, and moderate mandibular crowding before treatment. B. Occlusion after extraction of mandibular left central incisor; note excessive overjet. C. Progress records after 14 months of treatment, showing reduction of overjet through interproximal reduction of maxillary anterior teeth.

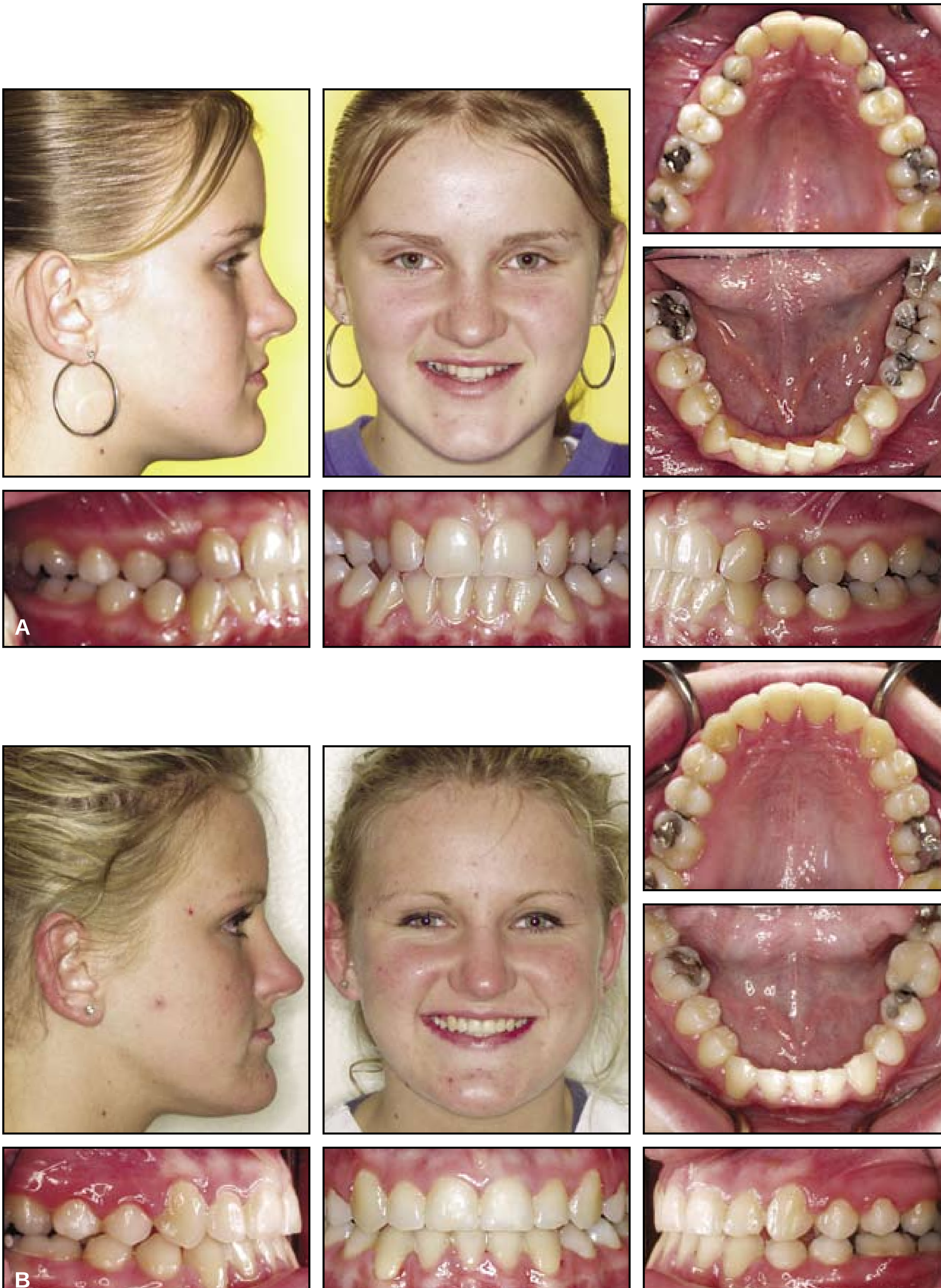

Fig. 3 Case 3. A. 13-year-old female patient with mildly concave profile and moderate Class III occlusion (half-cusp Class III relationship in left buccal segment) before treatment involving extraction of mandibular right central incisor. B. Patient after 38 months of treatment, showing slightly more concave soft-tissue profile, improved overjet and overbite, and unchanged buccal segments.

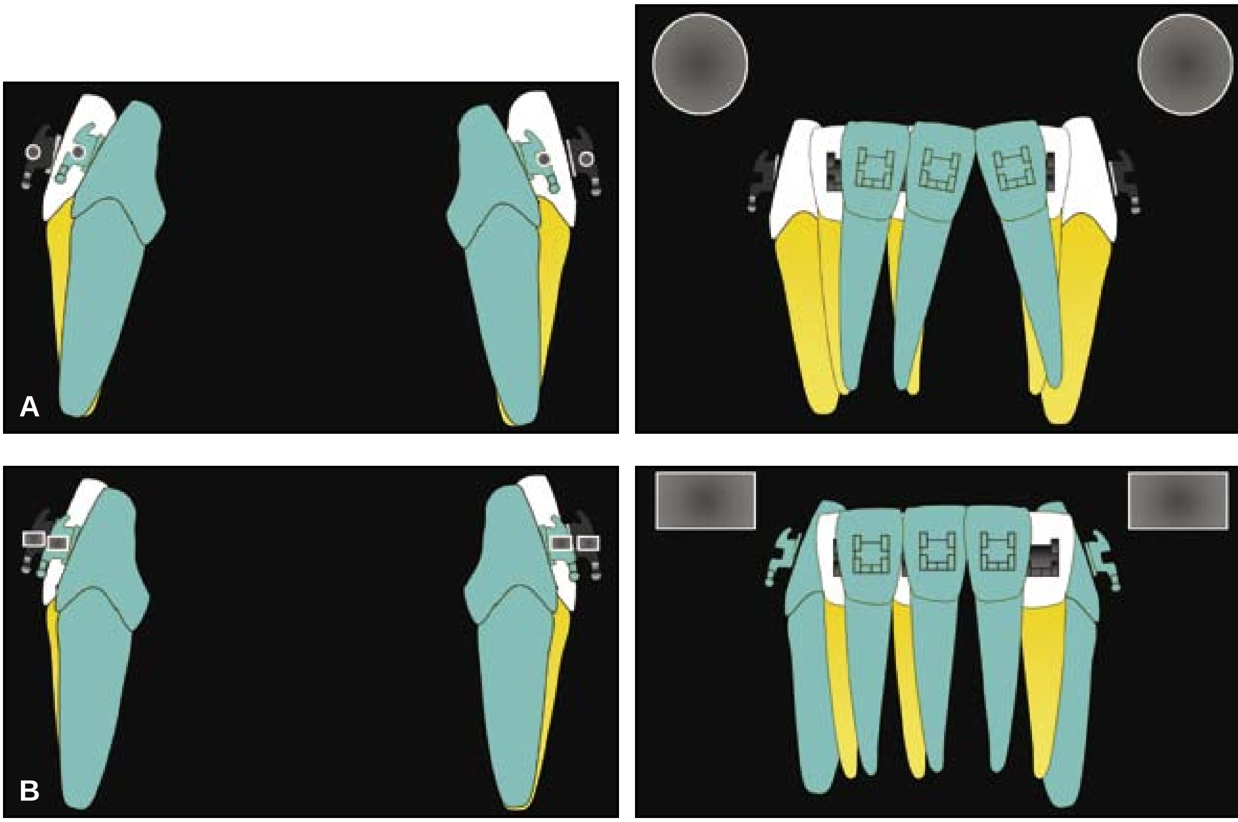

Fig. 4 A. Use of round wire for space closure can cause lingual tipping of canines (leading to excessive overbite in canine area) and mesial tipping of incisors; more incisal interproximal contact may create open gingival embrasure or "black triangle". B. Use of rectangular wire to fill bracket slot will control both types of undesirable tooth movement. (Green-shaded teeth show tooth positions resulting from different mechanical approaches.)

Zachrisson reported that in mild Class III patients who underwent mandibular incisor extractions, the lower incisors were tipped lingually by about 5° and 2mm at the incisal edges, the intercanine width was reduced by an average of 3mm, and the intermolar width did not change.[4] In the vertical dimension, the lower incisors moved not only lingually, but occlusally. Such extrusive movement would clearly be favorable in a patient with a mild Class III and anterior open bite.[4]

Mandibular incisor extraction may also be considered when the patient has congenitally missing maxillary lateral incisors and significant mandibular anterior crowding.[12,13] The Bolton discrepancy created by the missing mandibular incisors can be normalized by reducing the mesiodistal space of the implant sites. To maintain sufficient space for the implants, however, the width of these sites should not be reduced to less than 6mm.

Mandibular incisor extraction is generally contraindicated in a Class II patient, because it would result in a significant increase in overjet. The adult patient in Figure 2 presented with moderate mandibular crowding, a convex profile, and a Class II tendency. This patient had a history of trauma to the lower incisors, with a chronic periapical process on the mandibular left central incisor. In addition, Bolton analysis revealed a mandibular excess of .5mm. Given the tooth-size-arch-length discrepancy in the mandibular arch and the questionable prognosis of the mandibular left central incisor, it was decided to extract this tooth (Fig. 2B). Rather than extracting the maxillary premolars, we decided to significantly reduce the interproximal enamel of the six maxillary anterior teeth (Fig. 2C).

Mandibular incisor extractions are most

Fig. 5 Examples of black triangles of various sizes, from barely to very noticeable.

appropriate in patients who do not require anteroposterior alterations in the buccal segments. Therefore, it is generally not indicated in moderate-to-severe Class III malocclusions, because the buccal occlusion would not be corrected (Fig. 3).

Mechanics

The first challenge in mandibular incisor therapy is closure of the extraction space. To prevent excessive lingual tipping of either the incisors or the canines due to the forces generated by the elastomeric chain, space closure should be performed using the largest possible rectangular archwire (Fig. 4). This is particularly important in cases where the majority of the space will be closed by movement of the adjacent teeth. A rigid archwire will also prevent tipping of the adjacent incisors into the edentulous site, which would displace the tooth contact to the incisal edges, increasing the risk of black-triangle formation (Fig. 5).

Black triangles are not only common after mandibular incisor extraction therapy,[4,11] but have been found to occur in 40% of adults after any kind of orthodontic treatment.[14] This may be an important consideration, especially in older patients, since mandibular incisor display increases with age.[15] Adult patients should be informed of the potential for such side effects.

Development of black triangles has been attributed to a number of factors, including periodontal bone loss, more incisal interproximal contact, triangular incisors, and divergent root angulations.[16] In a study of interproximal contacts between all teeth, Tarnow and colleagues found that if the distance from the crest of the bone to the interproximal contact exceeded 5mm, a black triangle would appear 98% of the time.[17] Faerovig and Zachrisson reported no cases of black-triangle formation in a sample of patients who had undergone mandibular incisor extractions; they attributed their success to careful selection of patients with little pretreatment crowding, reduction of mesiodistal enamel as needed, and an emphasis on creating optimal axial inclinations of the lower incisors.[4]

In an unpublished study, we found black-triangle formation in nearly 70% of the patients who underwent mandibular incisor extractions, with the magnitude considered "significant" in 50% of the cases. No clear predictors were found, including age, sex, the amount of contact area before extraction, and whether the extracted incisor was central or lateral. We did find, however, that a more incisal interproximal contact after treatment was always followed by the formation of black triangles.

Although it may not be possible to eliminate black triangles completely, the risk can be reduced by limiting the distance from the crestal bone to the contact area. This involves either increasing the bone level in the occlusal direction or moving the contact gingivally. The latter is usually more predictable, and it can be accomplished in one of three ways. First, the root structures can be converged to displace the contact more gingivally, although an extremely low gingival contact will enlarge the incisal embrasure, possibly resulting in uneven incisal edges. Second, the teeth adjacent to the gingival embrasure can be slenderized and the space closed through bodily translation. This option has a potential disadvantage: it may accentuate the anterior Bolton discrepancy created by the mandibular incisor extraction. Third, the incisors adjacent to the extraction site can be built up with composite or veneers. This can be technically difficult, because mandibular incisors tend to be small and often have triangular crowns and roots.

Conclusion

Mandibular incisor extraction can be an effective treatment option in selected cases, particularly those with mild Class III malocclusions. In patients with moderate crowding and without excessive mandibular tooth mass, interproximal reduction may be a better alternative. Formation of open gingival embrasures or black triangles is a common side effect of mandibular incisor extraction. It is difficult to predict the risk of this phenomenon, but it may be an important esthetic consideration, especially in older patients.

ACKNOWLEDGMENTS: We are indebted to Dr. Brett Holliday for her contribution to the preparation of this manuscript.

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THE READERS' CORNER

JOHN J. SHERIDAN, DDS, MSD

(Editor's Note: The Readers' Corner is a quarterly feature of JCO in which orthodontists share their experiences and opinions about treatment and practice management. Pairs of questions are mailed periodically to JCO subscribers selected at random, and the responses are summarized in this column.)

1. In what percentage of cases are you using esthetic (ceramic, plastic, or miniaturized metal) brackets, and which esthetic brackets do you prefer?

Only two respondents indicated that they didn't use esthetic brackets at all, but nearly as few clinicians said they used them in every patient. The norm seemed to be around 25-30% of all cases; approximately an equal minority used esthetic brackets in fewer than 5% of their cases or in more than 60% of their cases.

The most commonly used esthetic bracket was Clarity (3M Unitek), followed by In-Ovation C and Mystique (GAC), Inspire and ICE (Ormco), Luxi II with the gold slot insert (RMO), and Radiance (American).

How would you compare the relative patient acceptance of ceramic, plastic, miniaturized metal, and conventional metal brackets?

There was a strong consensus that patients preferred esthetic brackets over conventional metal brackets. Many clinicians indicated that their acceptance rate was "excellent", with just a handful seeing no difference in patient acceptance between esthetic and conventional brackets.

Some typical comments included:

• "We have found that the acceptance rate of conventional metal brackets is significant if all the pluses and minuses are explained to the patients."
• "There is a definite trend in my practice. Kids like metal brackets and colored ligature ties. Adults prefer ceramic brackets."
• "Adults almost exclusively choose the Clarity bracket. Children prefer 'colors' and consequently choose metal. I do not charge a different fee for ceramic vs. metal, so cost is not an issue."
• "I don't feel guilty charging an extra fee for ceramic brackets. They cost me more, and I have to put up with the aggravation of dealing with fracturing, the extra time to rebond broken brackets, and grinding away fractured ceramic particles when debonding."

Where do you normally place esthetic brackets?

Most respondents said they restricted their use of esthetic brackets to the upper arches of adult patients—usually from first premolar to first premolar, occasionally from canine to canine, and even less frequently from second premolar to second premolar. Esthetic brackets were generally not placed on the lower anterior teeth, except for patients who conspicuously displayed those teeth in talking or smiling.

One clinician remarked:

• "I routinely place ceramic brackets on the upper anterior teeth, but I am reluctant to place them on lower incisors in deep-bite cases because porcelain can scar the lingual of upper incisors."

Do you use the same etching and bonding technique with esthetic brackets as with metal brack-

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ets, and if not, how does your technique differ?

Fully 72% of the respondents who reported using esthetic brackets said they used the same etching and bonding procedures as with metal brackets. Of the remainder, some used a bonding adhesive that they would not have used with precoated metal bases, and a few used porcelain primers to improve the adhesion of the esthetic bracket bases to the enamel.

What problems have you encountered with esthetic brackets?

About 10% of the respondents reported finding no specific difficulties with esthetic brackets. Most of the others were concerned about the fragility of esthetic brackets, indicating that they found the fracture rate on the bracket wings, especially when applying strong torque, to be unacceptable. Another frequently mentioned problem was the propensity of porcelain brackets to fracture during debonding, which required grinding off the remainder of the brackets. These issues became even more pronounced when brackets had to be repositioned.

Also mentioned were the cost of esthetic brackets, their tendency to discolor over time, the interference of bracket friction with sliding mechanics, the difficulty of precise positioning, the wearing away of plastic brackets, and the abrasion caused by ceramic brackets on the lower incisors in tight occlusion.

Representative responses included:

• "I have had very few problems with esthetic brackets. Occasionally there is fracture of the tie wings. I have found that the Clarity bracket debonds easily and acts like a conventional twin bracket."

• "Ceramics are not all that esthetic. They stain over time, the metal archwire is still obvious, and the elastic ligatures also tend to stain."

What improvements would you like to see in esthetic brackets?

The majority of respondents called for a stronger and smaller esthetic bracket with a much lower risk of fracture during treatment and debonding. Some said they would appreciate less expensive brackets, an improved capacity of the bases to allow microetching and rebonding, better hooks for elastics, more transparency, better technology to improve bracket positioning, and enhanced bonding tenacity for adhesion to porcelain crowns or facings.

Are you using esthetic brackets less than previously and if so, why?

Only about a quarter of the clinicians reported that they were using esthetic brackets less frequently. Their reasons included patient objections to the extra costs, prolonged treatment due to the fragility of the brackets, and excessive bracket friction. Other reasons given for declining enthusiasm included the bulkiness of esthetic brackets and their tendency to discolor. Many of the clinicians also noted that patients did not object to metal brackets if they were assured that treatment would likely be shorter and the outcome somewhat better.

Pertinent comments included:

• "I have a busy practice, and I much prefer the much more efficient metal self-ligating bracket."

• "My adult patients are usually enthusiastic about the esthetic quality of ceramic brackets. They are simply less obvious than metal brackets, and that's an esthetic step up."

• "They make treatment more difficult, and most patients don't seem to care. Some adult patients have been disappointed in the esthetic brackets because they were more bulky, less comfortable, and discolor."

2. How long have you practiced orthodontics?

As would be expected, there was a wide range of experience (5-41 years) among the orthodontists in this informal survey. The majority of respondents were centered in the 20-to-35-year range.

How many clinical/laboratory staff members are in your practice?

About 40% of the practitioners reported having three or fewer clinical/laboratory staff members. This was balanced by those who employed four to eight and a few who worked with 10 or more. One clinician had 18 clinical and lab staff members on his team.

What illnesses or other physical afflictions have you or your staff experienced that you can attribute to your practice of orthodontics?

Contact dermatitis, latex allergies, and skin reactions were much more prevalent among staff members than among the orthodontists themselves, with skin reactions being the most common afflictions. Respiratory conditions and skin hypersensitivity from working with resins and composites were rarely reported by either staff members or doctors.

Musculoskeletal pain and carpal-tunnel syndrome were roughly four times more prevalent among staff than among clinicians. The reported incidence of neck, shoulder, and back pain was higher for both groups, afflicting about 11% of the staff members and 5% of the orthodontists. Eye problems were less common, with about an equal distribution among staff and clinicians. Communicable diseases such as flu were rarely noted.

Pertinent comments included:

• "Neck/shoulder/back pain was usually associated with a stressful day. I have been diagnosed with two bulging neck disks, but I am asymptomatic now due to a physical therapy program."

• "I have no problems with eyes other than the times I need magnifying glasses to work on certain patients."

In the past 12 months, have you or your staff suffered any puncture wounds? If so, did they cause infection?

Respondents reported puncture wounds during the past year in about 18% of the doctors and 22% of staff members. Infections were rare, however, probably due to the immediate attention given to the wounds.

About how many work days have you lost due to occupational illnesses in the past 12 months?

A clear majority of the clinicians said that their staff members rarely lost work days and that the orthodontists themselves had lost none due to occupational illnesses over the past year. When staff members had to miss work, it was usually for a single day, with only two responses indicating lost intervals of six or seven days.

About how many work days have you lost due to work-related accidents in the past 12 months?

The replies indicated that orthodontists have tight control over job safety in their offices. Only one day each for one staff member and one doctor was reported lost because of work-related accidents.

What special equipment, products, or services (non-latex gloves, ergonomic furniture and equipment, etc.) have you purchased to alleviate any of these problems, and how effective have these products been?

The consensus was that special equipment, products, and services are effective in reducing or eliminating job-related afflictions. Non-latex gloves were most prominently cited, but powder- and vinyl-free gloves were sometimes mentioned as well. These were followed by the use of ergonomically designed stools and articulating head rests for better patient head positioning. Also noted was the adoption of protective eyewear, which might include magnifying features.

One respondent noted:

• "We use nitrile gloves, and we have Sirona full dental chairs with over-the-patient delivery for staff and doctor ergonomics, because conventional orthodontic chairs are poor for stressed posture positions."

What precautions or training have you initiated to avoid occupational illnesses or work-related accidents, and how effective have these been?

The most common precaution was the enforcement and periodic review of current OSHA guidelines. This was sometimes amplified by local and regional courses, online information, and staff meetings focused on barrier devices such as masks, gloves, and goggles. Many respondents recommended using ergonomically designed clinical furniture and specific physical exercise regimes for both doctors and staff members.

The clinicians definitely concurred that their precautions and training had been highly successful in avoiding occupational illnesses and work-related accidents.

Interesting comments included:

• "All of my employees and I get routine TB checks and tetanus vaccinations, as recommended by a physician, and all of us had hepatitis-B vaccinations."

• "All staff must wear comfortable closed-toe and -heel tennis shoes while working, and uniforms are provided and periodically cleaned. If a staff member gets a puncture, they are immediately sent to my physician for a checkup and vaccination if needed."

• "All chairside assistants and I must wear a facemask, protective eyewear, and gloves. Also, gloves must be worn when cleaning and handling instruments."

• "To avoid puncture wounds, handpieces with sharp burs are placed back on the chairside holder with the bur positioned away from hands or legs."

• "I pay one-half of my employees' health-club memberships to encourage better fitness."

JCO would like to thank the following contributors to this month's column:

Dr. Cecil E. Alumbaugh, Irving, TX
Dr. Kevin J. Andrews, Sparks, NV
Dr. Richard Arnstine, Solon, OH
Dr. Rick Ballard, Sandpoint, ID
Dr. M.C. Biermann, Portland, OR
Dr. Richard Bloomstein, Livingston, NJ
Dr. Kurt T. Bowers, Bloomington, IL
Dr. George A. Bullock, Doylestown, PA
Dr. Bruce D. Burns, Kernersville, NC
Dr. J. Randall Buttram, Panama City, FL
Drs. Kenneth S. Carlough, Jeffrey E. Burzin, and Laura J. Gagnon, Clinton, CT
Dr. Ileana L. Cavanagh, Colts Neck, NJ
Dr. Benjamin F.D. Chikes, Ephrata, PA
Dr. C. Charles Collins, Indianola, IA
Dr. Larry D. Cross, Clovis, CA
Dr. Todd A. Curtis, Sycamore, IL
Drs. Mark L. Dake and Wade L. Murphy, West Plains, MO
Dr. Michael K. DeLuke, Schenectady, NY
Dr. Mark Detrick, Lake Forest, CA
Dr. James Dyer, Grapevine, TX
Dr. Brett Eckley, Beckley, WV
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Dr. Russell B. Farquhar, Aurora, Ontario
Dr. John H. Ferguson, Milledgeville, GA
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Dr. Danny Weiss, Memphis, TN
Drs. C. Edwin Wentz and Holly W. Reeves, Lubbock, TX
Dr. Franklin M. Wheelock, Roanoke, VA
Dr. Robert E. Williams, Baltimore, MD
Drs. Jack L. Wilson and Ryan K. Van Laecken, Watertown, SD

CASE REPORT

Treatment of a Deeply Impacted Mandibular First Permanent Molar

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Accidental trauma to permanent teeth in children can result in the cessation of eruption due to ankylosis.[1-6] Although this situation almost always occurs in the anterior segments, histological analysis of permanent molars with arrested eruption has shown areas of ankylosis of unknown etiology.[4,7] The present article describes treatment of a patient with a deeply impacted and ankylosed mandibular first permanent molar with significant root dilaceration.

Diagnosis

An 11-year-old male in the mixed dentition was referred for orthodontic treatment by his general dentist because of an unerupted mandibular left first permanent molar. His medical history revealed early childhood asthma and glucose-6-phosphate dehydrogenase (G6PD) sensitivity, but no previous medical or dental trauma. Initial examination showed a symmetrical and well-balanced face with slight mandibular retrusion and a mild Class II malocclusion (Fig. 1).

The patient's dental age lagged somewhat behind his chronological age. A panoramic radiograph revealed the presence of all developing permanent teeth except the third molars. The mandibular left first permanent molar was deeply impacted, with a thin layer of bone over its occlusal surface. The roots were not fully formed; their apices were at the lower border of the mandible, and the distal root was severely dilacerated in a distal direction. The roots lacked an intact, continuous lamina dura, which is a typical sign of ankylosis.

Because carious lesions were noted on several deciduous teeth, the patient was referred for restoration, which included the placement of a stainless steel crown on the mandibular right second deciduous molar. Follow-up radiography six months later showed no intrabony eruptive movement of the presumably ankylosed molar. The cause of the mandibular molar impaction could not be determined; no pathologic lesion or local impediment to eruption was found, and the adjacent teeth appeared normal.

Treatment Plan

The treatment goals were to bring the impacted mandibular first molar into proper occlusal and functional position in the arch, correct the mild Class II malocclusion, and achieve normal overbite and overjet. Several different treatment options were presented to the patient and parents:
1. Surgical exposure and luxation, bonding of an attachment,

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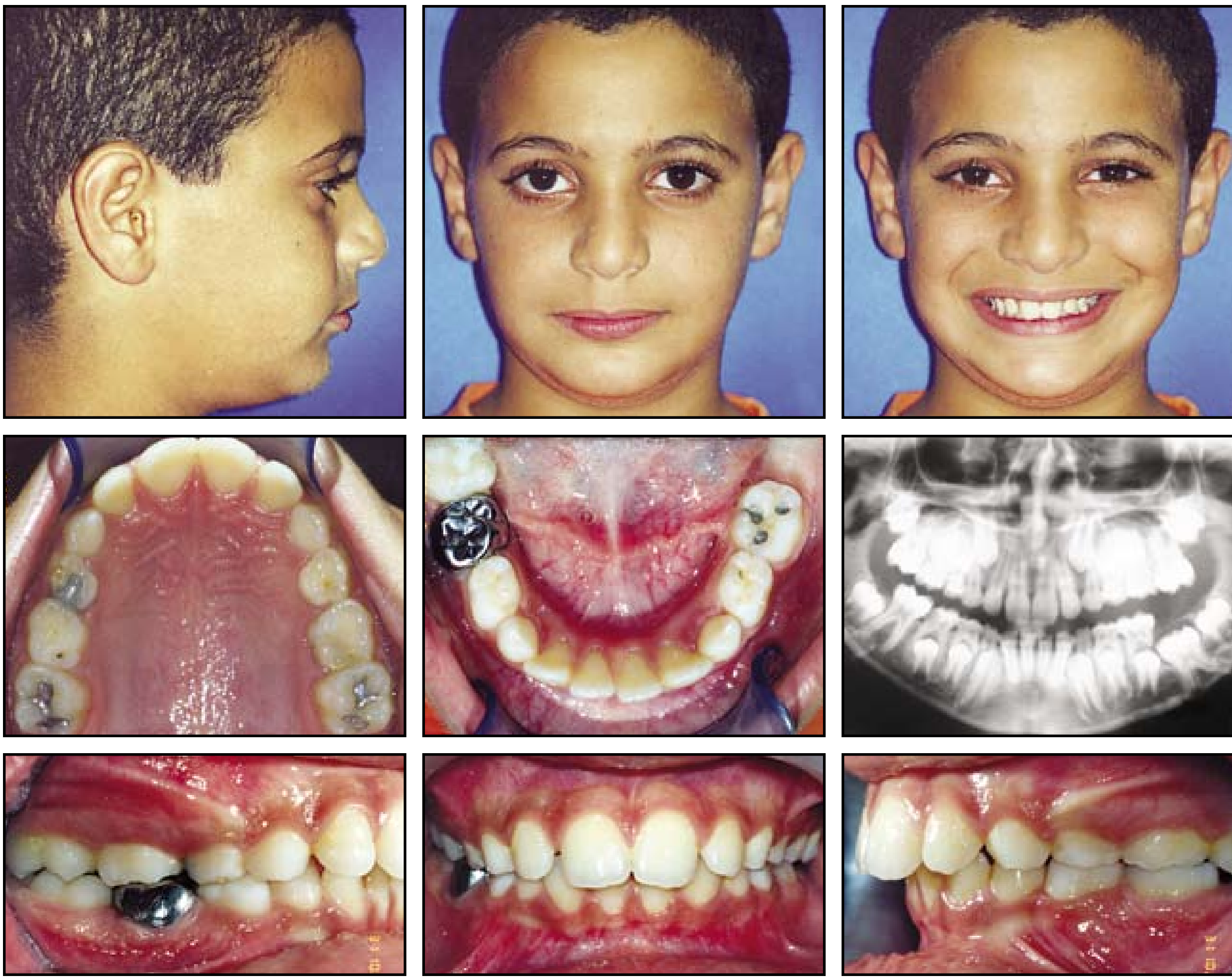

Fig. 1 11-year-old male patient in mixed dentition with deeply impacted mandibular left first permanent molar and mild Class II malocclusion (photographs were taken after restoration of carious teeth).

and vertical orthodontic movement of the impacted molar to the occlusal level. This would require prolonged treatment with no guarantee of success. If the tooth did not respond to the orthodontic forces, it would need to be extracted to allow the developing second molar to drift mesially into the position of the first molar.
2. Surgical extraction of the impacted molar, with no attempt to rescue it. Because of the tooth's proximity to the mandibular canal and the lower border of the mandible, this approach could have increased the risk of injury to the inferior alveolar nerve or even of a fractured mandible.
3. Surgical exposure and luxation, with no orthodontic intervention, in an attempt to prompt spontaneous eruption. The chances of success were limited.
4. Waiting for spontaneous eruption, with clinical and radiographic observation every three to six months. Given the deep impaction and ankylosis of the tooth, as well as its dilacerated root, the chances of natural eruption were considered low.

The patient and parents agreed to try the first option, with the understanding that a lack of response would require extraction of the tooth.

Treatment Progress

Orthodontic treatment was begun six months after the initial appointment. The maxillary first permanent molars were banded, and cervical headgear was used to correct the mild Class II relationship. After the first molars had been moved distally, a transpalatal arch was inserted. These appliances were later used as anchorage for the vertical forces on the impacted molar. A periapical radiograph taken just before surgery showed incomplete root formation, with the root apices at the lower border of the mandible (Fig. 2).

The impacted molar was surgically exposed and luxated, and a surgical pack was placed to promote tissue healing. The pack was removed a week later, and an eyelet was bonded to the occlusal surface of the tooth. Metal brackets were bonded to the mandibular incisors and to the second deciduous molars.

An .014" round stainless steel archwire was inserted, and a small helix was bent at its free end, distal to the second deciduous molar, and attached to the bonded molar eyelet with elastic thread. Six months later a lingual arch was added connecting the mandibular right first permanent molar with the mandibular left second deciduous molar. An uprighting spring, embedded in an acrylic extension of the lingual arch, was tied to the eyelet with elastic thread (Fig. 3). This spring exerted a light, continuous vertical force on the impacted molar, and the tooth slowly erupted. The lingual arch was removed after four months, a tube was bonded to the molar's buccal surface, and a vertical elastic was attached between the mandibular and maxillary molar tubes.

A periapical radiograph taken one year later showed further eruption of the molar, as well as root development and elongation, with the root apices moving away from the lower border of the mandible (Fig. 4). Meanwhile, all the patient's maxillary and mandibular permanent teeth had erupted and were bonded and aligned. Treatment was continued until the mandibular first molar was in full occlusal alignment. The final radiographs revealed complete formation of both the mesial and dilacerated distal roots, with their apices well removed from the lower border of the mandible and the mandibular canal (Fig. 5).

Unfortunately, the patient's compliance and oral hygiene were poor. He failed to wear the vertical elastic as instructed, missed numerous appointments, and experienced frequent bracket breakage. These factors unnecessarily prolonged the treatment time to a total of 40 months. After treatment, a mandibular bonded canine-to-canine fixed retainer and a maxillary Hawley retainer were delivered. Routine follow-up appointments showed stable results.

Fig. 2 Radiograph taken immediately before surgical exposure of impacted molar.

Fig. 3 Radiograph showing attachment of spring to eyelet on molar.

Fig. 4 Radiograph taken one year later, showing molar eruption and continued root development.

Discussion

Although any permanent tooth may become impacted, the third molars are most commonly affected.[8-11] Only a few cases of impaction of the mandibular first permanent molar have been reported.[12-18] Hook-shaped roots

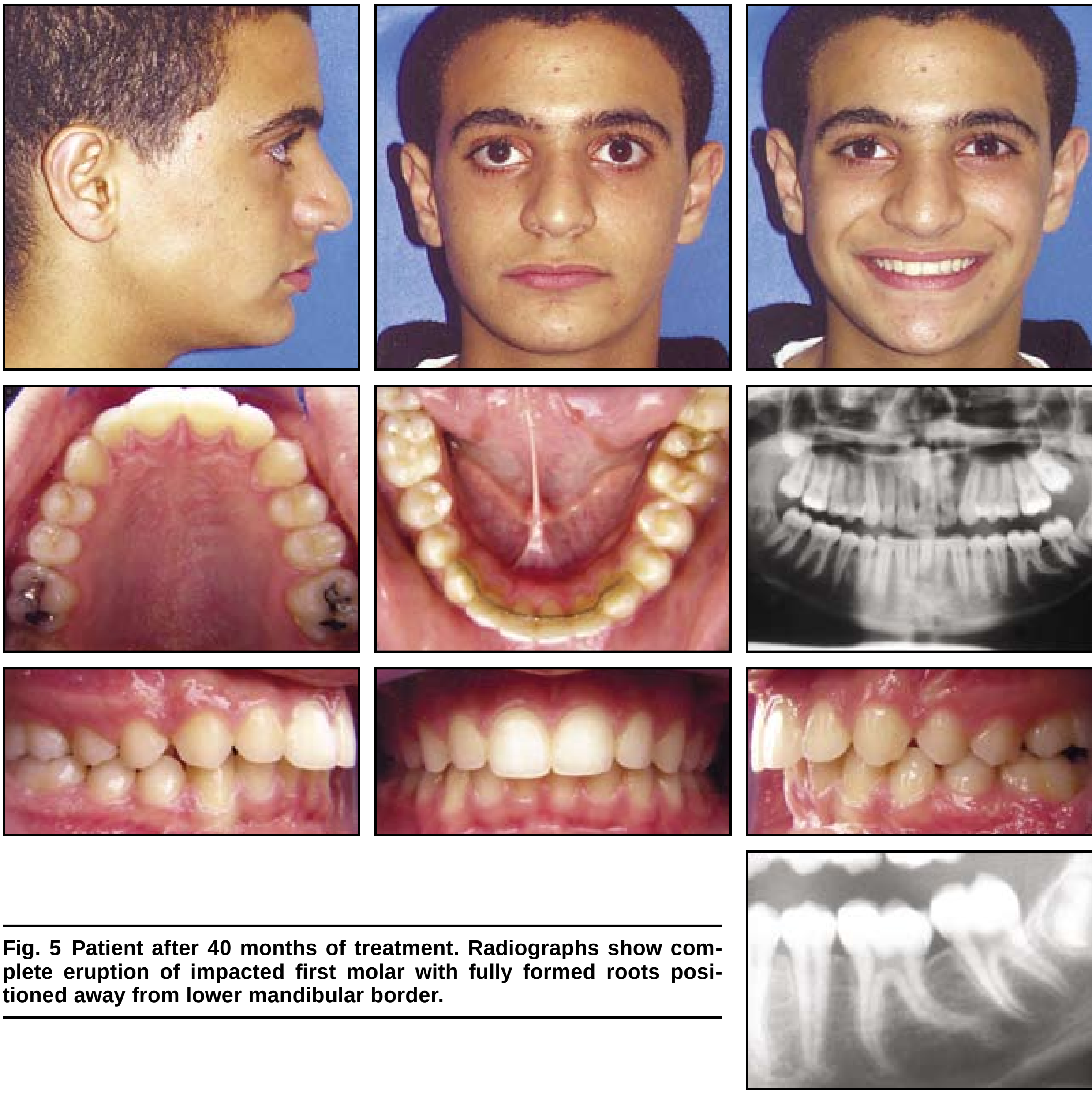

Fig. 5 Patient after 40 months of treatment. Radiographs show complete eruption of impacted first molar with fully formed roots positioned away from lower mandibular border.

and ankylosis have been described, but deep impaction and ankylosis combined with prominent distal root dilaceration is extremely rare. When a molar is deeply impacted close to the inferior border of the mandible, the developing root may be resisted and deflected by the compact cortical bone, resulting in dilaceration.[7]

Root dilaceration is usually found in the maxillary anterior region,[19] where the impact of trauma to a deciduous incisor may be transmitted to the developing permanent incisors, causing dilaceration in a labiolingual direction. Because the axis of the root is inclined in a different direction from the crown, the tooth does not erupt. Moving such a tooth is difficult and may require amputation of the apically dilacerated portion of the root, followed by root-canal treatment.[20-22]

In the present case, the likelihood of failure in attempting to rescue the tooth with a combined surgical-orthodontic approach, the risk of fracture of the dilacerated root during luxation, and the risk of re-ankylosis during treatment were all taken into consideration. There was adequate space for the first molar to be brought into the arch, and the maxillary first molar did not overerupt during mandibular molar traction. After proper vertical positioning of the impacted molar, however, the dilacerated part of the root was at an angle of nearly 90°, and thus could have delayed or even arrested the extrusive force.

Movement of a tooth with a dilacerated root is complicated: while most of the root moves upward, the distal segment of the dilacerated root becomes occlusally oriented and undergoes translation, effectively acting as the pressure side in a normal tooth movement. Therefore, it takes longer to achieve the desired tooth movement, and resorption of the dilacerated portion becomes more likely. A case-specific biomechanical design is required—for instance, in the case of a distally dilacerated root, an occlusal and mesial force can be applied so that the tooth is more likely to move in an arc, conforming to the curvature of the pulp chamber and the dilacerated root canal.

In this case, several light, continuous extrusive force vectors were applied, beginning immediately after exposure and luxation of the tooth and continuing until its full occlusal alignment. During eruption, both the mesial and dilacerated distal roots continued to develop and elongate. At the same time, the supporting alveolar bone followed the eruption. At the end of active treatment, the root apices and the alveolar bone were at the same levels as those of the adjacent teeth.

Conclusion

An impacted tooth with confirmed ankylosis and root dilaceration is often regarded as hopeless, with surgical extraction the only possibility. The present case shows that combined surgical-orthodontic treatment can be successful if carefully planned and executed. Preservation of a tooth as important as the mandibular first molar is clearly preferable to extraction. To ensure the best possible prognosis, treatment should be initiated as soon as the anomaly is discovered. The importance of early radiographic screening in children cannot be overstated.[23,24]

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