AN EVALUATION OF LUBRICANTS FOR DENTAL HANDPIECES AND CONTRA-ANGLES

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SINCE the advent of increased speeds of operation for the shaping of cavities, the problems associated with the care and maintenance of dental handpieces have become more significant.[14, 21] One of the most important is proper lubrication. The suggested materials and methods for the lubrication of handpieces and contra-angles are numerous and apparently many have been chosen rather empirically.

Proper care of the dental handpiece and contra-angle involves (1) cleaning, (2) sterilization, (3) lubrication, and (4) adjustment. It seems, therefore, that an evaluation of the lubricating properties of a representative group of lubricants would be the first order of investigation into the general problem of care and maintenance of these instruments. The methods of cleaning and sterilization are, at least to some extent, dependent on the type of lubricant used, while the mechanical adjustment of the handpiece is common with, but independent of, these factors.

The literature contains numerous references, but little information of value on the lubrication of dental handpieces and contra-angles, and only an empirical evaluation of the methods described.[3-6, 8, 10, 11, 14, 17, 19, 20] Except for one of these articles,[14] the lubrication described is accomplished during some form of hot fluid sterilization. Various cleaners or solvents are mentioned,[6, 10, 19, 20] but no basis for their selection is reported.

In this study, investigations of lubricating fluids were made in 4 areas: (1) viscosity, (2) stability of the fluids under heat, (3) practical evaluation in the straight handpiece, and (4) practical evaluation in the contra-angle.

Viscosity.—The viscosity of a fluid is its resistance to change of form or its "internal friction,"[12] and is one of the most useful characteristics in determining a suitable lubricant.[16, 25] Lubricating oils of low viscosity were suggested by various refineries[1, 9, 23, 24] as being most suitable for use on the straight handpieces and contra-angles.

The viscosity of a lubricating fluid varies according to the temperature, and becomes thinner, with a greater tendency to flow at higher temperatures. The viscosity is generally defined by the oil industry in Saybolt Universal Seconds, which is the length of time for 60 ml. of oil to flow through a given tube orifice at a given temperature. Temperatures of 70° F., 100° F., and 130° F.

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were chosen at the beginning of this study to test the viscosity, since it was believed these probably represented the extreme temperatures of use; such as a cool office, and beginning use of the handpiece, and a heated handpiece becoming uncomfortable to both the operator and patient.

A Saybolt Standard Universal Viscosimeter was used to record the viscosities of the various fluids sold specifically for dental handpiece lubrication and those suggested by companies in the lubricative field. These lubricants are shown in Table I. The viscosities presented in Fig. 1 and 2 show an extreme variation in the mineral oil and synthetic lubricants suggested for the dental handpiece, with greater dispersion of viscosities of the various fluids at 70° F. than at 100° F. and 130° F. The mineral base lubricants marketed specifically for dental handpiece use range from 67 to 358 Saybolt Universal Seconds at 100° F. The only proprietary dental synthetic lubricant in Fig. 2 is a silicone, which has a viscosity of 387 Saybolt Universal Seconds at 100° F.

TABLE I

Mineral Oil Lubricants	
A. Prorex C, Socony-Vacuum Oil Co.	K.* Ritter Engine Oil, Ritter Co., Inc.
B. Gargoyle Velocite Oil No. 6, Socony-Vacuum Oil Co.	L. Cadet Oil B, Sinclair Refining Co.
C.* Midwest M. O. Lubricant, The Midwest Dental Manufacturing Co.	M. Prorex D, Socony-Vacuum Oil Co.
D. Tellus Oil No. 15, Shell Oil Co.	N. Tellus Oil No. 23, Shell Oil Co.
E. Corvus Oil, The Texas Co.	O. Hydra Oil, The Texas Co.
F.‡ AC_{10} (Dental), The Midwest Dental Manufacturing Co.	P.* S. S. White Lubricating Oil, S. S. White Dental Manufacturing Co.
G. Lily White Spindle Oil AX, Sinclair Refining Co.	Q.* Solubri Oil, The Cleveland Dental Manufacturing Co.
H.* Germilitol, Kerr Dental Manufacturing Co.	R. L-912, Shell Oil Co.
I.* Denslube, Densco, Inc.	S.* Young's Dripless Oil, Young Dental Manufacturing Co.
J. Finol, USP	T.† Kadex Sterilizer Oil, The William Getz Corp.
	U.† Pelton Sterilizing Oil, Pelton-Crane Co.
Synthetic Lubricants	
1. OS-45, Monsanto Chemical Co.	5. Ucon LB-140-X, Carbide and Carbon Chemicals Co.
2. WS-2824, Penola Oil Co.	6. P-35, Penola Oil Co.
3. P-16, Penola Oil Co.	7. Ucon LB-170-X, Carbide and Carbon Chemicals Co.
4. SD-17, National Advisory Committee for Aeronautics	8.† DC-550, Dow Corning Corp.

*Proprietary dental lubricating oils.
†Proprietary dental sterilizing fluids.
‡Proprietary dental emulsifying oil for sterilization.

The proprietary dental sterilizing fluids tested are much more viscous than those oils used purely for lubricating purposes. This seems proper, since the less viscous fluids tend to volatilize at the higher temperatures of sterilization. The hydrocarbon lubricants *L, M, N* (Fig. 1) suggested by 3 oil refineries[1, 23, 24] as being the most suitable for use as sterilizing fluids were found to have similar viscosities. Although the viscosities of 3 greaselike lubricants as listed in Table III were not recorded, it has been observed that greases will act as their basic oils at speeds of around 20,000 r.p.m. with the close tolerances used in the handpieces.[26,29]

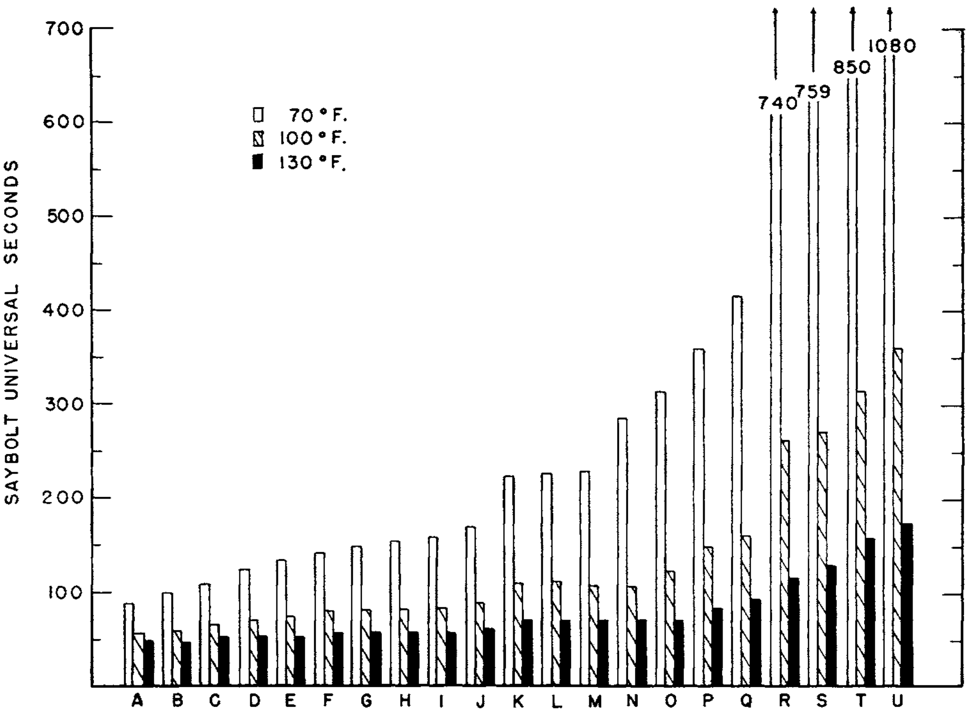

Fig. 1.—Viscosity—mineral oil lubricants.

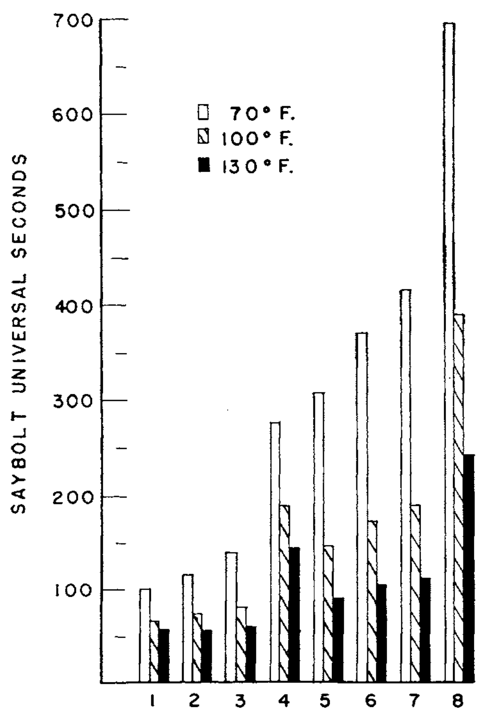

Fig. 2.—Viscosity—synthetic lubricants.

Stability of Fluids.—Many products are available to the dental profession which are advocated for use as a hot sterilizing fluid and lubricant. The oil refineries[1, 2, 9, 23, 24] contacted all expressed serious doubt that a straight mineral oil could be used for the purpose of sterilization at 300° F., because of the lack of thermal stability. A lubricant of suitable viscosity for the dental handpiece will generally be prone to give excessive volatilization at 300° F.[1, 2, 24] Three refineries,[1, 23, 24] however, submitted oils which they believed to be the most satisfactory for use for sterilization at 300° F.; the fourth[9] stated that a straight petroleum product would not be satisfactory. Some synthetic lubricants were suggested[23, 25] for testing as a sterilizing medium, since it was believed they might be more stable at the high temperatures of use.

To check the thermal stability of the various fluids, a Lindberg hot plate was used which has a uniform heating surface. Two-hundred-fifty milliliter Erlenmeyer flasks were each filled with 100 ml. of the fluid. Thermometers resting at the bottom of the flasks registered 300° F. for 50 hours. Odor and color were noted before and following the heating. The volume loss was also recorded. From Table II it is evident that of the mineral oil lubricants tested for thermal stability, those white oils of highest viscosity appear to be most stable in color and odor. Those oils which had slight yellow coloration before being heated had the greatest color change. The volume loss of the mineral base products ranged from 4.5 to 15.0 per cent and appears to be independent of viscosity, color, or odor. Color can be misleading as an indication of oil breakdown, however, since some high temperature antioxidants turn color quite easily on heating with no change in the base oil.[27]

Of the synthetic fluids, WS-2824, a diester, and SD-17, a silicone-diester blend, both produced a heavy sediment with the former also having an objectionable odor. OS-45 and tetra (2-ethylhexyl) silicate, both silicate esters, seemed to hydrolize in the presence of moisture. It was noted that when 2 per cent of water was placed in the fluid and the fluid held at 98° F. for an extended period of time, hydrolysis occurred resulting in the formation of a fine precipitate. Water added to the tetra (2-ethylhexyl) silicate at 250° F. resulted in the formation of a gel-like mass within a few hours. This precipitate was not soluble in benzene, carbon tetrachloride, or Stoddard Solvent. Such an occurrence in practice would exclude the use of this material, since greater abrasive wear might occur.

The UCON lubricant LB-170-X, a polyalkylene glycol, is essentially the same type of lubricant as LB-70-X, the difference being in the molecular weight of the polymer. The former has a viscosity of 170 Saybolt Universal Seconds at 100° F. while the latter is 70 Saybolt Universal Seconds at 100° F. The difference in volume loss should be noted, the less viscous material losing about five times as much as the other. The color change is also less with the LB-170-X. The odor of all the UCON products is satisfactory both before and following heating. During use in the sterilizer, a slight nonobjectionable odor of alcohol persists immediately over the surface of the fluid.

TABLE II

THERMAL STABILITY OF LUBRICANTS

PRODUCT	COLOR	ODOR AT ROOM TEMPERATURE	VOLUME LOSS (ML.)
Mineral Oil			
Pelton Sterilizing Oil	Clear white to light straw yellow	None to sweetish oil	9.0
Johnson Sterilizing Oil	Clear white to light straw yellow	None to slight oily	15.0
Kadex Sterilizer Oil	Light straw yellow to orange	Slight oily to slightly objectionable	7.0
Shell Tellus 23	Light straw to brownish black, sludge	Pungent oily to very objectionable	11.5
Sinclair Cadet B	Light straw to wine red	Oily to slightly objectionable	4.5
Socony-Vacuum Prorex D	Light straw to dark wine red	Oily to decidedly objectionable	5.5
Synthetic			
SD-17	Light greenish-yellow with slight dark sediment to deep reddish brown with much black sediment; reddish crystalization at neck of flask	Slight lacquer, unchanged	5.5
OS-45	Clear orange, unchanged	Characteristic pungent odor became objectionable during first 3-4 hours of heating, then disappeared; at room temperature, unchanged	7.0
UCON LB-170-X	Clear orange to clear red	Slight alcohol odor, disappears	3.5
WS-2824	Greenish orange with slight green sediment to deep reddish black with heavy sediment	Slight pungent to objectionable	4.0
UCON LB-70-X	Clear orange to dark reddish brown	Alcohol to none	17.0
UCON di (2-ethylhexyl) adipate	Very light clear orange to dark red	Slight alcohol to none	3.0
UCON 818-X	Clear orange to dark reddish brown	Slight alcohol to none	3.0
UCON HB-100-X	Clear orange to dark reddish brown	Very slight alcohol to none	5.5

Lindberg Hot Plate.
Temperature: 300° F.
Time: 50 hours.
Volume: 100 milliliters.

The DC-550 silicone has been in use for some time in the clinic at the School of Dentistry, University of Michigan, and has shown excellent thermal stability at 300° F.

A Pelton Hot Oil Sterilizer which operates at 250° F. was used to check the thermal stability of LB-170-X and Whip-Mix Sterilization Fluid No. 20 for 675 continuous hours. The LB-170-X had the same color change as noted when exposed to 300° F. for 50 hours. No objectionable odor was noted immediately over the surface of the fluid during heating or following. No objectionable odor was noted with the Whip-Mix fluid, but the color change was from clear white to deep wine red.

Although no viscosity measurements were run following heating of any of the fluids, it seemed apparent that an increase in viscosity did occur in all the fluids.

Practical Evaluation of Lubricants in the Straight Handpiece.—The lubricative ability tests were carried out directly on the handpiece under the conditions in which the lubricant would be used. It has been observed that bench tests give little or no reliable information concerning the lubricating ability of a product.[25] There is no laboratory research apparatus which reproduces, in all respects, the conditions under which the lubricant must perform.[15]

The properly adjusted straight handpiece was held in the middle area of the sheath by a clamp on a ringstand at a 20-degree angle from horizontal, with the nose end pointing downward. A mandrel was inserted through a ball bearing support from which a weighted pan was hung so that a load could be placed on the handpiece.

Chromel-alumel thermocouples were held in intimate contact with the sheath directly over the nose bearing and rear bearing by means of rubber elastics. The temperatures were recorded each minute for each bearing on a Leeds-Northrup Recorder during the 5-minute continuous run.

The handpiece was cleaned before each test run with Stoddard Solvent by using a small spiral brush, then blown dry with filtered compressed air, and the lubricant sparingly applied from the original container with a clean metal rod, while the handpiece was disassembled. The belt tension was properly adjusted for a particular handpiece, and all tests carried out for that handpiece, so far as possible, to eliminate the necessity of changing belt tension for each run. The belt tension was established by running the handpiece with the foot control in the highest position to establish the maximum spindle speed, as determined by a tachometer, and at the same time having the belt free from oscillations. With experience, this maximum speed can be approximated by ear, but should be checked with a tachometer to establish the speed of rotation. The belt tension thus established allowed a 7.5 to 8.0 cm. separation between the drive and return sides of the belt when a 200-gram weight was placed on the middle of the belt. The speed used was 15,400 ±600 r.p.m. A constant check was maintained on the belt tension.

It should be noted that the Chayes Model 3 handpiece was lubricated with Molykote and cleaned with the recommended cleaner according to the manufacturer's instructions. This was accomplished following the check tests made with other lubricants because of the nature of the Molykote lubricant and its tendency to adhere to the bearing surfaces even when a cleaner is employed.

The data in Table III represent the rise in temperature above the ambient temperature, measured directly over the bearings on the sheath at the end of the 5-minute run. Three new handpieces were used each with a 200-gram load.

The use of lubricants, not otherwise discarded for various reasons, shows that for most tests runs the nose bearing of the Chayes Model 3 dental handpiece ran cooler than did the nose bearings of the S. S. White No. 9 and Midwest Hi-Speed. However, the rear bearing of the Chayes handpiece ran consistently warmer than the rear bearing of the other 2 handpieces. The Chayes rear bearing ran warmer than the nose bearing when the viscosity went above 150 Saybolt Universal Seconds at 100° F. This difference in temperatures developed is probably due to mechanical design and physical construction of the bearing surfaces.

For lubricants with a viscosity below 150 Saybolt Universal Seconds at 100° F., the temperature rise above the ambient temperature in the Chayes handpiece did not exceed 35° F. for either bearing. The highest temperature recorded was 61° F. for the rear bearing while using a silicone DC-550; the nose bearing temperature rise was 46° F.

The lowest temperature rise for the combination of both bearings was obtained with Prorex C, a Socony-Vacuum oil with a viscosity of 58 Saybolt Universal Seconds at 100° F. in the Chayes Model 3 handpiece.

TABLE III

PRACTICAL EVALUATION OF LUBRICANT IN STRAIGHT HANDPIECE

	VISCOSITY AT 100° F. (SUS)	°F. RISE ABOVE AMBIENT TEMPERATURE					
		S. S. WHITE NO. 9		MIDWEST HI-SPEED		CHAYES MODEL 3	
		REAR	NOSE	REAR	NOSE	REAR	NOSE
Mineral Oils							
S/V Prorex C	58	9	36	15	32	26	16
S/V Gargoyle Velocite	61	6	29	11	33	14	28
Midwest Lub.	67	8	44	22	47	26	33
Shell Tellus 15	71	15	39	16	41	25	32
Texaco Corvus	75	10	46	13	43	26	27
AC_{10}	78	12	42	21	33	29	30
Sinclair Lily White AX	82	7	33	21	31	30	30
Germilitol	84	15	36	18	38	28	30
Denslube	84	17	41	22	47	30	33
Finol, USP	91	20	45	8	35	28	28
Ritter Engine Oil	108	16	33	31	32	25	35
Texaco Hydra	125	10	35	13	38	24	32
S. S. White Lub. Oil	148	21	36	26	46	33	24
Solubri	160	24	44	30	45	38	34
Shell L-912	263	17	49	18	34	30	41
Young's Dripless	271	35	70	18	56	39	37
Kadex Ster. Oil	315	20	49	45	37	46	36
Pelton Ster. Oil	358	15	62	50	89	50	35
Pfingst Zenith Oil*		16	60	32	76	32	40
Johnson Ster. Oil*		50	49	52	100	33	47
Greaselike Lubricants (Mineral Base)							
S. S. White Handpiece Ease*		15	49	29	51	34	45
Densco Absorbed Oil*		13	47	37	59	35	45
Lubriplate*		19	73	40	55	34	52
Synthetic Lubricants							
UCON LB-70-X*		14	29	21	41	34	34
UCON 818-X*		23	34	24	36	32	25
UCON Adipate*		13	36	21	41	18	31
UCON 50-HB-100-X*		15	39	30	66	30	44
UCON LB-140-X	146	15	62	27	47	16	36
UCON LB-170-X	187	20	56	41	87	48	47
DC Silicone 550	387	57	92	50	92	61	46
DC Silicone XF-4140*		40	80	51	106	45	44
GE Silicone 81406*		18	113	42	87	51	34
Linde Air Silicone X-522*		43	77	54	93	28	51
Whip-Mix Ster. Fluid #20*		34	32	26	58	43	40
Molykote*				8†	88†	5	17

*Saybolt viscosity not determined on these products.
†Stopped run at end of 3 minutes.

The S. S. White No. 9 and Midwest Hi-Speed handpieces have similar rises in temperature over the bearings. In all test runs on the S. S. White No. 9 and Midwest Hi-Speed except one, the nose bearing heated more than the rear bearing, the ratio being as low as 31°/32° to a high of 8°/44°. The exception occurred with the Whip-Mix Sterilization Fluid No. 20 on the S. S. W. No. 9 where the ratio of temperature rise of rear and nose bearing was 34°/32°.

The S. S. White Handpiece Ease and Densco Absorbed Oil reacted similarly in each of the 3 handpieces. When using grease type lubricants, the temperature rise over the nose bearing varied from 45° F. to 73° F.; over the rear bearing from 13° F. to 40° F., being highest with the Midwest handpiece.

Although there is a general trend toward higher bearing temperatures as the viscosity of the lubricant increases, there are many fluctuations which occur.

The Densco Ball Bearing Handpiece was tested using Denslube on the nose bearing; the rear bearing is packed at the factory. At the end of 5 minutes with a 200-gram load there was a temperature rise of 8° F. and 10° F. over the rear and nose bearings, respectively.

Practical Evaluation of Lubricants in the Contra-Angles.—The lubricants used in the contra-angles were evaluated in essentially the same manner as was used for the straight handpieces. The straight handpiece was positioned in a plane 20 degrees to vertical so that the mandrel in the contra-angle was lying horizontally. The load thus placed on the contra-angle would be similar to that when a pulling force was applied to the handpiece during cavity preparation.

The thermocouples were placed at the head of the contra-angle and at the elbow. No water or air coolants were used with the Chayes WWCL. The results obtained are shown in Table IV.

TABLE IV

PRACTICAL EVALUATION OF LUBRICANT IN CONTRA-ANGLE

LUBRICANT	VISCOSITY AT 100° F. (SUS)	°F. RISE ABOVE AMBIENT TEMPERATURE					
		SSW-U		DENSCO UFS		CHAYES WWCL	
		ELBOW	HEAD	ELBOW	HEAD	ELBOW	HEAD
Prorex C	58	10	11	19	21	22	25
SSW Lub. Oil	148	17	21	25	30	25	21
Pelton Ster.	358	29	37	26	30	52	60
Densco Absorb.	—	26	29	23	26	40	51
50-HB-100-X	100*	16	21	26	32	40	54
Angle-Lube (grease with molybdenum disulfide)	—					45	47
81406 (silicone)	—	31	37			40	37

*Reported by Carbide and Carbon Chemicals Co.

Five representative lubricants from the low, middle, and high viscosity mineral base products, as well as a grease and synthetic fluid were tested with three contra-angles. A grease containing molybdenum disulfide, and a new silicone product were also checked in 2 of these contra-angles.

It is shown in Table IV that all 3 contra-angles ran progressively warmer as the viscosity of the mineral oil increased. The use of the greaselike lubricant resulted in slightly lower temperatures than with the most viscous oil, while the synthetic UCON lubricant reacted similar to the middle viscosity oil in the S. S. White and Densco contra-angles, and as the grease in the Chayes contra-angle. The head of the contra-angles operated at a slightly higher temperature than did the elbow in most of the test runs.

Cleaners.—

The gears and bearings of the contra-angles and straight handpieces may become contaminated with bits of some revolving instruments, cut tooth tissue, polishing material, and fluids during use in the mouth. Cleaning immediately after use, therefore, becomes essential, otherwise abrasive wear will tend to occur more rapidly.

Various cleaners have been advocated including carbon tetracholoride and various petroleum distillates. The carbon tetrachloride is generally not used industrially for the cleaning of precision machinery. This solvent, in the presence of moisture and light, liberates traces of hydrochloric acid which are very corrosive to metals.[7, 18] Statements are sometimes made that carbon tetrachloride leaves a residual film. This residual film upon examination has been proved to be either residual moisture (which the carbon tetrachloride does not remove) or particles of insoluble dust that adhere to the surface. Although carbon tetrachloride is a good solvent for most industrial lubricants, it does not touch some.[13]

Carbon tetrachloride has the advantage over any of the petroleum distillates of being noninflammable, although it has a fairly high toxicity. Of the petroleum products which appear suitable for use as a handpiece cleaner, Stoddard Solvent has a flash point (closed cup) of more than 20° F. higher than the others. Marsden[18] stated that Stoddard Solvent is almost identical with British Standard White Spirit and very similar to American "Mineral Spirit." Its flash point is 100° F. This solvent is generally not considered to present any industrial hazard due to its relatively low vapor pressure and it is not corrosive to metals. Sax[28] listed Stoddard Solvent as "safety solvent naphtha" which is a flammable liquid of moderate fire hazard, but not susceptible to spontaneous heating. Quadland[22] called Stoddard Solvent a high flash point petroleum solvent of low toxicity.

Stoddard Solvent was generally used during this investigation for the removal of the various lubricants. Its effectiveness, as judged empirically, was good. Solvents which meet the Standard Stoddard's specifications are inexpensive and readily available from petroleum distributors.

Since moisture may be a contaminator of the handpiece and contra-angle, and since neither the petroleum nor chlorinated solvents used are miscible with this moisture, difficulty might arise in obtaining suitable cleanliness of the instruments. It appears possible that some of this moisture, along with other contaminators, might be trapped in bearing crevices or between gear teeth.

This trapped material would become an undesirable residue. Thus, some method of dispelling this moisture and any suspended particulate matter would seem highly desirable.

DISCUSSION

Viscosity is obviously an important factor in the selection of a lubricant as is illustrated by the difference in temperature rise of the sheath directly over the bearings when using fluids of different viscosities. This temperature is probably of greatest practical interest to the dentist, since the temperature of the sheath will influence both his and the patient's reactions toward the handpiece and the life of the handpiece bearings.

It was noted that there was progressively closer agreement in viscosities when tested at 100° F. and 130° F. than at 70° F. This phenomenon can be graphically shown by projecting the measured viscosities on an A.S.T.M. Standard Viscosity—Temperature Chart. If the temperature rise of the sheath ranges from 6° to 113° F., the temperature rise at the interface of the bearings, or of the lubricant itself, probably is much higher, since a great amount of heat is dissipated throughout the surrounding area of the bearing. While the handpiece is in operation, the viscosity of the lubricants will be in closer agreement with each other than is indicated by the observations recorded in Figs. 1 and 2. At 70° F. the viscosities of the mineral base products range from 89 to 1080 Saybolt Universal Seconds; at 100° F. from 61 to 358 Saybolt Universal Seconds; at 130° F. from 52 to 170 Saybolt Universal Seconds; and when projected to 200° F., they range from about 35 to 60 Saybolt Universal Seconds. Therefore, there probably is some quality other than viscosity which influences the ability of a fluid to lubricate the dental handpiece.

Some of the lubricants obtained from the refineries contained antifriction additives while others were straight mineral oils. The presence of additives in the proprietary dental lubricating oils was not determined. It appears that the use of some nontoxic additive material to reduce friction and increase the load carrying ability of the lubricant might be employed to some advantage. More study of the nature of additives in lubricants for dental handpieces and contra-angles is indicated.

Certain of the more viscous white oils could be used as sterilizing or disinfecting fluids with some restrictions on the temperature and length of time used. Mineral base oils tend to become acid when they decompose.[26] The data show, however, that the use of such an oil would not provide sufficient lubrication at moderately high speeds of operation with light loads. Although the data presented showing temperature rises over the bearings were recorded at the end of a 5-minute run, it was noted that approximately 50 per cent of this rise occurred at the end of 1 minute and 75 per cent at the end of 2 minutes. Thus, it is probable that for relatively short interrupted runs, the temperature might readily become uncomfortable to the operator and patient.

Of the various types of synthetic fluids tested, the polyalkylene glycol derivatives (UCON products) appear to warrant further investigation. Although the polyalkylene glycol derivatives are not as stable as the silicones, they are much better lubricating fluids. When the UCON fluids break down at decomposition temperatures, they tend to form soluble fluids or volatile products instead of sludge or varnish. The UCON products are available in a wide range of viscosities in either water-soluble or insoluble form; their toxicity is low.

The mechanical design and the material used in the construction of the dental handpiece will influence to some extent the effectiveness of a lubricant. Differences will exist from one handpiece to another of the same manufacturer. Each handpiece will also vary in its performance due to differences in care and use.

The belt tension is quite critical and influences both speed of the handpiece and temperature rise over the bearings. A speed of 14,800 r.p.m. was achieved with one handpiece with a belt tension which provided a separation of 7.5 cm. between the drive and return sides of the belt with a 200-gram load hung from the middle of the span between the motor and the elbow. The speed decreased to 12,250 r.p.m. when the belt tension was increased to give a 5.0 cm. separation. Table V shows the temperature rise in degrees Fahrenheit over the rear and nose bearing when the Midwest Hi-Speed handpiece is operated with a 100-gram load and no load, and with varying belt tension. The lubricant was Midwest M. O. Lubricant.

Table V
Effect of Belt Tension on Bearing Temperature

		Belt Tension 7.5 cm.		Belt Tension 5.0 cm.	
		No Load	100 gm.	No Load	100 gm.
		°F. Rise Above Ambient Temperature			
1 min.	Rear Bearing	12	12	9	10
	Nose Bearing	22	23	53	32
2 min.	Rear Bearing	18	20	19	19
	Nose Bearing	30	34	65	29
3 min.	Rear Bearing	20	23	24	26
	Nose Bearing	30	43	72	38
4 min.	Rear Bearing	25	27	32	30
	Nose Bearing	26	43	75	51
5 min.	Rear Bearing	25	29	34	32
	Nose Bearing	27	44	81	59

It was observed that when a handpiece was placed into a sterilizing fluid and the excess oil drained off leaving the residual oil as the lubricant, the temperature rise of the bearings was somewhat greater than when the cleaned handpiece was lightly lubricated with an applicator. The greater the amount of residual oil removed from the handpiece, the less was the temperature rise of the bearings. This occurrence might substantiate the common thought that excess lubricant is detrimental. Difficulties resulting from overlubrication far outweigh those arising from underlubrication; excessive heat generation, rapid deterioration of the lubricant and leakage from the instrument will result.[2] Since viscosity is a measure of a lubricant's internal friction, it would appear that the more viscous a lubricant and the greater the amount of lubricant, the more shear forces would occur between the molecule of the fluid. Thus, a greater quantity of heat would be given off.

SUMMARY

This report has presented an evaluation of a representative group of lubricants for the dental handpiece and contra-angle. The viscosities of the liquid petroleum lubricants range from very light oils to heavy oils at 70° F., but become much less widely dispersed as their temperature approaches the operating temperature of the bearings. The greases react as a medium viscosity oil.

The fluids for use as sterilization media, thus far investigated, are either not stable or are of too great viscosity to provide good lubrication. A few of these synthetic fluids have some favorable characteristics and should be investigated more thoroughly.

Some factors to consider in the selection of a proper cleaner for the handpiece and contra-angle are discussed. The effect of belt tension on the speed of the handpiece and operating temperature of the bearings is pointed out.

It appears that from the evidence presented in this report, certain suggestions could be made for the proper day-to-day care of the handpieces and contra-angles, which are to be used at speeds up to 15,500 r.p.m. For operating speeds in excess of 15,500 r.p.m. further investigation should be accomplished.

1. Stoddard Solvent readily removes the petroleum and synthetic lubricants used in this study from the disassembled handpiece and contra-angle. This solvent is of relatively low toxicity, and with reasonable precautions it should present no great fire hazard. Ethyl alcohol might profitably be used as a secondary cleaner to remove moisture from gears and bearings.

2. Highly refined oils of a viscosity less than 150 Saybolt Universal Seconds appeared to provide acceptable lubrication in the 3 handpieces tested when applied sparingly to the disassembled instrument. Molybdenum disulfide appears to lubricate stainless steel on Pyrex sleeve bearings when used according to manufacturer's instructions.

3. The light oils provide adequate lubrication for the gears and bearings of 3 contra-angles tested when sparingly applied directly to these parts.

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