ROOT RESORPTION OF MAXILLARY CENTRAL INCISORS

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TABLE OF CONTENTS

INTRODUCTION

The phenomenon of root resorption during orthodontic tooth movement is well known to all dentists. Little knowledge is presently available about its cause, incidence, or what steps can be taken to minimize the problem.

Phillips[1] classified root loss following full banded orthodontic therapy into four catagories: slight, moderate, excessive, and questionable. Slight cases showed minimal blunting of the tooth apex. Teeth with approximately one-fourth or less of root length loss were termed moderate. More than one-fourth resorption was classified as severe. On this basis he found that 4.6% of all teeth studied showed moderate and severe blunting. Maxillary centrals and laterals showed involvement most often at 84% and 83% respectively.

In this study we will attempt to measure resorption on a more direct quantitative basis. By measuring cephalometric headfilms from orthodontic patients before and after treatment by the .022 bracket edgewise appliance we should be able to determine the amount and frequency of occurrence of root loss in maxillary central incisors. The amount of root loss will also be compared to other treatment factors such as age, sex, length of treatment and amount of tooth movement during treatment. A relatively large sample size will be chosen in an effort to obtain an improved estimate of the magnitude of the clinical problem. This sample should also allow us to bring in more examples of the extreme root length variation which may be expected in the treatment population, and attempt to establish causative environmental factors which may be under control of the clinician.

LITERATURE REVIEW

Ketcham[2] in 1929 investigated radiographs of 500 orthodontically treated cases. He found that 19% of these cases showed some root resorption of anterior teeth compared to only 1% of 1038 nontreated cases. Of the treated cases, the maxillary teeth seemed to be slightly more involved. Ketcham suggested that diet and type of orthodontic appliances might play a role. He also felt that some patients might have a greater predisposition to resorption than others and that possibly the resorption seen during tooth movement was an exacerbation of a pre-existing systemic condition.

Becks[3] felt that resorption was not caused by orthodontic forces alone. He blamed the problem on hypothyroidism and other systemic factors such as cholesterol levels and low basal metabolic rate. Carmen[4] supported this theory with a single case of hypothyroidism with root resorption that showed arrest of resorption after treatment of the systemic condition.

Carpol[5] was not able to confirm this later, however. He compared

55 hypothyroid patients with 55 paired normal patients, none of whom had any orthodontic treatment. He could not find any greater incidence of root resorption in the hypothyroid patients.

Stuteville[6] studying tooth movement in dogs, found root resorption to be more directly related to the distance through which a force is active than the amount of force. He felt that root resorption occurs in virtually all orthodontic cases but is generally repairable. Also appliances that caused a jiggling or interrupted movement were more apt to cause resorption than more rigid appliances.

Rudolph[7] evaluated intraoral radiographs from 513 patients treated with the labial arch appliance. He found that longer treatment time showed greater incidence of resorption. In evaluating the age at start of treatment for ages 9, 12, and 15 years, he found slightly greater resorption with the older patients at onset of treatment.

Henry and Weinman[8] studied histologic sections of 15 human dentitions who had not received any orthodontic treatment. They felt that it is "normal but not physiologic for a tooth to incur some resorption during its life." They felt that age is a contributing factor to resorption and that the apical third of the tooth is more susceptible to resorption.

Massler and Malone[9] studied the problem in 708 patients ranging in age from 12 to 49 years of age who had not had orthodontic treatment. A subjective analysis was made from viewing intraoral radiographs using a classification of mild, moderate, severe, or very severe. They found that every patient showed some evidence of resorption and that 86% of all teeth were involved. In order of severity 71% of involved teeth were termed mild resorption, 9% moderate (aaprox. 2-4 mm), .3% severe (4 mm to ¼ of root length), and .11% very severe. They found that severity seemed to increase with age. Eighty-one orthodontically treated cases were also studied and they felt that the orthodontic treatment worsened a pre-existing tendency to root resorption found in all individuals. In these cases 14% of all teeth showed severe degrees of resorption.

Phillips[1] studied root resorption of 69 orthodontically treated cases. He studied intraoral radiographs before and after treatment, assigning values of slight, moderate, excessive, and questionable to root shortening. He found that 39% of all teeth showed some involvement after orthodontic treatment. The maxillary central incisors were the most commonly involved with 84% showing some resorption. The maxillary laterals were next with 83% and mandibular centrals and laterals at 72% and 66% respectively. In addition he studied lateral head films of 61 orthodontic cases and measured types and amount of movement of maxillary centrals. No correlation was found for resorption and (1) age of patient at start of treatment, (2) length of treatment, (3) amount of tooth movement for 3 different types of movement, and (4) amount of movement of apices lingually.

DeShields[10] studied pre- and post-orthodontic intraoral radiographs of 52 patients. Assigning scores according to 5 subjective grades of resorption. He concluded that sex was not likely to be a factor in root resorption but that length of treatment and the mechanisms used did have some bearing on the severity of root loss.

Sjolien and Zachrisson[11] in a study of periodontal bone support and tooth length measured 59 cases with Class II division 1 malocclusions. Radiographs from before and after treatment were measured directly. The mean difference of the maxillary central incisors was found to be 1.52 mm.

Newman[12] studied 47 cases of moderate and severe resorption. The sample included both orthodontically treated cases and non-treated cases. He studied genetic background of patients but could make no definite conclusions. He did find an unusually high frequency of anterior open-bites and also found that orthodontic treatment could cause greater resorption than normal in patients that showed evidence of resorption before treatment.

It would appear that this is a universal problem found in all types of orthodontic treatment, but a very much understudied one. No consensus can be found in the existing literature to offer any logical route to prevent or minimize root loss. It may also be said that little work has been done on root loss in the non-orthodontic treatment patient. Therefore, valid incidence data are lacking.

MATERIALS AND METHODS

The sample consisted of 200 patients treated at the orthodontic clinic of the University of Oregon Health Sciences Center. Cases were selected from the clinic files on the basis of completeness of records and were limited to caucasians that were less than 20 years of age at the beginning of orthodontic treatment. All types of malocclusions were measured except those cases requiring surgical treatment. Of those selected 135 were female and 65 were males.

The length of the central incisors were measured on lateral headfilms taken before and after orthodontic treatment with a vernier caliper reading to the nearest 0.1 mm. Due to the superimposition of these teeth on the film only one measurement was made for the two teeth. No attempt was made to differentiate the right from left central incisor but where the teeth were not the same length the longest measurement was used. When the two teeth were found at different angulations before treatment the length of the tooth with the most labially placed root was used.

On each headfilm the angle formed by the long axis of the central incisors to the sella nasion line was measured directly to the nearest degree using a Baum cephalometric protractor and the net change recorded as a positive or negative figure.

From the patients' treatment record the length of treatment time was recorded as the time between band placement on the central incisors and band removal from these teeth at the end of treatment. This time was recorded to the nearest month.

The amount of overbite was measured directly on the orthodontic models of each patient taken before and after treatment using the vernier caliper. This measurement was recorded as the distance between the incisal edges of the maxillary central incisors and the average vertical height of the incisal edges of the mandibular central and lateral incisors as a positive or negative figure. The posterior occlusal plane was used as a horizontal reference plane where needed. The molar relationship before treatment was recorded as Angle Class I, II, or III.

For an error determination the lengths of the incisors were measured on the headfilms a second time and compared to the original measurement. In cases where this discrepancy was greater than .3 mm a third measurement was made and utilized. In addition ten cases were selected at random and all measurements repeated a second time. A standard error of the measure was computed for each type of measurement utilizing the formula: $SEMeas = \sqrt{\frac{\Sigma d^2}{2n}}$.

The student unpaired t test was used to determine statistical significance between males and females for treatment time, angulation change, overbite change, and amount of root loss. The t test was also used to test mean root loss in cases with increased overbite to mean root loss in cases with decreased overbite; and mean root loss in Angle Class I, II, and III.

Correlation coefficients were determined for: length of treatment time to root loss, angulation change to root loss, amount of overbite change to root loss, and direction of overbite change to root loss. Further standard statistical techniques were utilized to examine any highly suspect extremes of root resorption, tooth movement, and treatment time variables.

FINDINGS

The mean, variation, standard deviation and standard error of the mean were computed for each of the measured variables (Table 1). The mean length of treatment was found to be 22.6 months. The mean angle change of the central incisors to the sella nasion plane was 8.5^{o} and mean overbite change was 1.9 mm. On the average it was found that the maxillary central incisors lost 2.0 mm of length during the course of orthodontic treatment with a range from 0 to 5.6 mm. By means of the student t test the after treatment measurements were found to be significantly different from the before treatment measurements.

The mean, variation, standard deviation and standard error of the mean were also computed separately for males and females (Table 2). The means were then compared using the student t test (Table 3). Since no significant difference could be shown between the two groups based on these measurements, the two groups were thereafter combined.

Correlation coefficients were computed for: (1) the amount of root resorption to length of treatment; (2) the amount of root resorption to the net angle change between the central incisors and the sella nasion line; (3) the amount of root resorption to the angle change with regard to direction of change; (4) the amount of root resorption to the net overbite change; and (5) the amount of root resorption to the amount of overbite change with regard to intrusion or extrusion. Also those cases that showed increased overbite during treatment (39 cases) were compared to the amount of root resorption using correlation coefficients, and similarly for those cases showing decreased overbite (160 cases) a correlation coefficient was determined for root loss. These correlations were all found to be quite low. The largest being .238 for length of treatment (Table 4). Those cases in which there was decreased overbite or intrusion of the central incisors showed significantly ($t=-2.02$) greater root loss ($\bar{x}=2.12$ mm) than those cases in which the central incisors were extruded or were found to have greater overbite ($\bar{x}=1.65$ mm) (Table 5).

The amount of root resorption was also examined for each of the three classes of malocclusions at the beginning of treatment (Table 6). No significant difference was found between the three.

Histograms were constructed to visually portray the incidence of root resorption and the length of treatment. Figures 1, 2, 3.

Forty-one cases with minimal root resorption (0-.7 mm) were studied separately and compared to 25 cases with the greatest amount of resorption (3.6-5.6 mm). Only treatment time was found to be significantly different (t=2.97) when comparing the two groups (Table 7).

The standard error of the measure was found to be 1.5^{o} for the angle of the central incisor to the sella nasion line, .11 mm for overbite measurements, and .35 mm for incisor length measurements using the standard formula of Hixon.

DISCUSSION

This study undertook the examination of several variables in an effort to gain further understanding of the problem of root resorption during orthodontic treatment. A sample size of 200 was selected in an attempt to minimize the effect of possible variation extremes which may be found in this type of biologic sample. Although this would appear to be a sample of adequate number, one must be careful in defining and selecting the sample to match the problem under investigation. It was felt that since root resorption is a rather universal problem seen to some extent in all orthodontic cases, a more or less random selection of such cases would be the best approach. It may be that the biologic variability would be so great that much larger sample sizes are needed. It might be useful to restrict the sample to specific types of cases such as those with severe amounts of resorption or non-growing individuals also.

We found no significant differences between sexes in any of the variables studied. The sample was more heavily weighted to females (135 females to 65 males) but probably reflects the ratio found among orthodontic patients in this treatment facility.

The change of the angle formed by the central incisor and the sella nasion plane was used as an indication of tipping action undergone by the tooth during treatment. This measurement had little correlation with the amount of root loss. By itself this measurement does not account for all of the horizontal movement of the tooth and the problem is further compounded in growing individuals since the tooth is being moved by alveolar growth at the same time as orthodontic forces are acting on it.

It seems logical to assume that if orthodontic forces acting on a tooth are causing root resorption, a longer time of action will cause more resorption. Although very low, the correlation coefficient for length of treatment to root loss was the highest of those examined. When comparing cases with the least amount of resorption to those with greatest resorption a significant difference in treatment time was found. The length of treatment was taken as the time during which the central incisors had bands in place. This, of course, only approximates a time of actual tooth movement force being applied to these teeth. Some cases will have greater and longer acting forces than others for a similar length of time banded depending on mechanics used, patient cooperation, and the skill of the orthodontist, as well as the distance through which the tooth is moved.

The change in overbite was used in an effort to measure tooth movement in a vertical direction. No clinically significant correlation was found between either amount or direction of movement and amount of root resorption. Cases involving open bites at the beginning of treatment showed no greater resorption on the average than the total sample. In fact just the opposite was found for cases in which the overbite increased during treatment, with these cases having slightly less resorption then those involving intrusion or decrease of overbite. Here again the effect of growth was not accounted for. A sample of non-growing individuals might be useful in an effort to eliminate this variable.

Although little cause and effect information was found from this study, a greater appreciation of the problem was derived. While the damage in most cases did not affect the health of the teeth, at least one case was observed in which the resorption was so severe that virtually no root was left with bony support. The availability of orthodontic treatment to relatively large numbers of the population has only occurred quite recently. As this population of young people grows older it seems more and more likely that the loss of root structure will have an effect on early loss of teeth when natural recession and periodontal disease reduce the available bone support. We do know that on the average two millimeters of tooth structure will be lost from the maxillary central incisors during orthodontic treatment. The length of these teeth must be carefully observed before orthodontic treatment begins. If the loss of approximately two millimeters of root structure of a central incisor would strongly jeopardize the support of the tooth because of beginning root length, the desirability of treatment should be carefully reconsidered.

SUMMARY AND CONCLUSIONS

Root resorption during orthodontic treatment was analyzed for the maxillary central incisors from measurements taken on lateral headfilms of 200 cases.

1. Mean root loss for the maxillary central incisors was 2.0 millimeters.
2. No differences could be shown between males and females for root loss, length of treatment, incisor angle change, or overbite change.
3. No clinically useful correlation could be found between root loss and length of treatment.
4. In two groups with extremes of root resorption, treatment time was significantly longer for the group with greater root loss.
5. No clinically useful correlation could be found between root loss and angle change of the incisors.
6. The overbite change during treatment did not show

significant correlation to root loss.

7. Cases with decreased overbite after treatment had greater resorption than cases with increased overbite.

8. No significant differences of root resorption were found between different Angle classes of malocclusions.

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TABLE 1

Statistical data from the root resorption study sample (N=200)

	$\overline{X}$	S^2	S	SEM
Age at treatment start (months)	161.3	335.2	18.3	1.3
Age at treatment end (months)	184.0	370.1	19.2	1.4
Length of treatment (months)	22.6	55.7	7.46	.53
Angle Central Incisor to SN at start of treatment (degrees)	75	78.6	8.9	.6
Angle Central Incisor to SN at end of treatment (degrees)	79	42.7	6.5	.5
Change of Angle CI to SN (degrees)	8.5	40.3	6.4	.4
Overbite start of Treatment (mm)	3.3	4.2	2.0	.14
Overbite end of Treatment (mm)	1.96	.6	.8	.06
Overbite change (mm)	1.9	1.7	1.3	.1
Length of Central Incisor Before Treatment (mm)	25.96	4.38	2.09	.15
Length of CI after Treatment (mm)	23.93	5.66	2.38	.17
Root Loss (mm)	2.0	1.7	1.3	.1

TABLE 2

Statistical data broken down according to sex (male N=65, female N=135)

	$\overline{X}$	S^2	S	SEM
Length of treatment females (months)	22.96	53.8	7.3	.6
Length of treatment males (months)	21.98	59.8	7.7	.96
Angle change CI to SN females (degrees)	8.7	41.7	6.4	.6
Angle change CI to SN males (degrees)	8.15	37.9	6.15	.8
Overbite change females (mm)	1.9	1.8	1.3	.1
Overbite change males (mm)	2.1	1.7	1.3	.16
Root loss females (mm)	2.03	1.8	1.3	.1
Root loss males (mm)	1.99	1.6	1.3	.16

TABLE 3

Student t values of male vs. female sample

	v	t
Treatment time	198	.87
Angle change CI to SN	198	.58
Overbite change	198	1.02
Root loss	198	.19

TABLE 4

Pearson correlation coefficients of the root resorption study sample

	r
Length of treatment to amount of root loss	.238
Net Angle change CI to SN to amount of root loss	.068
Angle change and direction CI to SN to amount of root loss	-.042
Net overbite change to amount of root loss	.121
Overbite change and direction to amount of root loss	-.111
Increase overbite to amount of root loss N=39	.221
Decrease overbite to amount of root loss N=160	.061

TABLE 5

Statistical data associated with overbite change

	$\overline{X}$	S^2	S	SEM
1. Root loss with increased overbite N=39	1.65	1.94	1.39	.223
2. Root loss with decreased overbite N=160	2.12	1.64	1.28	.101

t for x_1 to x_2 $t = -2.02$

TABLE 6

Data of root resorption associated with type of malocclusion

Angle Class	Resorption (mm)				
	N	$\overline{X}$	S^2	S	SEM
I	49	1.83	1.64	1.28	.18
II	138	2.13	1.73	1.31	.11
III	13	1.58	1.91	1.38	.38

	V	t
Class II-I	185	1.39
Class II-III	149	1.44
Class I-III	60	.61

TABLE 7

Root resorption extremes

	Root Loss	N	$\overline{X}$	S^2	S	SEM	t
Length of treatment (months)	0-.7 mm	41	19.1	45.6	6.75	1.05	
Length of treatment (months)	3.6-5.6 mm	25	24.5	60.5	7.78	1.6	-2.97
Net Angle change SI to SN (degrees)	0-.7 mm	41	6.6	24.1	4.91	.77	
Net Angle change SI to SN (degrees)	3.6-5.6 mm	25	8.7	25.5	5.05	1.0	-1.67
Overbite change including direction of change (mm)	0-.7 mm	41	-.75	3.06	1.75	.27	
Overbite change including direction of change (mm)	3.6-5.6 mm	25	-1.1	5.0	2.23	.45	.71

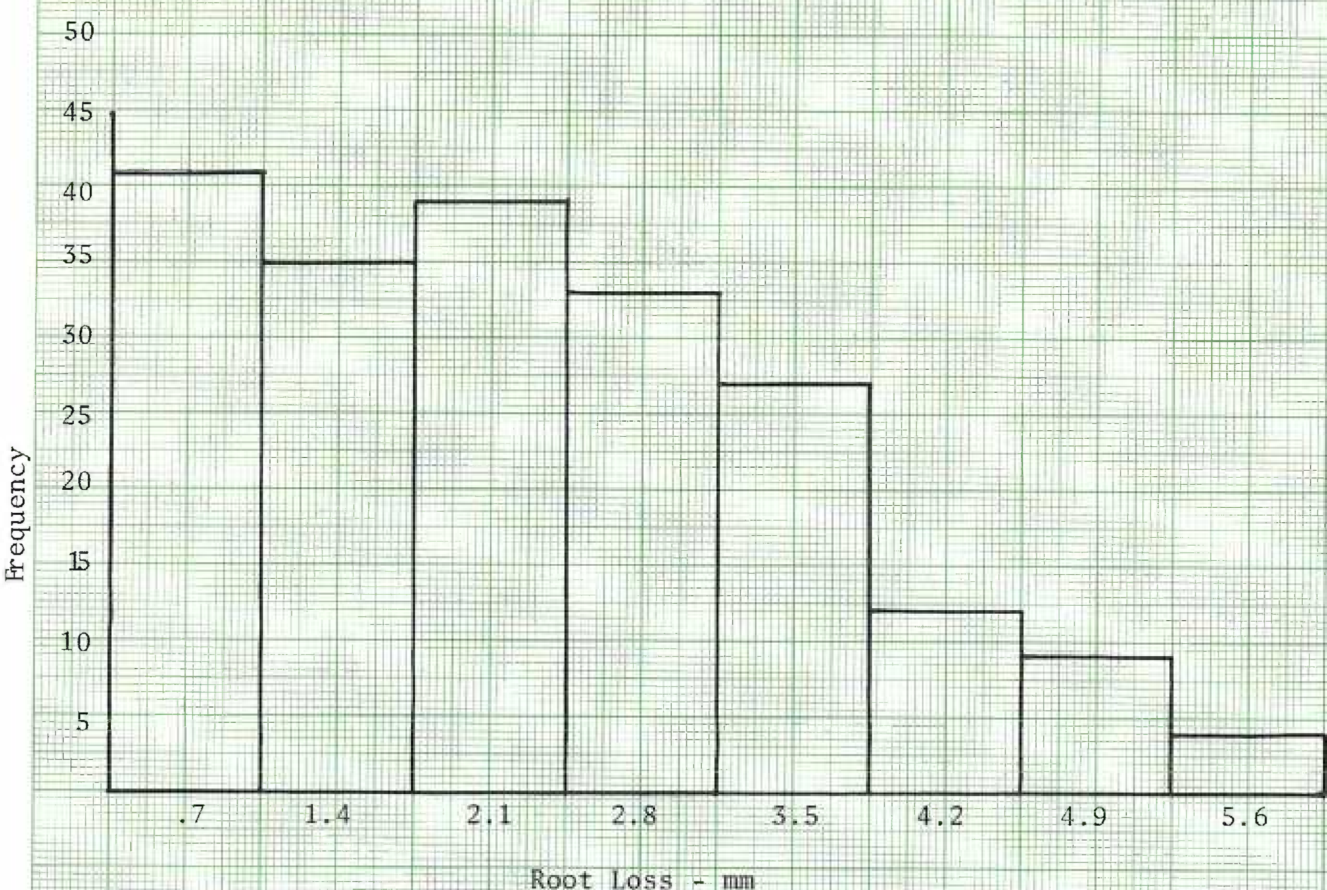

Figure 1 Histogram of Root Loss

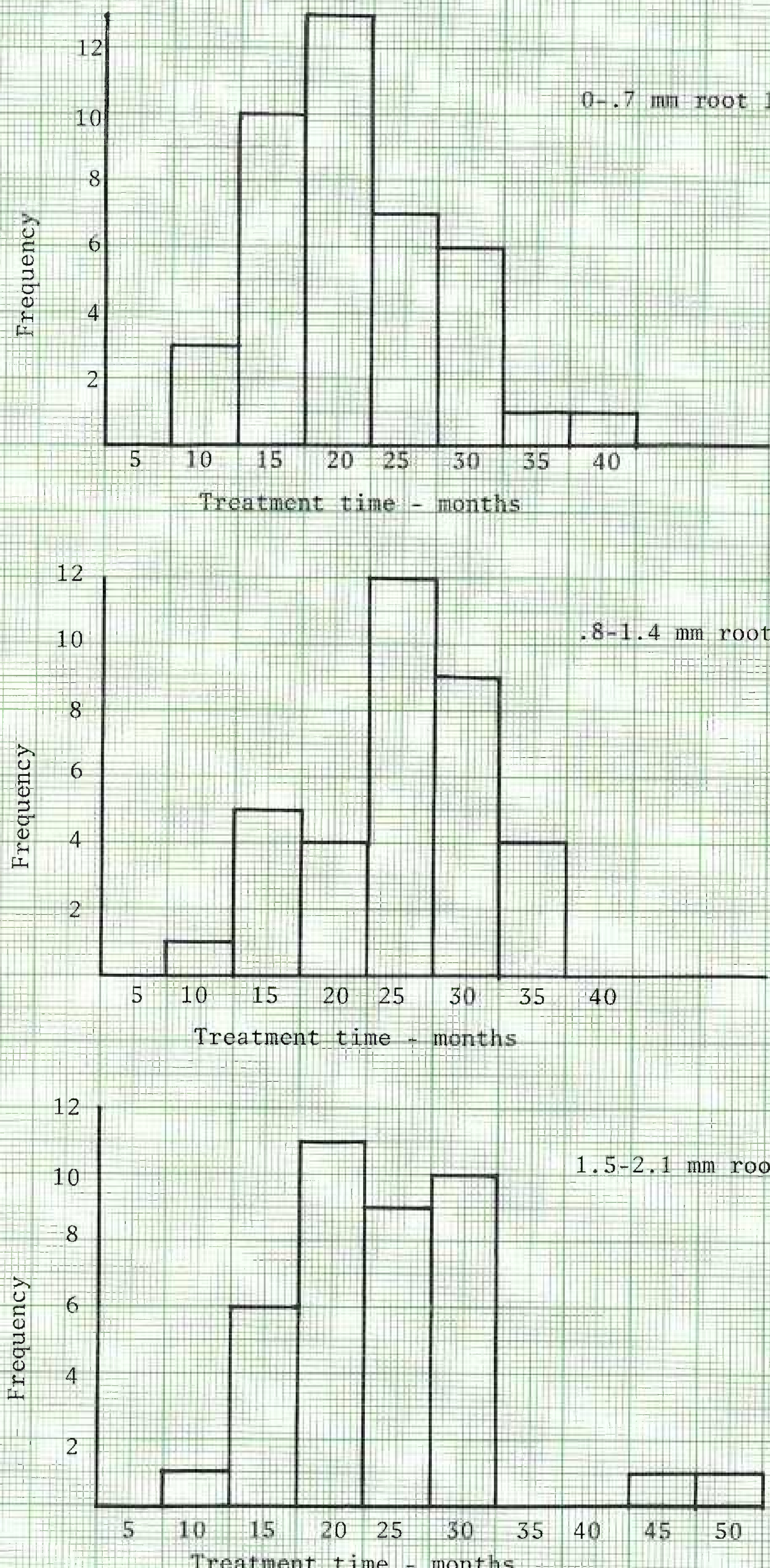

Figure 2 Histograms of treatment times for 0-.7 mm root loss; .8-1.4 mm root loss; and 1.5-2.1 mm root loss.

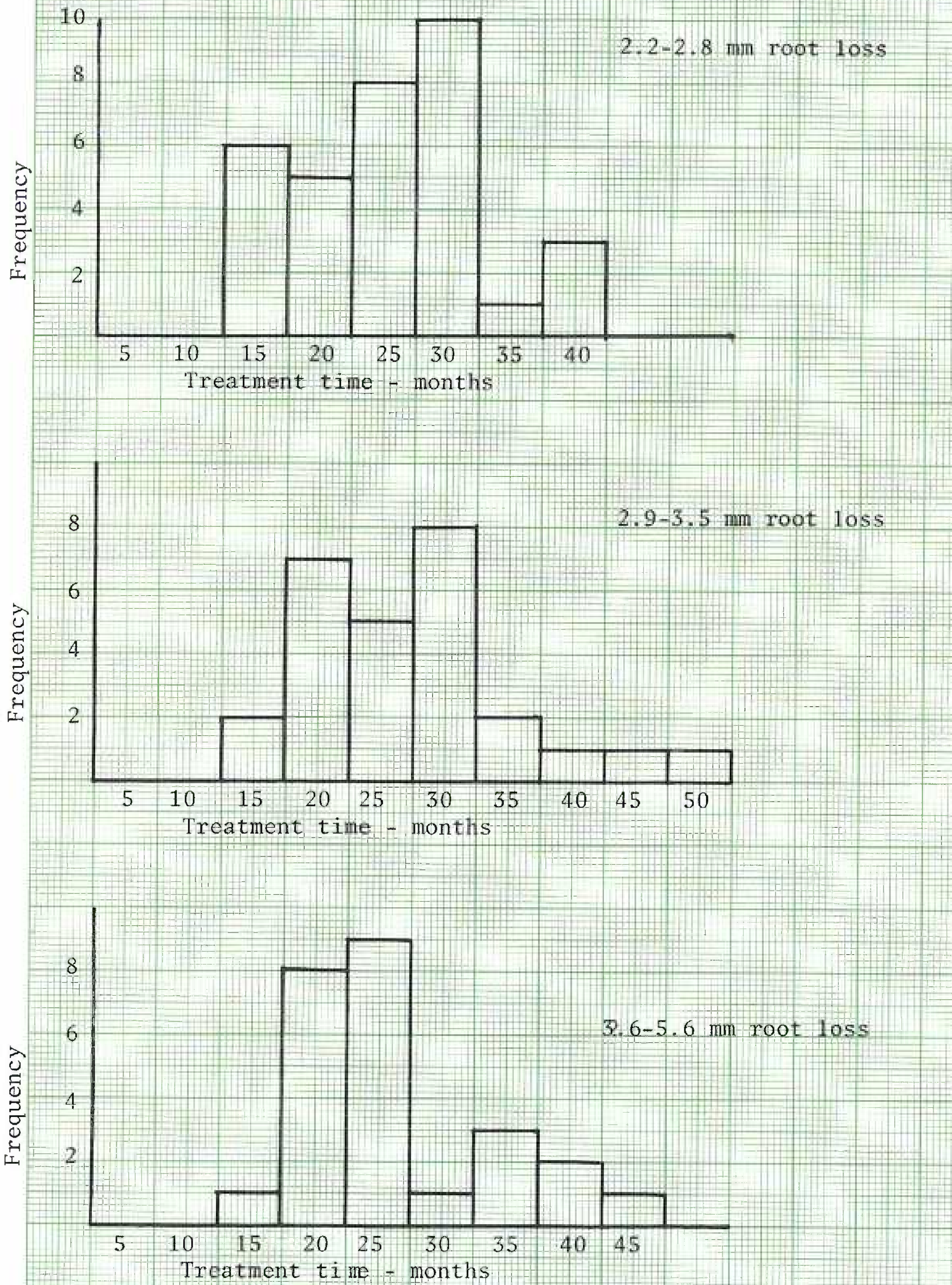

Figure 3 Histograms of treatment times for 2.2-2.8 mm root loss; 2.9-3.5 mm root loss; and 3.6-5.6 mm root loss.