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HIGH-SPEED OR CONVENTIONAL DENTAL ENGINES FOR THE REMOVAL OF BONE IN ORAL SURGERY

I. A STUDY OF THE REACTIONS FOLLOWING REMOVAL OF BILATERAL IMPACTED LOWER THIRD MOLARS

by

ERIK ÅGREN

"Tuto, celeriter, jucunde."

INTRODUCTION

Any surgical operation involves trauma, especially if bone is removed, as is usually the case in oral surgery. Complications may then ensue, such as swelling, pain and trismus, and sometimes even infection and fever. The course of the postoperative reactions is dependent on a number of factors, among them the extent of the trauma to the tissues. In theory, the reactions should be determined by the degree of trauma, but in practice they may vary under apparently similar conditions, so that the postoperative course is difficult to predict.

In dentistry the drilling technique has been used widely for destruction and removal of hard tissues, because it offers certain practical advantages. The introduction of high-speed engines has been followed by intensification of research on the effect of trauma in cavity preparation and the reaction of the pulp to cutting or grinding of the dental hard tissues with rotating instruments at different speeds (*Langeland*, 1957 & 1960; *Brännström*, 1961).

Reactions to trauma resulting from surgery on the jaws with engines running at different speeds have also been studied, but it would seem that attention has been restricted largely to clinical impressions. Since this part of the operative procedure is an important one it was considered that a clinical study, with an objective method for evaluating the results, might prove rewarding. Accordingly, the investigation reported in this paper was planned. Its objects were the following: (*i*) In the first place by recording the magnitude and duration of postoperative reactions such as swelling of the face and trismus, and on the basis of the postoperative pain, infection and general reactions that could be checked by a medical examination, to obtain a statistically verified impression of whether high-speed drilling engines (about 48,000 r.p.m. under load) are more suitable for bone surgery than those running at conventional speeds (about 8000 r.p.m.). (*ii*) To evolve a simple and practical method by which swelling of the face can be recorded. (*iii*) By disappearance measurements with ^{22}Na, autoradiography and microradiography on laboratory animals, to study and compare the healing following operations on the bone with carbide burs and low- and high-speed burs engines. The latter part of the investigation will be published later.

PREVIOUS INVESTIGATIONS

Various recording methods by which the extent of oedema or swelling of the face can be followed after surgery have been published. They are reviewed briefly below. These methods for measuring this manifestation of the course of inflammation are based on only one component of this complicated process, viz. the outflow of plasma and blood corpuscles into the inflamed tissue.

A photogrammetric method for measuring the variations in the oedema in experimentally produced incision wounds on the fingers which healed without trace of infection has been published by *Adams-Ray* (1949). The mean error of the method was about 0.1 mm. The oedema was most marked on the second and third days.

A photogrammetric method for measuring the volume of a postoperative facial swelling has been reported by *Björn, Lundqvist &*

Hjelmström (1954). The standard deviation of the volume measurements, determined from repeated registrations of the same swelling, was 1.7 cc. After removal of the lower third molars the swelling usually reached its maximum one or two days after surgery.

A simple method for measuring the thickness of the cheek using the Boley gauge and sliding calipers has been evolved by *Flechhaus* (1956), who used the method for following the course of oedema after removal of impacted third molars; he performed a statistical analysis of the measurements obtained in this way. In this study the swelling reached a maximum one or two days after the operation.

A radiographic method for recording soft tissue swelling of the cheek developed by *Forsberg* (1957) was used for estimating the swelling maximum after removal of impacted lower third molars. The technique enables an objective evaluation of the variation in swelling to be made accurately enough for a clinical examination. The maximum swelling was noted after 1—3 days.

Systemic reactions may also be observed after oral surgery. These, like the local reactions, constitute a natural process, recovery from which is usually spontaneous, but occasionally some intervention may be indicated to shorten the period of convalescence. The normal course after trauma such as is inflicted during an oral operation has received little attention, however. What applies to general surgery is of course also applicable to oral surgery. There may be a moderate transient *increase in temperature* during the first 24—48 hours. According to *Menkin* (1947) this is due to a globulin fraction which forms in the exudate resulting from the traumatic inflammation, and which affects the temperature regulation *via* the blood. It can raise the body temperature of the rabbit or dog by about 1.5°C. *Menkin* calls this pyrogenic factor pyrexin.

Under normal physiologic conditions a fairly constant amount of biologically active corticosteroids is formed in the adrenal cortex, and these are secreted to the blood and hence to the body. The concentration of corticosteroids required under different conditions is dependent on several factors. Mental or physical stress is reflected in the adrenal cortical function.

Fischer & Sprechler (1958) and *Thorén* (1960) have found that the requirements of adrenal cortical hormones are greater in, for instance, surgical trauma. *Via* the hypophysis, which governs other endocrine glands, the adrenal cortex is then stimulated to produce and secrete a *greater amount of corticoids*. The body responds with alarm or stress reactions (*Selye*, 1950). This is evident from the rapid increase in the concentration of 17-hydrocorticosteroids in the plasma (only 30 minutes after trauma or anaesthesia the level is 3—4 times the normal). The increase is related to the severity of the trauma (*Moore & Ball*, 1952; *Fischer & Sprechler*). The mechanism of this increase in activity is not known for certain; it has been suggested that it is due to adrenalin- and histamine-like substances liberated by the trauma. The increase in the concentration of 17-hydrocorticosteroids in plasma in turn gives rise to a number of changes in the blood and tissues, including a reduction in the number of eosinophilic blood cells. *Thorén* (1960) found eosinopenia 2—4 days after moderate surgical trauma.

A rise in *the globulin fraction* (serumglucoprotein, serum mucoids) was observed by *Böttiger & Eklund* (1959/60) after major surgical operations with a maximum on the fourth postoperative day. *Thorén* also points out that the globulins rise above the initial level a day or two after trauma.

Another systemic reaction elicited by trauma that has aroused interest is *the erythrocyte sedimentation*. In a study of the blood flow in traumatized striated muscle of the mouse *Knisely, Eliot & Block* (1945) showed that agglutinated blood in the capillaries of the involved area was transported into the nearest large vein and hence into the systemic circulation. Trauma is regularly accompanied by general intravascular agglutination (*Heinbecker & Bigelow*, 1950), and erythrostasis has been observed after fractures in man (*Gelin*, 1956). In a study of wound healing and trauma, with special reference to intravascular agglutination of erythrocytes, *Zederfelt* (1957) found that fractures of the rabbit femur were followed by a rise in *the erythrocyte sedimentation rate*, with the peak mean of 8 mm occurring 2 days after the fracture. The E.S.R. recovered its normal level about 7 days after the trauma.

On the third day after removal of impacted third molars of

26 patients *Aksdahl* (1961) found a mean rise of about 5 mm in the E.S.R.

The relationship between *leucocytosis* and oedema after various oral operations has been studied by *Burch & Morris* (1962) in 121 patients. There was no statistically significant correlation on the first and second days after the operations.

The surgical removal of bone has for many years been performed by means of *chisels* of various types or with *burs* with cutting edges similar to that on a chisel. While some authors favour the chisel (*Brinch*, 1949; *Ward*, 1956; *Forsslund*, 1957) others prefer the bur (*Axhausen*, 1950; *Thompson & McConnel*, 1955). *Hertz* (1961) recommends the chisel in many instances but also uses the bur. Yet other authors consider that there is little to choose between the methods so long as accepted surgical principles are adhered to (*Dingman & Hayward*, 1947). The essential is that the instrument should be sharp and trauma should be minimal.

The human protoplasm is sensitive to increase in temperature and may be severely damaged by heating. When the bur is used in hard tissue, heat is generated which may be great enough to cause irreversible damage to the protoplasm of bone. Unless the site of operation is flushed simultaneously, the protoplasm may suffer damage, the bone chips clump and the efficiency of the bur be impaired. The chips collect in the wound, fuse with blood and saliva and plug the marrow spaces so that the formation of granulation tissue is delayed. In histologic experiments on the dog, *Brinch* (1949) showed that if a round bur is used in intraoral surgery the spongiosa spaces are clogged with small particles of bone and blood; this, he considered, interferes with the circulation in the bone and soft tissues, and causes oedema in the area. This did not happen when a hammer and chisel or curettes were used. *Brinch* could find no difference in the healing following application of the latter two methods.

Hudack & McMaster (1932) found that a temperature of 42—43°C maintained for 7 minutes was enough to cause serious changes in the ear of the mouse. *Shafer & Skow* (1938) showed in animal experiments that peripheral nerves undergo irreversible damage at temperatures exceeding 45°C. There seem to be no data on the critical temperature for bone; the tolerance would, however, seem to depend on the type of tissue. As a rule, temperatures

in excess of 49°C result in pathologic alterations, and the tolerance may differ considerably for animals and man (*Reed & Hopkins*, 1962).

In a preliminary study of the rise in temperature accompanying the drilling of cavities in teeth *Anderson & van Praagh* (1942) found that the temperature readily increased by about 8—11°C and that the actual rise was dependent on the applied force and the speed of rotation. On reducing the applied force by one-third and using no coolant, the time required to raise the temperature by about 8°C was 12—16 sec. irrespective of whether the drilling was continuous or intermittent. These workers consider that a dangerous rise in temperature is not so easily caused if a low-speed engine is used with no increase in pressure, and they recommend sharp burs and reduction of the speed.

Studies of histologic reactions in bone in the mandible of the dog, and the generation of heat on drilling in bone at low speed with no coolant have been performed by *Thompson* (1958). "The Roger Anderson extraoral skeletal pin" was used in all the experiments and the drilling engines had speeds ranging from 125 to 2000 r.p.m. The drilling time was varied from 2.5 to 20 sec. and the temperature from 37.2° to more than 65.5°C, measured in the bone 2.5—5 mm from the drill hole. One of the engines used was a portable dental model with a speed of 1000 r.p.m. In a similar experiment drilling for 9.4 sec. gave a temperature of 65.5°C at 2.5 mm from the bur.

In an experiment with a turbine-powered handpiece and no. 8 round carbide burs operated at a speed of about 350,000 r.p.m., *Rafel* (1962) recorded a rise in temperature of about 2.4 and 1.5°C with continuous and intermittent cut, respectively, for 10 sec. with no water spray. In another experiment at a speed of 10,000 r.p.m. under otherwise the same experimental conditions the maximum rise was about 4.8°. The experiments were performed in the mandible of a human cadaver, and the temperature was recorded by means of a needle-type probe housing a sensitive microthermocouple at its tip attached to an electric thermometer. The probe was inserted 3 mm into the bone, 3 mm from the bur cuts. *Rafel's* figures for the maximum rise in temperature at different speeds were, however, based on a single test on each occasion.

Wound healing after the use of a bur in the removal of teeth of monkeys was studied histologically by *Simpson* (1961). Bone debris in the alveoli gave rise to severe inflammation, and debris beneath the flap interfered with healing. When, on the other hand, the bone particles were removed by spraying with physiological saline, the inflammatory reaction was much weaker.

Falkman (1961) discussed tooth preparation as a technical machining problem to which he applied the experience and results of investigations gained in industry. An account is given of the physical laws that govern the yield, generation of heat and the rise in temperature, and of the measures that may be taken to avoid too great a rise in temperature and consequent damage. The major part of the generated heat is dissipated with the bone chips, but nevertheless the temperature of the latter and the work-piece is considerably lower than that at the cutting edge. The stronger the material worked the greater the amount of heat generated. In addition, the temperature at the cutting edge is affected by the rate of cutting and the applied force, the former being the more important factor in this respect. *Falkman* stresses the importance of cooling, the value of which increases with the speed; the water-spray should impinge on the cutting edges. The risk, in spite of cooling, of raising the temperature of the tissues to a dangerous level through the involuntary application of excessive force increases with the drill speed.

The use of high-speed engines in oral surgery has facilitated the removal of both bone and dental tissue. To remove impacted third molars from 28 patients *Kilpatrick* (1958) used the ultra-speed method (150,000 r.p.m.) for 28 teeth and the chiselling technique for 30. The great majority of the patients stated that they preferred the burs and engine because of the small pressure required and the absence of vibration. *Kilpatrick* found that in most cases the time required for the operation was reduced by at least one-third and that the postoperative course as regards pain, swelling and tenderness in the temporomandibular joint was more satisfactory when the drill was used. *Hall* (1959) removed 120 impacted teeth using an engine running at 200,000—350,000 r.p.m. A comparison with the results obtained with the chiselling or low-speed method (10,000—20,000 r.p.m.) demonstrated the superiority of the high-speed engine, the time being shorter by

some 30—40 per cent, and trauma and postoperative pain being reduced by about 50 per cent. He maintained that the vibrations associated with the low-speed engine and the pressure required result in more severe trauma, which makes the operation more difficult for patient and surgeon, alike. The findings of *Kilpatrick* and *Hall* are based only on uncontrolled clinical impressions, however.

In a carefully controlled investigation by *Szmyd, Shannon, Schuessler & McCall* (1963) in which the higher bur speed technique (air turbine) was compared with the conventional mallet and chisel method, an analysis of the reactions did not reveal any advantage of the former. The material consisted of 100 impacted third molars, 50 of which were removed by the bur technique and 50 by chiselling. The choice of method was made at random. The evaluation of the postoperative status was performed by one person, who was unaware which technique had been used. The reactions assessed were pain, swelling, trismus and haemorrhage. The period covered was 7 days, with 2 observations during the first 3 days. No significant differences between the reactions in the two groups were found, and the time required for the operation was about the same as with the bur technique.

Three methods for removing bone in surgical operations on the mandible of the dog were compared by *Mazorow* (1960) with respect to the time required and the postoperative course. The instruments compared were a mechanical chisel (an "Impactor"), an ultrasonic apparatus with no. 15 Bard-Parker blades and a Weber Air Turbine Unit, with a speed of about 200,000 r.p.m. unloaded. The drilling machine gave the best healing histologically. After 8 weeks the bone defect was practically normal in anatomic structure. The bone was also removed most rapidly by this method.

AUTHOR'S INVESTIGATION

Method

The material consisted of 19 healthy subjects with lower third molars that were partly or totally impacted and that, according to radiographic evidence, were similarly situated. There were 8 men and 11 women, with ages ranging from 17 to 40 years, and all

had undergone a medical check-up. All had applied to the Department of Oral Surgery for removal of these teeth on various grounds (Table I, Figs. 1—6). They were treated as outpatients.

Table I

Diagnosis and distribution of bilateral impactions in the lower jaw; 19 patients.

Diagnosis		Number of patients
Retentio dentis totalis	horizontal impaction	1
	mesial angular impaction	4
	unerupted impaction	4
Retentio dentis partialis	horizontal impaction	3
	mesial angular impaction	3
	vertical impaction	4

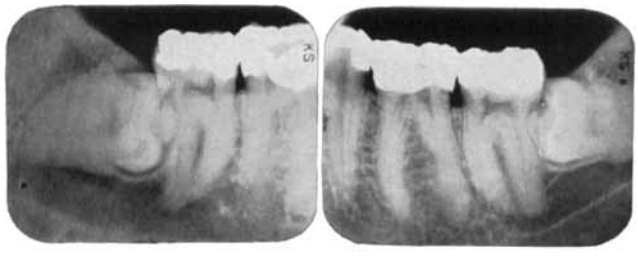

Fig. 1. Retentio dentis totalis, horizontal impaction.

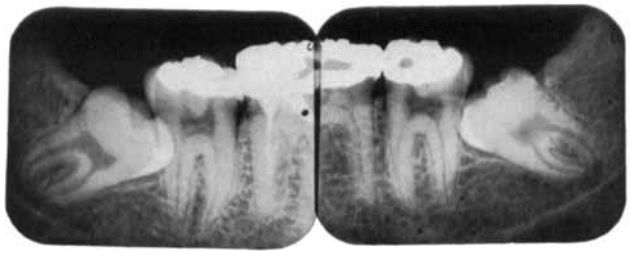

Fig. 2. Retentio dentis totalis, mesial angular impaction.

Fig. 3. Retentio dentis totalis, unerupted impaction.

Fig. 4. Retentio dentis partialis, horizontal impaction.

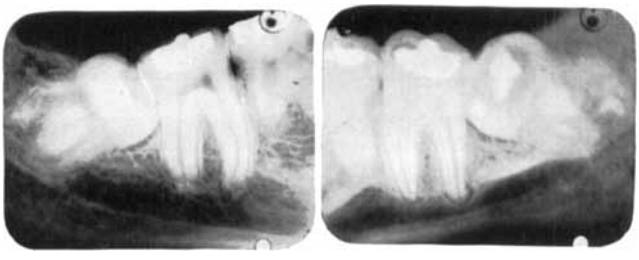

Fig. 5. Retentio dentis partialis, mesial angular impaction.

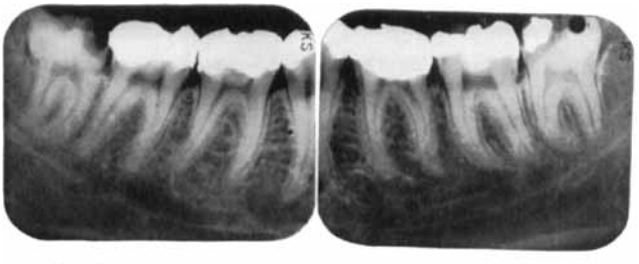

Fig. 6. Retentio dentis partialis, vertical impaction.

The dental engines compared were the Atlas Copco Dental Air-Rotor*, with a turbine-powered handpiece having a loaded speed of about 48,000 (Figs. 7a, b), and the Svedia Technomotor, No. 8186**, with a speed when loaded of about 8000 r.p.m. (Fig. 8). Dentatus No. 8 round carbide burs were used for both bone and teeth. The coolant was sterile physiologic saline at room temperature, with which the operative field was sprayed constantly as required. A jet of this liquid could be directed on the cutting

* Atlas Copco, Stockholm, Sweden

** Svedia, Stockholm, Sweden

Fig. 7 a. Atlas Copco turbine-powered handpiece connected by a plastic hose to a 20 ml Record syringe, which provides a jet of saline at room temperature on the bur head.

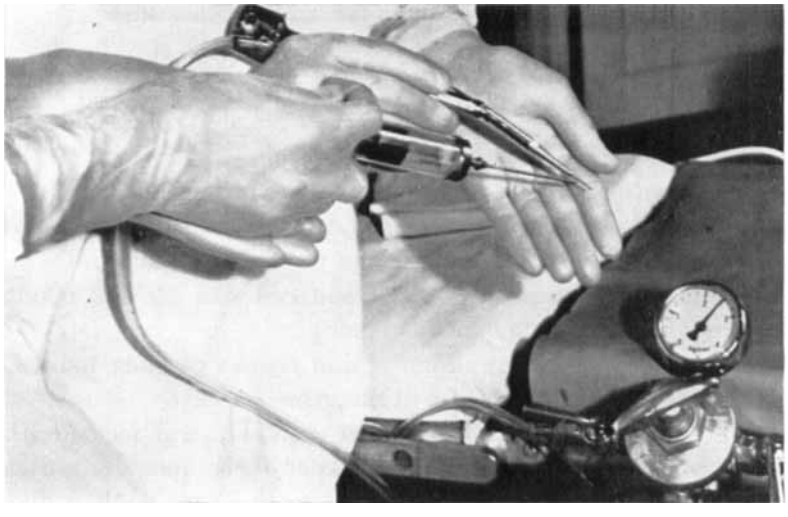

Fig. 7 b. A modification for surgical use of the above.

Fig. 8. The Tecno dental engine.

edges of the drill by means of a 20 ml Record syringe connected to a small-calibre metal tube on the handpiece.

All the patients were given medical examinations before the operation and on the third and sixth days afterwards. The examinations consisted of determinations of the sedimentation rates and the haemoglobin concentrations, blood cell and platelet counts, bleeding and coagulation times, paper-electrophoretic analysis of serum proteins and total albumin, and checks of body temperature and of proteins or glucose in the urine.

Prior to operation the thickness of the cheek was measured at a point just in front of the anterior border of the masseter muscle, using bow calipers modified for the purpose (Figs. 9a, b, c). The mean thickness of the cheek for 20 measurements on a particular

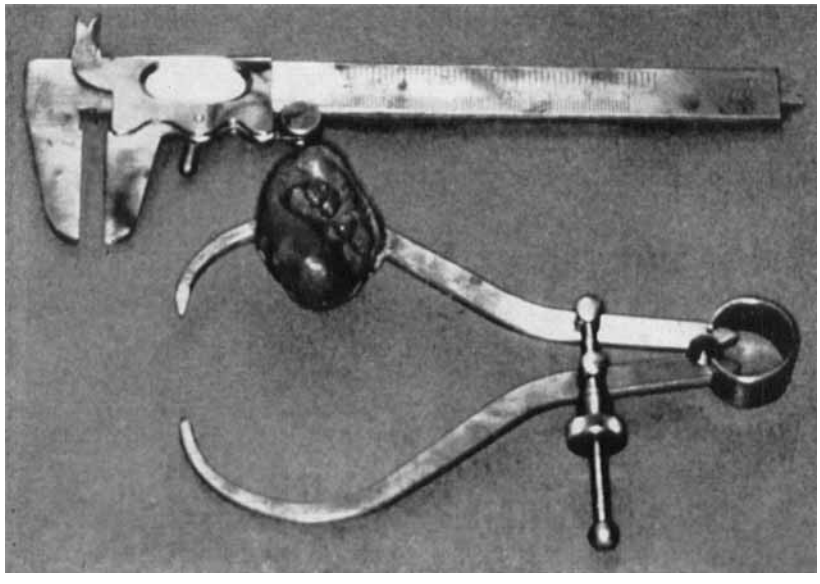

Fig. 9 a. Instruments for measuring the thickness of the cheek.

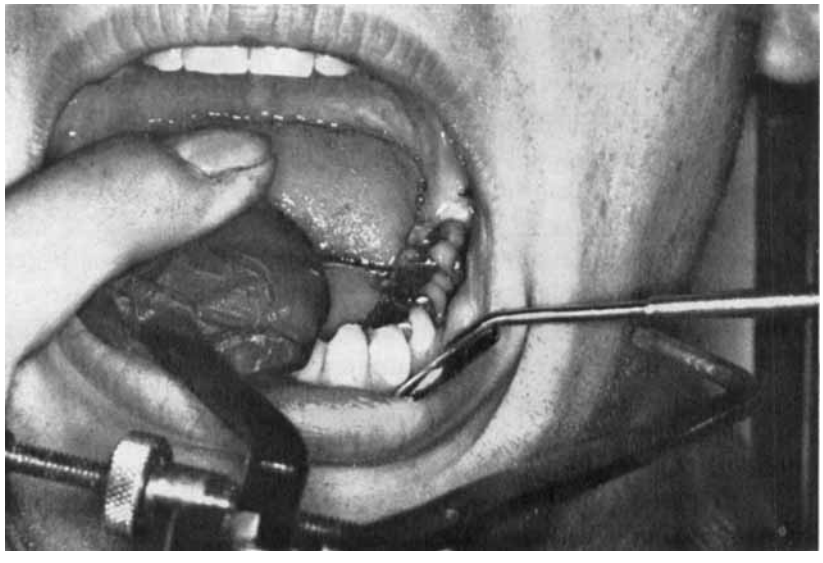

Fig. 9 b. Application of the calipers. The tip of the calipers is inserted into the lingual proximal space between the lower first and second molars.

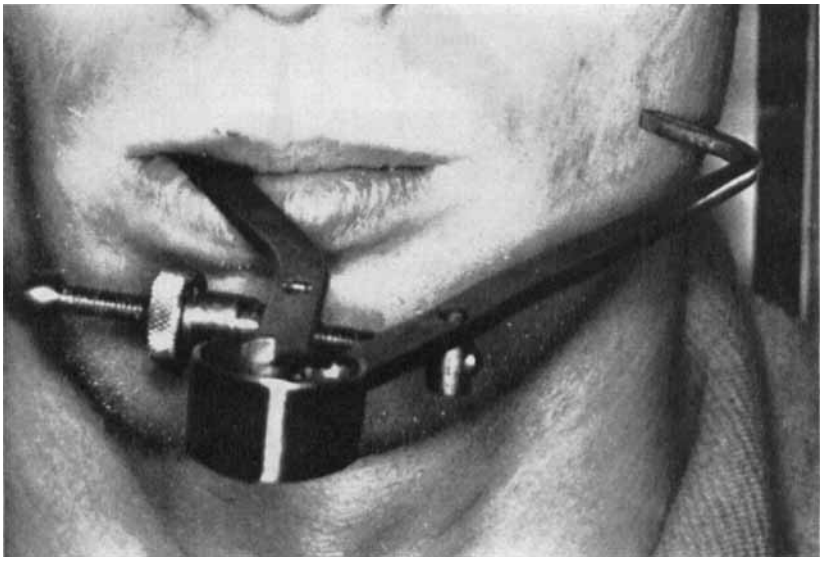

Fig. 9 c. Measuring the thickness of the cheek. The teeth are closed on the impression of 3--5 teeth in the upper and lower jaws. This stable arrangement enables the measurements to be reproduced with fairly high accuracy.

patient was 29.2 mm (standard deviation 0.3). The error of measurement was small enough in relation to the biologic variation of the series to be ignored. Another possible source of error, the day to day variation in the thickness of the cheek, was controlled by taking measurements at a particular site of the cheek at 9 a.m. on 10 consecutive days. The subject examined showed practically no day to day variation (mean 40.0 mm, standard deviation 0.4). The measurements of the thickness of the cheek were performed with the calipers, and the maximum opening of the jaws and the postoperative trismus were measured with sliding calipers (Fig. 10). These measurements were repeated on the first 5 or 6 postoperative days and thereafter at intervals of a day or two until the values recovered their preoperative level. Each value recorded was the mean of 3 measurements. If the patient was unable to appear for the check on a particular day, the mean of the previous and following days' values was recorded.

All the patients were premedicated with pentymal, 0.15 g, taken

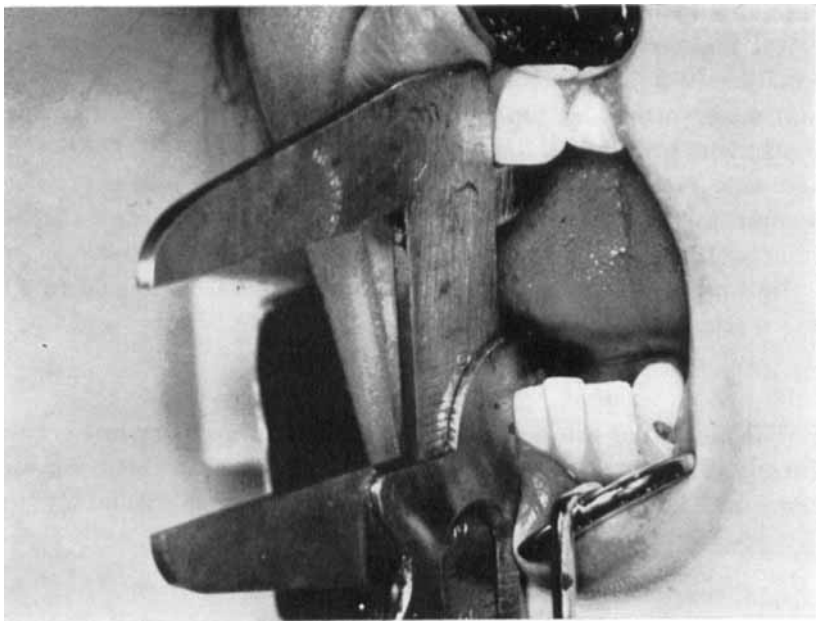

Fig. 10. Measurement of trismus. Expressed as a reduction in maximum opening of the jaws.

by mouth, and 0.5 per cent methyl scopolamine by submucosal injection into the vestibular fornix. The operation was performed under block injection (2.2 ml of 2 per cent Xylocaine-Exadrin Special*) and at intervals of at least 2 weeks. The choice of third molar and dental engine for the first operation on each patient was determined by drawing lots. The same surgeon performed the operation, followed the patients and recorded the findings.

In each case the method for the left and right sides was as nearly as possible the same. The operation technique was as follows: The load on the temporomandibular joint and its ligaments was relieved during the operation by means of a McKesson's rubber plug. The impacted tooth and the surrounding bone were exposed so as to obtain a clear operative field. The bone was removed on the vestibular, distal and, when necessary, the occlusal aspects, so that the tooth could be removed from its bed without the need for appreciable force. The bone was always removed to

* AB Astra, Södertälje, Sweden

the same extent on the vestibular and distal aspects to the level of the highest prominence of the crown or to the cementoenamel junction. Where the tooth was locked against the second molar and where otherwise indicated, a groove was first drilled in the tooth, which was then devided with an osteotome. The follicular sac and proliferating gingival epithelium were removed. The wound was sutured primarily or left to heal by granulation. Eight tablets of an analgesic, usually Fenalgin forte* were given.

In 8 cases there was primary healing on both sides and in 11 cases secondary healing.

Results

The means for the systemic and local reactions were fairly uniformly distributed in the two experimental series, except for the trismus. The systemic reactions were insignificant (Table II). In

Table II

Systemic reactions to surgical operation; 19 patients.

	48,000 r.p.m.		8000 r.p.m.	
	Increase in number of patients	Range	Increase in number of patients	Range
ERS (mm i 1 hr.)	13*)	7—25	10*)	6—26
White blood cells (per mm³)	5*)	8100—10,500	5*)	6200—8800
Temperature (C)	2	37,7; 37,9	2	37,8; 38,0
α_2 — serum globulin	Slight insignificant increase		Slight insignificant increase	

*) Increase in ESR and white cells was calculated on the basis of values corrected according to variations of normal values published in tables by *Dahlberg & Josephson* (1953): ESR ♂ = 3.8; ♀ = 4.5; white blood cells = 1400.

both series there was on an average a slight increase in the E.S.R. on the third and sixth days. On the third day the E.S.R. rose by a mean of about 4 mm in both series. On the sixth day the mean rise was 3.1 mm in the 48,000 r.p.m. series and 4 mm in the 8000 r.p.m. series (Fig. 11). The white corpuscles increased slightly in number in 5 cases of both series. There was no statistically significant correlation between the extent of the oedema and the

* AB Astra, Södertälje, Sweden

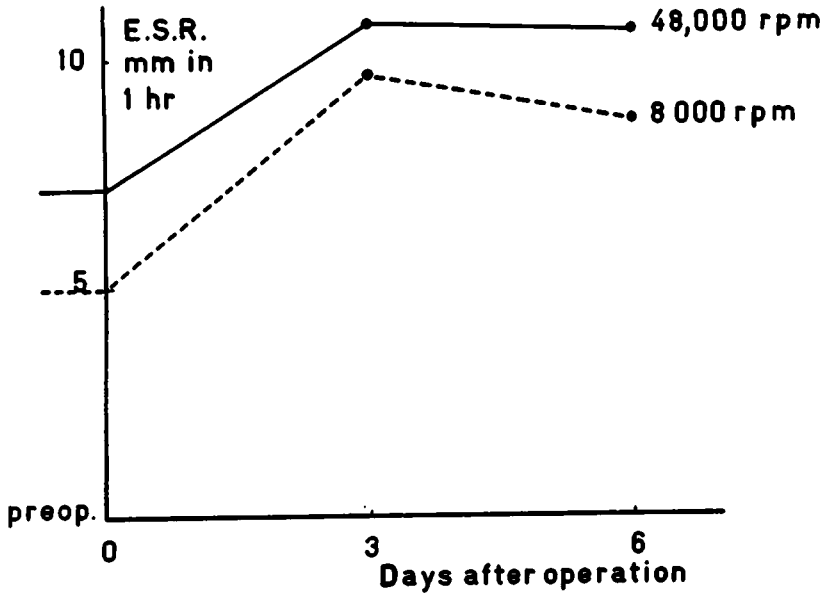

Fig. 11. The E. S. R. (Westergren's method) on the third and sixth postoperative days.

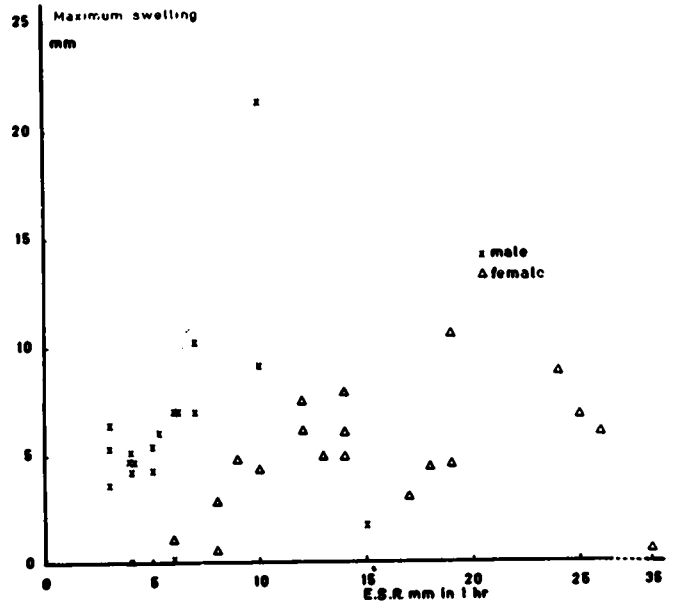

Fig. 12 a. Scatter diagram. No correlation was found between maximum swelling and E. S. R.

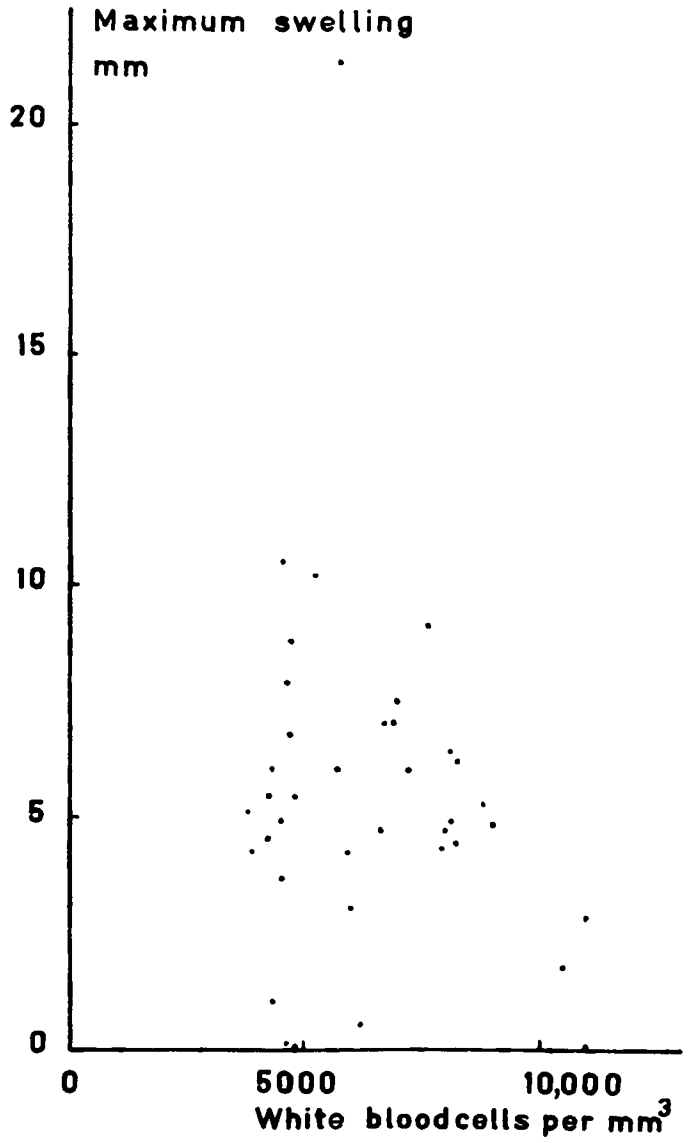

Fig. 12 b. Scatter diagram. No correlation was found between maximum swelling and leucocyte count.

rise in E.S.R. or the white cell count, nor between the maximum E.S.R. and the leucocyte count on the same postoperative day (Figs. 12a, b, c). There was no decrease in the number of eosinophil blood cells. In 2 cases the body temperature rose to 38°C on

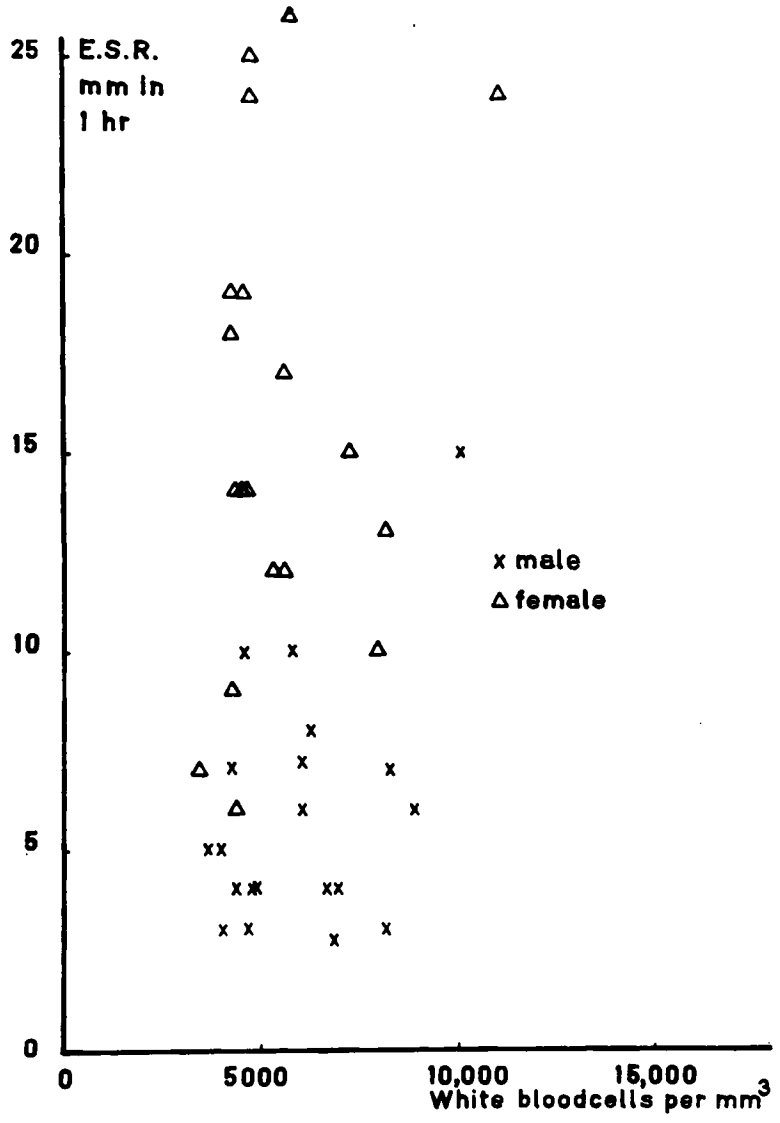

Fig. 12 c. Scatter diagram. No correlation was found between E. S. R. and leucocyte counts.

the evening of the day of the operation, but had returned to normal on the following day. In these cases an increase in temperature was recorded on removing both third molars; while this may have been a coincidence it may have a constitutional explanation.

Table III

Local complications after surgical operation; 19 patients.

Tooth*)	Speed/r.p.m.	Healing	Symptoms	Days after operation	Symptoms disappeared after
8—	8000	secondary	swelling and erythema around the wound, weak putrid odour (on 3rd postop. day slight angina)	6	2 days
—8	48,000	secondary	food remnants, weak putrid odour, pains	8	2 days
—8	8000	secondary	slight pains, food remnants, weak putrid odour	6	2 days
—8	48,000	secondary	slight pains, putrid odour from Gelfoam	2	1 day
—8	48,000	primary	slight discolouring of the cheek	2	
8—	48,000	primary	haemorrhage in the night after operation, discolouring of the cheek	1	immediately after applying Surgicel gauze
8—	8000	secondary	haemorrhage on the night after operation	1	compression
			recurrent haemorrhage	5	compression
			recurrent haemorrhage	7	definitely after 2 Surgicel cones

*) 8— right lower M 3, —8 left lower M 3.

Table IV

Comparison between the 8000 and 48,000 r.p.m. techniques with respect to maximum swelling and trismus and the duration of these reactions; 19 patients.

	48,000 r.p.m.					8000 r.p.m.					Difference between 8000 and 48,000 r.p.m. (intra-subject)		
	Mean	SD	Standard error of the mean	Coefficient of variation per cent	Range	Mean	SD	Standard error of the mean	Coefficient of variation per cent	Range	Mean	SD	Mean error
Maximum swelling (mm)	5.5	4.1	0.9	74	0.0—21.3	5.7	2.2	0.5	38	0.5—10.2	0.2	4.2	1.0
Duration of swelling (days)	7.1	3.7	0.8	52	0.0—14.0	7.6	1.8	0 4	24	5 0—10.0	0.5	3.5	0.8
Maximum trismus (mm)	16.2	7.4	1.7	46	0.0—32.3	17.6	10.1	2.3	57	0.2—39.0	1.4	8.5	2.0
Duration of trismus; 17 subjects (days)	8.6	4.9	1.1	58	0.0—19.0	10.5	5.7	1.3	56	0.0—20.0	1.8	3.9	1.0

Confidence interval (95 % level) for mean difference between 8000 and 48,000 r.p.m., *i.e.* mean difference ± 2 × mean difference error:

Swelling: 0.2 ± 2.0

Trismus: 1.4 ± 4.0

In both series there was a slight postoperative rise in the α_2-globulins in serum. While there were no signs of general infection, 4 cases displayed symptoms of secondary infection of the sockets (Table III).

There was no statistically significant difference between the two series with respect to the mean maximum swelling, extent or duration of the swelling. The mean maximum degree and duration of the trismus, on the other hand, were slightly smaller for the 48,000 than for the 8000 r.p.m. group, but did not reach a significant level (Table IV). The intra-subject mean difference (maximum swelling 0.2 mm, maximum trismus 1.4) was small in relation to the standard deviation (4.2 and 8.5, respectively). This indicates that with respect to the appearance of these reactions the biologic variation is more important than the difference in technique for the removal of bone. The differences of 0.2 and 1.4 in the means are small in relation to the individual means for maximum swelling and trismus at 8000 r.p.m. (5.7 and 17.6, respectively). From the clinical standpoint the differences in magnitude observed are not of practical importance.

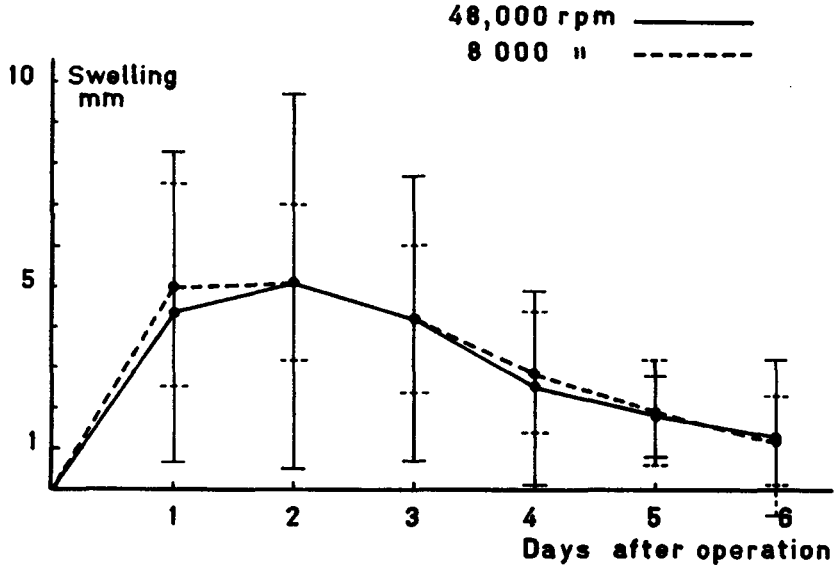

Fig. 13. Swelling: mean values and standard deviations on the first six postoperative days.

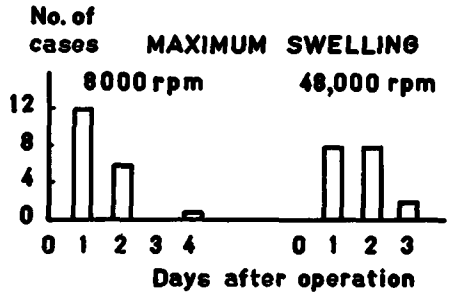

Fig. 14. In the majority of cases the maximum swelling occurred on the first and second postoperative days.

On the other hand, the observed differences need to be bounded by limits of confidence that include the true value with a high level of probability. Thus, the confidence interval for facial swelling was 0.2 ± 2.0 and for trismus 1.4 ± 4.0 (see comments to Table IV). The largest difference between 48,000 r.p.m. and 8000 r.p.m. that need be noted is 2.2 mm for a swelling and 5.4 mm for trismus, which corresponds to the upper limit of the confidence interval. From a practical point of view, if the maximum difference in swelling had been 2.2 mm for one of the two methods it could hardly have been ascribed any significance; such a difference would probably not be observable by subjective inspection. On the other hand, the upper limit of the confidence interval for trismus was too large to be neglected. From the findings presented in Table IV it may thus be concluded that there was no major difference between the two groups with respect to maximum facial swelling. The differences noted would seem to be related to the duration of trismus.

The means for the swelling were practically coincident for the first 6 postoperative days (Fig. 13). The maximum swelling occurred on an average on the second day and the swelling had practically disappeared by the sixth day, judged clinically. Moreover, there was no major difference in facial swelling in the two groups. In most cases the maximum swelling for the various subjects was recorded on the first and second postoperative days (Fig. 14).

The means for trismus relating to the first 6 postoperative days were not in such close agreement as those for facial swelling

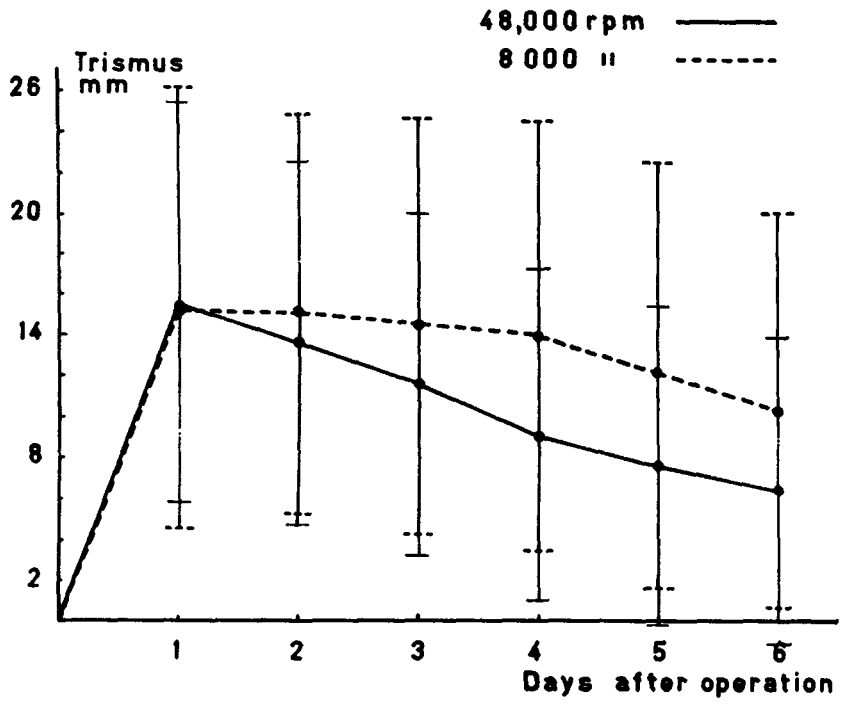

Fig. 15. Trismus: mean values and standard deviations for the first six postoperative days expressed as the reduction in maximum opening of the jaws.

(Fig. 15). In both series maximum trismus occurred on the first postoperative day, when the means were practically the same; thereafter, the mean was greater in the 8000 r.p.m. series. The difference between the means was, however, not statistically significant, but the findings indicate that if there is any difference it is associated with trismus and its duration. Trismus was still marked on the sixth postoperative day in both groups. The maximum trismus for the individual subjects usually occurred on the first postoperative day (Fig. 16).

Pain, being a subjective symptom, could not be recorded objectively. By using the following classification a mean index can be calculated, however, that might provide a certain guide (Table V). After the operation each patient was given 8 tablets of a compound analgesic, usually Fenalgin forte (barbital 75 mg, phena-

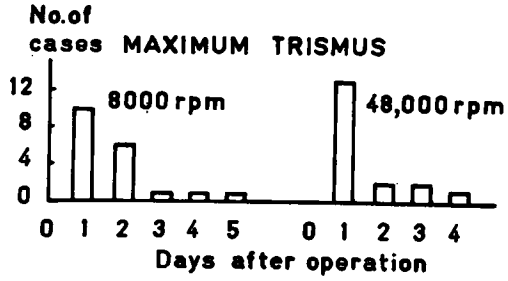

Fig. 16. In most cases the maximum trismus occurred on the first postoperative day.

cetin 150 mg, papaverin hydrochloride 5 mg). When the pain could be alleviated by one tablet as the anaesthesia began to wear off and/or one tablet in the evening, it was denoted as mild (index 1). If 2 tablets taken together were required, the pain was recorded as moderate (index 2). If more tablets were required, the pain was classed as severe (index 3). By multiplying the number of cases in the three classes by the respective index, adding the products and dividing by the number of cases, that is, 19, a mean index of pain was obtained. There was no significant difference between the mean index in the two experimental groups after either 24 or 48 hours (Table V). The mean index was, however, insignificantly higher for the 8000 r.p.m. series. With a few exceptions the patients did not need to take the tablets after 48 hours.

It is evident from the scatter diagrams in Figs. 17a—c, which show the correlation between maximum swelling and trismus for the individual patient, that there could be severe trismus with little if any facial swelling, and that facial swelling with little or

Table V

Pain reaction to surgical operation; 19 patients.

	48,000 r.p.m.					8000 r.p.m.				
	None (0)	Slight (1)	Moderate (2)	Severe (3)	Mean index	None (0)	Slight (1)	Moderate (2)	Severe (3)	Mean index
24 hours postop.	4	5	8	2	1.42	1	7	9	2	1.63
48 hours postop.	17	2	0	0	0.10	17	0	2	0	0.21
72 hours postop.	19	0	0	0	0.00	18	1	0	0	0.05

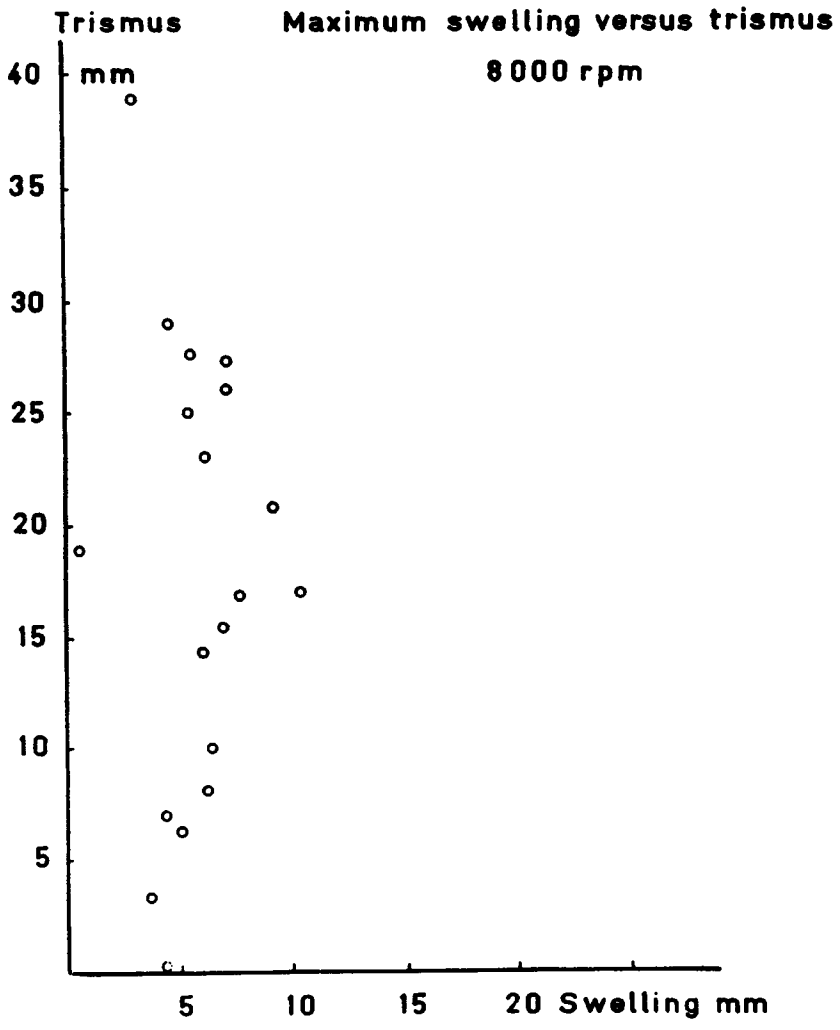

Fig. 17 a, b, c. Scatter diagrams for maximum swelling versus trismus in the 8000, 48,000 and 8000/48,000 r.p.m. series. There was neither a positive nor a negative correlation between these two reactions.

no trismus occurred, but that the more marked swelling was often accompanied by relatively marked trismus. The scatter diagrams for trismus and facial swelling on the first and second days, when these complications were usually at their maximum, have largely the same appearance and therefore bear out the above conclusions.

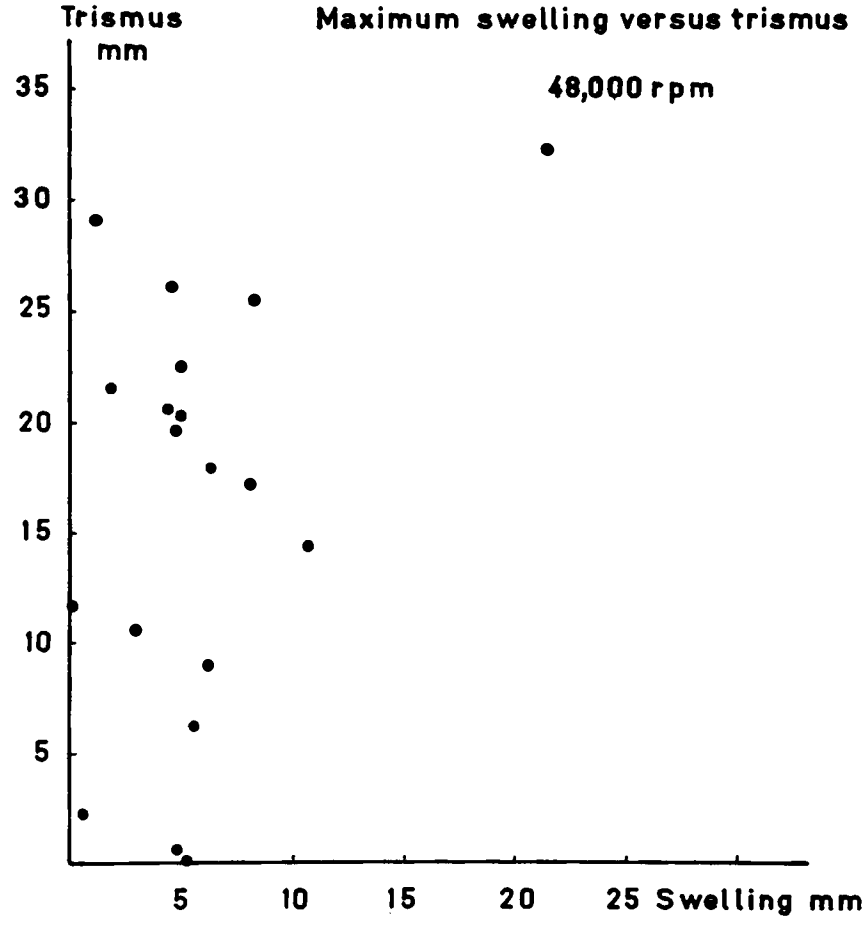

Fig. 17 b.

As regards the operation time, the 8000 r.p.m. method required on an average about 2 minutes longer than the 48,000 method (Table VI).

Table VI

Time required for removing bilateral impacted lower third molars; 19 patients.

Speed (r.p.m.)	Mean time (min.)	Range (min.)
48,000	16.7	8—35
8000	18.8	10—30

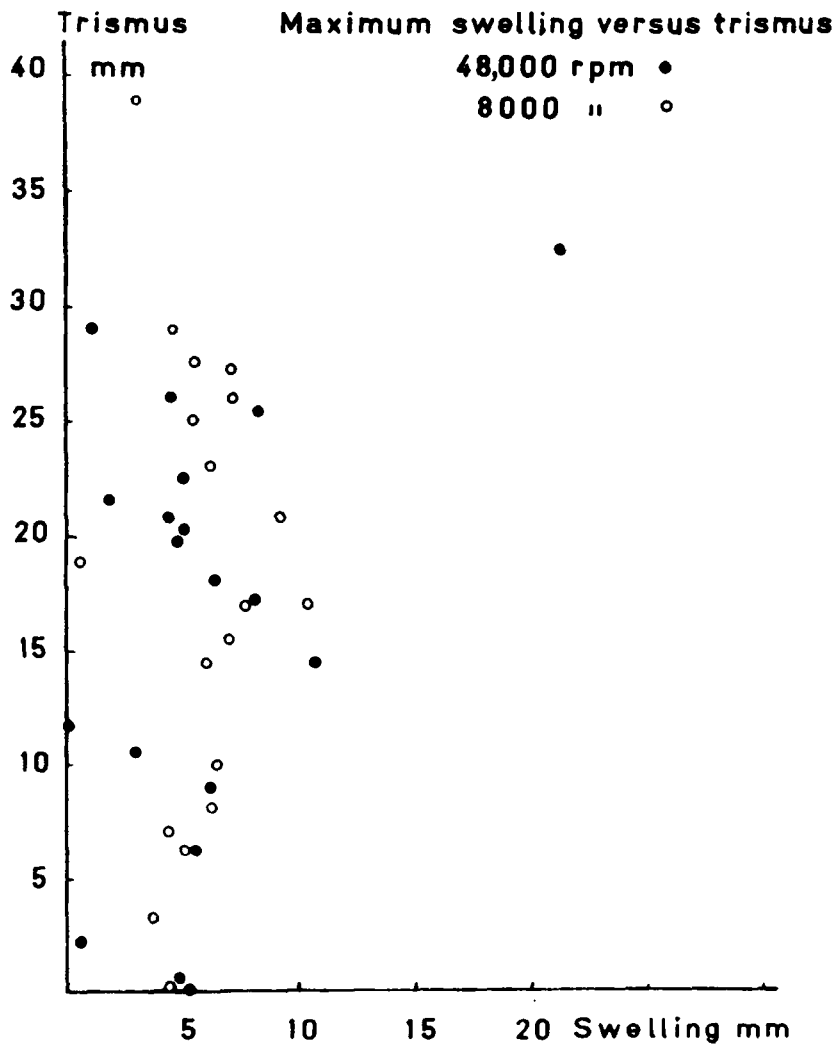

Fig. 17 c.

DISCUSSION

The type and extent of the reactions resulting from the operation were all dependent on constitutional differences between the subjects, as well as on the trauma. To reduce the former factor as much as possible the patients served as their own controls. To reduce the influence of variations in the technical procedure the

operations were performed by a standardized technique and by the same surgeon. For the same reason only patients with radiographically similarly situated third molars on both sides were included in the series. The test side and the method for removing the hard tissue were determined in each case by drawing lots.

It might be expected that these precautions would reduce the intra-subject standard deviation for a particular subject as regards swelling and trismus; that is, the standard deviation of the differences between the means in Table IV would be less than the standard deviation for the same characteristics for the 48,000 and 8000 r.p.m. techniques. As regards the duration of trismus the intra-subject standard deviation was 3.9, which is less than that for either the 48,000 r.p.m. (4.9) or the 8000 r.p.m. technique (5.7) (Table IV). In this case the difference is thus striking. On the other hand this was not the case for maximum swelling. A closer study shows also that the correlation between the swelling on the left and right sides of a particular subject was low (r=0.20). As regards facial swelling, this matching experimental arrangement with homologous teeth was of no significance. In the evaluation of trismus, on the other hand, it was of some importance. As regards the relevant reactions it would seem that the use of homologous teeth was not a factor of major importance.

There were no significant differences between the two techniques with respect to the recorded reactions (Table IV). It should be emphasized, however, that a non-significant difference implies that the methods are not equivalent as regards the reactions concerned. It is conceivable that in fact there were differences in the mode of reaction to the two speeds of rotation that were not manifested owing to incidental factors or the small number of subjects in the two groups.

A guide as to how the observed differences shall be evaluated is provided, however, by the confidence intervals, for these include the true differences with a 95 per cent probability. If both the upper and the lower boundaries of the interval lie within the limits that might be accepted as equivalent from the clinical point of view, it is justifiable to conclude that, for practical purposes, the two procedures are equivalent. Thus, if the confidence interval for swelling which lay between —1.8 mm and +2.2 mm (that is to say, the recorded values of swelling in the 8000 and

48,000 r.p.m. groups varied by not more than 2.2 and 1.8 mm respectively—a clinically negligible difference), the procedures are equivalent with respect to this reaction.

As regards trismus, on the other hand, the confidence interval for which lay between —2.6 mm and +5.4 mm, the 2.6 mm difference may be considered negligible for clinical purposes, whereas the 5.4 mm difference is of practical significance.

Though the series was small, the results show a distinct trend. To obtain a clearer picture of the true differences a larger series is required. If the practical limit for the clinically acceptable difference is set at 2.5—3 mm for both swelling and trismus, to demonstrate any existing difference it would be necessary to increase the present series of 38 teeth by some 200, as the first measure. However, it did not seem to be justified to expand the study in this way since, as mentioned above, the intra-individual values also indicated that the biologic variation was more important than the effect of the difference in technique; moreover, the medical examination provided no evidence of any major difference between the two methods. This is borne out by the fact that, in their carefully controlled study on 50 teeth in each group, *Szmyd et al.* found no significant difference in respect of pain, swelling, trismus or haemorrhage when technically different methods such as higher bur speed were compared with the conventional mallet and chisel technique. It is, moreover, more important in clinical investigations that general planning problems should be solved in a satisfactory manner than that the series should be large.

If a study can be performed as a double blind test a subjective evaluation is in principle as good as an objective one. It is an advantage to have more than one person judging the reactions and to make separate analyses of their evaluations. As this study was planned, and when it is a case of judging a reaction, an objective evalution is probably to be preferred, since this does not entail so great a dependence on the subjective error. The recording of swelling was probably not influenced appreciably by subjective errors. In the case of trismus, however, the possibility of this form of error cannot be ruled out entirely. The opening of the jaws (measured in millimetres) is, of course, dependent on whether the patient feels pain, and this may influence the re-

cordings to some extent. To reduce the risk of subjective error here the values recorded were as a rule the mean of 3 consecutive readings. To reduce the subjective factor in the evaluation of pain a special method of evaluation was used. The assessment of systemic reactions is based on objective determinations.

For an evaluation of facial swelling the method of registration used was simple and economical of time. As in the studies by *Forsberg, Björn et al.* and *Flechhaus,* the oedema usually reached its peak on the first or second day after the operation. The maximum facial swelling occurred on an average on the second day, and on the sixth day the swelling had in most cases practically disappeared. While the method applied by *Björn et al.* of measuring the whole volume of the swelling will give a more accurate impression of the appearance of the swelling than registrations at one or more points, it may be of value to know the height of the swelling, since the patients are more affected by its prominence than by its extent. Moreover, photogrammetric registration requires expensive apparatus and is time-consuming and difficult to perform. The method used in the present study whereby the facial swelling was measured at a single point just in front of the anterior border of the masseter muscle, where the maximum of oedema might be expected, would therefore seem to be sufficiently reliable. A check of the accuracy of the method showed that the measurement error was small enough in relation to the biologic variation for it to be negligible. Since repeated measurements gave approximately the same results, the values could be subjected to statistical analysis.

It is commonly considered that trismus is associated with facial swelling, but the findings suggest that this is not always the case (Figs. 17 a, b, c). Trismus following removal of impacted third molars may occur owing to reactions located chiefly in the masseter or medial pterygoid muscles, or both. In the case of exudate or haemorrhage in this region fluid may spread into loose connective tissue beneath the skin of the face, beneath the mucous membranes and/or into the interstitial connective tissue of the muscles. If the facial swelling is severe, it is more likely that the exudate will spread to the masticatory muscles and give rise to abnormal activity. Minor exudate in the muscle may, however, give rise to muscle activity also by stimulation of the nerve re-

ceptors and result in trismus. In electromyographic studies of muscle activity *Carlsöö* found that a bilateral muscle activity is often elicited by reflex action. The exudate may be in such a position that, although of limited extent, it may affect the receptors of afferent pathways and hence the normal pattern of innervation of the chewing muscles. Such stimulation of the afferent activity might raise the mandible by reflex action, so that at least one of these muscles on each side is activated during the opening movement, thus preventing maximum opening.

These observations may explain why exudation of such limited extent that it might be overlooked at an extra- or intra-oral inspection may give rise to trismus. It would thus seem as if the site of the oedema in the muscle may in some measure determine the extent of trismus.

Clinical pain is difficult to assess since the interpretation of the patient's reaction is affected by a variety of factors. It is dependent on, for instance, the susceptibility to suggestion. According to *Tudhope* (1962) the only possibility of judging the efficiency of an analgesic is to test it when treating patients suffering from pain of different origin, for the response to experimentally induced pain in animals or man is not a direct indication of its value in alleviating or banishing clinical pain. Conversely, the number of tablets that a patient consumes after the operation might provide an indirect impression of the severity of the pain. The method of evaluation used in the present study is therefore not based on the patient's subjective statements of the intensity of the pain but on the consumption of tablets. It is inevitable that some of the patients should take tablets "for safety's sake" but, on the other hand, in other cases the pain was described as severe when relief was provided by a single tablet. It is a familiar observation that normally pain appears at certain intervals after an operation. The pain seems first to appear some hours after the operation, presumably as a direct consequence of tissue trauma, and is later intensified during the 24 hours following the operation, when the inflammatory reaction is manifested. To diminish the influence of individual behaviour patterns to some extent, the patients were instructed to take one tablet when the pain appeared for the first time, presumably when the analgesia began to wear off, and if after 15 minutes this proved insufficient, a further tablet should

be taken. The same instruction was given regarding medication when retiring. The method is by no means objective but was used in the absence of any better basis of evaluation.

The fact that general reactions such as a rise in the E.S.R., leucocytosis and an increase in the α_2-globulin fraction and temperature were of minor degree indicates that there was only slight trauma. However, those general reactions that were recorded, were fairly evenly distributed throughout the experimental series. The most definite reaction was a slight increase in the sedimentation rate—on an average about 4 mm—which was noted in about two-thirds of the cases. This is what might be expected from the experience reported by, for instance, *Aksdahl.* As in the study by *Burch & Morris,* no association was found between oedema and leucocytosis. No direct comparisons can be made since the problem has not been widely studied, in spite of its importance in respect of adequate postoperative care. The fact that no reduction in the eosinophilic blood corpuscles was found in this study might, according to *Thorén,* indicate that the tissue trauma was of minor degree.

In spite of this and the mildness of the systemic reactions, the local reactions were relatively marked. As regards the swelling, this may be due to generous vascularity, and a relative abundance of loose connective tissue in the facial regions; the oedema would then be more pronounced after operations in the mouth than elsewhere in the body. Mild oedema that is resorbed and disappears after 5—6 days may be regarded as a natural sequela of an operation of this type.

Apart from the slightly more marked trismus after the use of the conventional dental engine, the local and general reactions were fairly uniformly distributed in the two experimental groups. It would thus seem that a more rapid instrument does not traumatize the tissues appreciably less than a low-speed engine. The opinions voiced in the literature vary considerably. *Kilpatrick & Hall,* whose views were, however, based on uncontrolled clinical impressions, had a strong preference for the ultra-rapid technique, while *Szmyd et al.* in a well-controlled study could not find any significant difference in the local postoperative reactions in a comparison between a higher bur speed technique (air turbine) and the conventional mallet and chisel technique in the

removal of impacted teeth, and the time required for the operation was approximately the same for the two methods.

In the present study there was a mean difference of about 2 minutes in favour of the 48,000 r.p.m., which is of course an advantage. The gain obtained with a rapid instrument should not, however, be overestimated, since the work in hard tissue is often a small part of the operation compared with the other manipulations. One advantage of the high-speed instrument is that a smaller pressure is required, and this reduces the risk of tissue damage and is a mark of a good technique in the use of such engines.

It would thus seem that more important than the choice of instrument in bone surgery of the jaws is that the instruments should be used properly, with due adherence to accepted principles of surgery. The risk of postoperative complications can be reduced by limiting the tissue damage through careful handling of soft tissue, by avoiding traumatization and overheating of the bone, and by means of careful haemostasis, drainage where indicated, intermittent drilling under light pressure, effective cooling and use of efficient ejectors to remove bone debris. The technical aids have changed through the ages, but the golden rule of surgery, as formulated in antiquity and ascribed to one of its more famous doctors Asklepiades from Prusa in Bitynia is still appropriate today—"tuto, celeriter, jucunde" (reliable, rapid and comfortable).

SUMMARY

A study has been performed of the effect of traumatic and thermal damage on postoperative reactions following the use of burs in bone surgery of the jaws. The instruments used were a high-speed Atlas Copco Dental air rotor, with a speed when loaded of 48,000 r.p.m. and an engine with conventional speed of about 8000 r.p.m. (Tecno, Svedia, Stockholm, Sweden). They were applied for the removal of bilateral impacted lower third molars of 19 patients aged 17—40 years. The two molars were similarly situated in the jaw, according to radiographic examination.

(1) The systemic reactions were mild, fairly uniformly distributed and not correlated with facial swelling or trismus. Agglu-

tination of blood in connection with tissue trauma, caused a slight to moderate rise in the sedimentation rate in about two-thirds of the cases. There was also a rise in the α_2-globulin fraction in the blood but this was mild and not statistically significant. The absence of any reduction in the eosinophilic cell count indicates that the trauma was mild.

(2) If a difference of 2.0 mm in the facial swelling is accepted as not indicating any clinically significant difference between the two methods these may be regarded as similar with respect to this variable.

(3) As regards the distribution of postoperative pain there was no significant difference between the methods.

(4) Trismus, on the other hand, appeared to be slightly less marked and of shorter duration for the 48,000 than for the 8000 r.p.m. technique; the difference was not statistically significant, but this does not rule out the possibility that there was in fact a difference that was not manifested, perhaps owing to accidental circumstances or the small number of cases comprising the series.

(5) Trismus was not always related to facial swelling. The site of the oedema in the closing muscles and the severity of the oedema may to some extent determine the degree of the trismus.

(6) The speed of the engine appeared to be less important than the biologic variation in determining the occurrence of local reactions. The use of homologous teeth did not appear to be a factor of importance.

(7) The trend and distribution of values in both objective and subjective registrations suggest that from the standpoint of trauma there is no essential difference between the two techniques.

(8) The gain in time and the lighter pressure required with the more rapid instrument are factors of value in the surgical work.

(9) The method for registering swelling measurements provides a simple, practical and time-saving way of following the postoperative course in the jaws. Since the instrument error in measuring facial swelling is small (coefficient of variation about one per cent) in relation to the biologic variation and since repeated measurements provided approximately the same results, the values obtained could be subjected to statistical analysis.

Acknowledgements

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RÉSUMÉ

MACHINES DENTAIRES À HAUTE RAPIDITÉ OU À RAPIDITÉ CONVENTIONELLE POUR L'ÉLOIGNEMENT D'OS EN CHIRURGIE MAXILLAIRE

I. UNE ÉTUDE DES RÉACTIONS APRÈS L'EXTRACTION BILATÉRALE DE DENTS DE SAGESSE ENCLAVÉES DANS LES MANDIBULES

Pour étudier l'effet des lésions thermo-mécaniques sur les réactions post-opératoires après l'emploi de fraises dans l'ostéochirurgie maxillaire l'auteur s'est servi d'une part d'une fraise d'une rapidité de 48.000 révolutions par minute sous pression (Dental air-rotor, Atlas Copco, Stockholm, Suède), et d'autre part d'une fraise à la rapidité conventionelle de 8.000 rpm, pour l'extraction bilatérale de dents de sagesse enclavées dans les mandibules de formation homologue sur 19 patients âgés de 17 à 40 ans.

On a pu tirer les conclusions suivantes:

1) Les réactions générales étaient insignifiantes, de distribution relativement égale et sans corrélation à l'oedème du visage ni au trismus. L'agglutination de sang accompagnant la lésion du tissu a causé, dans à peine deux tiers des cas, une augmentation modérée de la sédimentation sanguine. On a aussi constaté une légère augmentation post-opératoire de la fraction α_2 des globulines sériques du sang, mais celle-ci était peu importante. On n'a non plus observé de réduction dans le nombre de globules de sang éosinophiles, ce qui indique que la blessure était de dimensions limitées.

2) Si on accepte qu'une différence de 2.0 mm dans l'oedème du visage est sans importance pour le choix entre les deux méthodes, celles-ci peuvent être considerées comme égales en ce qui concerne cette variable.

3) Aucune différence dans la douleur post-opératoire n'a indiqué préférence entre les deux méthodes.

4) Au contraire, le trismus a paru moins fort et de plus courte durée après l'application de 48.000 rpm qu'après l'application de 8.000 rpm, bien que la différence ne soit pas de significance statistique. Il est cependant possible qu'il y ait en réalité une différence que l'auteur n'a pu observer à cause des circonstances de l'investigation et du nombre limité des cas examinés.

5) Les trismus n'était pas toujours corrélatif à l'oedème du visage. La gravité du trismus est déterminée par la grosseur de l'oedème ainsi que de sa localisation dans la musculature fermante.

6) La variation biologique a paru plus importante pour la génèse de réactions locales que la variation de rapidité entre les fraises, et l'emploi de dents homologues n'a pas semblé avoir de conséquences importantes.

7) La tendance et la distribution des valeurs obtenues, que celles-ci aient été relevées de façon objective ou subjective, ont indiqué que, par rapport au traumatisme, il ne doit pas exister de très grande différence entre les deux méthodes.

8) Cependant, le temps gagné et la pression moins forte exercée par la fraise à haute rapidité sont des facteurs importantes dans la chirurgie dentaire.

9) La méthode dont on s'est servi pour mesurer l'enflure est un moyen simple, rapide et pratique de suivre un développement post-opératoire dans les maxillaires. Comme l'erreur des instruments en mesurant l'enflure du visage est minime par rapport à la variation biologique (coéfficient corrélatif environ 1%) et que des mensurations répétées donnent presque les mêmes résultats, les valeurs obtenues peuvent être soumises à des calculs statistiques.

ZUSAMMENFASSUNG

TURBINENMOTOREN ODER MASCHINEN VON KONVENTIONELLER GESCHWINDIGKEIT ZUR KNOCHENABTRAGUNG IN DER KIEFERCHIRURGIE

I. EINE UNTERSUCHUNG ZUR FESTSTELLUNG DER REAKTIONEN NACH DEM ENTFERNEN VON BILATERALEN RETINIERTEN WEISHEITSZÄHNEN IM UNTERKIEFER

In einer Untersuchung zur Feststellung der Wirkung von traumatischen und termischen Schäden betreffs der postoperativen Reaktionen im Gebrauch von Bohrern bei der chirurgisch-techni-

schen Arbeit im Kiefer wurde ein Turbinenmotor mit einer Geschwindigkeit von ca. 48.000 Umdrehungen bei Belastung (Dental air-rotor, Atlas Copco, Stockholm, Schweden) mit einer Maschine von konventioneller Geschwindigkeit, ca. 8.000 Umdrehungen (Tecno, Svedia, Stockholm, Schweden) verglichen. Die Untersuchung wurde an 19 Patienten mit bilateralen, retinierten Weisheitszähnen unternommen. Die Patienten waren im Alter zwischen 17 und 40 Jahren.

Ergebnisse:

1. Die allgemeinen Reaktionen waren unbedeutend und gleichmässig in beiden Serien verteilt und standen nicht in Zusammenhang mit Gesichtsschwellung oder Trismus. Agglutination von Blutkörpern bei Gewebetrauma verursachte eine leichte bis mässige Steigerung von α_2-Globulinfraktion im Blut, jedoch war diese Steigerung unbedeutend und nicht statistisch signifikant. Es kam zu keiner Verminderung der Anzahl von eosinophilen Blutkörperchen, was auf ein Trauma von geringer Grössenordnung hindeutet.
2. Wenn man eine Gesichtsschwellung von 2 m/m als klinisch unbedeutend ansehen kann, so kann man beide Methoden als gleichgestellt ansehen.
3. Bezüglich der nach Operation eintretenden Schmerzen, gab es zwischen den beiden Methoden nichts, was die eine von der anderen unterscheidet.
4. Dagegen war Trismus anscheinend etwas geringer und von kürzerer Dauer beim Gebrauch von 48.000 als bei 8.000 Umdrehungen. Der Unterschied war dagegen statistisch nicht signifikant. Dieses schliesst jedoch die Möglichkeit nicht aus, dass wirklich ein Unterschied vorhanden war, der auf Grund von Zufällen oder einer relativ geringen Anzahl von Fällen nicht sichtbar war.
5. Auf Trismus folgte keineswegs immer Gesichtsschwellung. Die Lage und Ausbreitung der Schwellung in den Kaumuskeln bestimmt im gewissen Sinne den Grad des Trismus.
6. Für die Entstehung der örtlichen Reaktionen schien die biologische Variation von grösserer Bedeutung zu sein als die verschiedenartige Geschwindigkeit der Bohrmaschinen. Anscheinend wurde die Anwendung von homologen Zähnen nicht von besonderer Bedeutung.
7. Die Tendenz und die Verteilung der Resultate von objektiven,

wie auch von subjektiven Registrierungen deutet darauf hin, dass kein offenbarer Unterschied in der Traumawirkung zwischen den beiden Methoden vorhanden ist.

8. Die Zeitgewinnung und der leichtere Druck beim Gebrauch der schnelleren Bohrmaschinen sind von Wert bei der Ausübung der chirurgischen Tätigkeit.

9. Die für die Messung der Gesichtsschwellungen angewandte Methode ist einfach, praktisch und wenig zeitraubend. Da die Messfehler mit dem Instrument im Verhältnis zu den biologischen Variationen unerheblich sind, und da wiederholte Messungen ungefähr das gleiche Resultat gaben, können diese einer statistischen Analyse zu Grunde gelegt werden.

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