Useful adjuncts for vitreoretinal surgery

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SUMMARY Many vitreoretinal procedures are performed in offices and hospitals where cost control is important. We describe three useful devices and techniques that facilitate these procedures at minimal expense and often greater convenience. These include an accurate method for localising the pars plana without the use of callipers, an inexpensive, reliable, pressure regulated air pump for fluid-air exchange, and an easy method for intraocular injection of silicone oil through 20 gauge instrumentation without the need for expensive pumps. These procedures and techniques should prove to be useful in the treatment of vitreoretinal disease.

Vitreoretinal surgical techniques are characterised by rapid technological change to treat eye disease optimally. Complicated retinal detachments associated with proliferative diabetic retinopathy and proliferative vitreoretinopathy are treated by vitrectomy, membrane dissection, long-acting gases, and in selected cases silicone oil. Endophthalmitis is often initially treated by vitreous aspiration and injection of intravitreal antibiotics. Pars plana injection of gas and air may be done in the office as part of pneumatic retinopexy and post-vitrectomy fluid-air exchange. We describe three instruments and techniques that should prove useful to the vitreoretinal surgeon. The techniques facilitate certain procedures which may now be done in the office or at hospitals that may not be fully equipped for vitreoretinal surgery.

Simple method for measuring the pars plana location in outpatient procedures

The pars plana ciliaris is considered to be the ideal site for the insertion of instruments and needles in posterior segment surgery and for intravitreal injections.[1] The pars plana occupies a zone between the posterior margin of the pars plicata ciliaris, approximately 2 mm posterior to the limbus, and the anterior border of the ora serrata. This zone is approximately 3 mm wide in the nasal quadrants and 4·5 mm wide in the temporal quadrants because of the varying location of the ora serrata.[2]

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The pars plana entry site is usually made 4 mm posterior to the limbus in phakic eyes so as to avoid the crystalline lens.[1] In aphakic or pseduophakic eyes an entry is made 3·5 mm posterior to the limbus to provide an additional margin of safety to avoid making peripheral retinal breaks.

In outpatient procedures such as pneumatic retinopexy,[3] air-fluid exchange,[4] and intravitreal antibiotic injections[5] it is important to localise the entry site accurately. These procedures must often be done in the office, sometimes on an emergency basis, where sterile callipers are frequently not available. We describe a method of marking the pars plana accurately with an easily identifiable ring imprint by means of a readily available, sterile, disposable syringe.

A lid speculum is placed between the lids. Retrobulbar or subconjunctival anaesthesia may be used. The conjunctiva is prepared with povidone-iodine and then irrigated with sterile saline. The distal end of a semi-rigid (plastic) 3 ml disposable syringe is pressed firmly and squarely on to the conjunctiva so that one edge of the tip is touching the limbus (Fig. 1). This makes a ring indentation 4·0 mm in diameter. An intravitreal injection placed at the posterior edge of the mark will be accurately located 4·0 mm from the limbus (Fig. 2).

The syringe may also be used after opening the conjunctiva to mark the sclera. Should a more lasting mark be desired, a sterile, surgical felt-tip marking pen may be used to stain the tip of the syringe. Pressing the stained syringe tip on the sclera leaves a 4·0 mm ring mark.

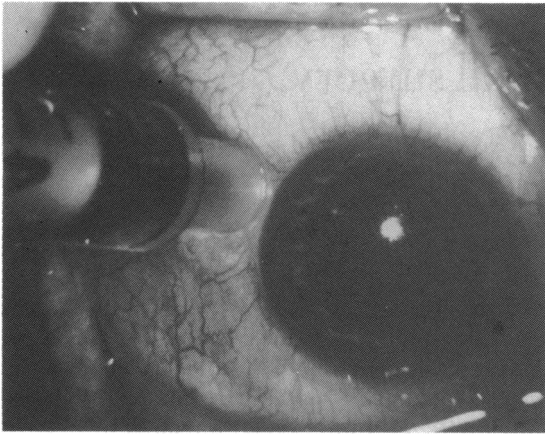This procedure provides a quick and easy method

Fig. 1   *A syringe tip is used to make a conjunctival imprint with the anterior margin at the limbus.*
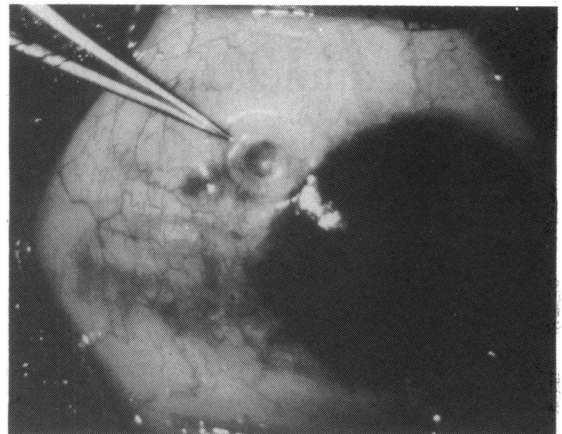

Fig. 2   *The forceps indicate the posterior margin of the ring imprint, which measures 4 mm in diameter and allows accurate placement of intravitreal injections.*

for accurately localising the mid pars plana zone for intravitreal injections in the outpatient setting. Semi-rigid plastic syringe tips have standard outer diameters of 3·925–4·027 mm as required by the American National Standard Institute/Health Industry Manufacturers Association.[6] The dimensions are the same for both Luer lock and Luer slip tips. These syringes are available in most hospitals and offices, are sterile, disposable, and inexpensive. Accurate localisation of the pars plana injection site in the office should decrease the incidence of complications associated with this procedure.

Simple, inexpensive, pressure regulated air pump for fluid-air exchange during pars plana vitrectomy

Automated fluid-air exchange is an important technique in the repair of complex retinal detachments.[7] Several air pumps are commercially available at a cost between $2000 and $2500 to infuse air into the eye at a constant controlled pressure during aspiration of intraocular fluid.[8–10] These units will keep the eye inflated at accurate pressures during intraocular manipulation, scleral plug exchange, sclerotomy closure, and pneumohydraulic reattachment of the retina. This is a major improvement over previous techniques of fluid-air exchange by means of syringes[11 12] or hydrostatic pressure from intravenous bottles to displace air from a second bottle.[13] We have designed an inexpensive apparatus for fluid-air exchange that infuses air at a precise pressure, is continuously adjustable, and is as effective as instruments of much greater cost.

An aquarium style air pump outflow line is connected to the eye via a sterile 0·2 μm filter (Millipore Corp, Bedford, MA), disposable tubing (Model K-50L, American Pharmaseal, Valencia, CA), and a

vitreous infusion cannula. In this line are two ports. The first port acts as a bleeder line and is attached to a needle pressure relief valve. The second port is conected to a mercury or aneroid manometer borrowed from a sphygmomanometer (Fig. 3). The air pump has a rheostat to adjust gross changes in air flow. The rheostat is set during the initial case to deliver sufficient flow to prevent ocular collapse during rapid aspiration of vitreous chamber contents; thereafter the flow is the same with subsequent vitrectomies. The intraocular pressure is adjusted by turning the needle pressure relief valve. The manometer, calibrated in 2 mm increments, accurately measures the intraocular pressure in millimetres of mercury.

The components of this system can be purchased for less than $150, are portable, easily assembled, and reliable. As with expensive commercial models, this system maintains the intraocular pressure at a preset level during drainage of subretinal fluid, pneumohydraulic retinal reattachment, and other manipulations. This and similar units have been used as a primary instrument by the authors in over 100 vitrectomies in hospitals where cost control is important. It may also be used as a replacement should a primary commercial model become inoperable. We have found this unit to be safe and effective as a commercial fluid-air exchange pump with no complications and no noticeable difference in performance.

Useful technique for intraocular silicone oil injection

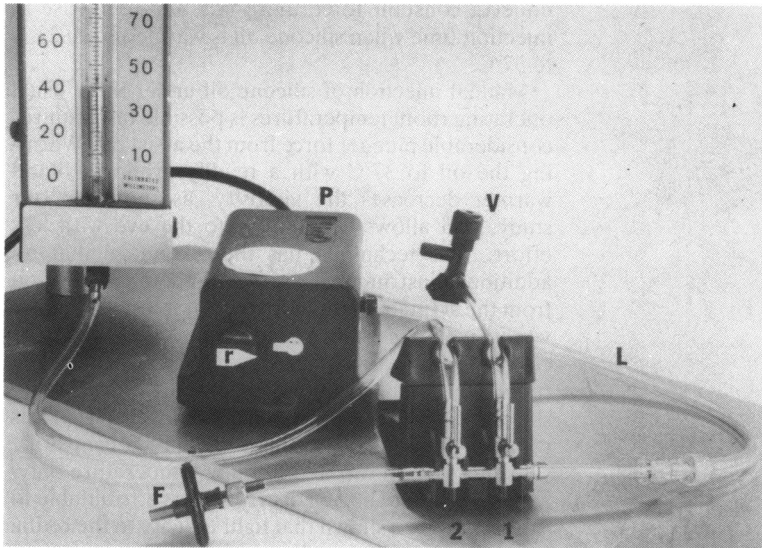Silicone oil tamponade is a useful adjunct in the repair of complex retinal detachments after intra-

Fig. 3 *Front view of pressure regulated vitrectomy air pump. The air pump (P) outflow line (L) is connected to the eye via a sterile Millipore filter (F) which can be coupled to a standard K-50L infusion line. In the outflow line are two ports. The first port (1) is attached to a needle pressure relief valve (V) to adjust the intraocular pressure. The second port (2) connects to the manometer for accurate measurement of the intraocular pressure. The rheostat (r), on the air pump, adjusts gross changes in air flow.*

ocular membrane dissection.[14-16] Motorised pumps[17] have been developed to inject the highly viscous oil through a 20 gauge needle into the eye. These pumps are expensive, may be awkward, and many require a source of compressed gas. Shortened 16 and 18 gauge needles have been reported to make injection and aspiration of the oil possible without special pumps, but this technique necessitates a much larger pars plana opening.[18] We have found that warming silicone oil to body temperature, using a water bath blood warmer found in most operating rooms, allows manual injection, with little resistance, through a 20 gauge infusion cannula; no extra instrumentation or pumps are necessary.

MATERIALS AND METHODS
We measured the time of a falling sphere through a known length of 1000 centistoke polydimethylsiloxane in a graduate cylinder as described by Gibson and Jacobs.[19]

The Stokes equation

$$\text{velocity}_{sph} = 2/9 \cdot \text{gravity} \cdot (\text{radius}_{sph})^2 \cdot \frac{\text{density}_{sphere} - \text{density}_{oil}}{\text{viscosity}_{oil}}$$

predicts that sphere velocity is an inverse function of liquid viscosity. The Walthers equation

$$\log\log(\text{viscosity}_{liq} + \text{constant}_{liq}) = \text{constant}_{liq}\log\text{temp}_{abs} + \text{constant}_{liq}$$

shows that viscosity is inversely proportional to temperature.[20] With all other variables kept constant, measurements of sphere velocity as a function of liquid viscosity were performed with ceramic balls (density=3·88 g/cm³) and nylon balls (density=1·32

g/cm³) at constant temperatures of 25°C and 37°C. Care was taken to perform measurements in the middle section of the cylinder to allow the ball to achieve uniform velocity. Wall effect was kept to a minimum by selecting a ball of small size and dropping it in the centre of the fluid column.

In addition we measured the time required for 3 ml of silicone oil to flow under force through a 1 inch (2·54 cm) 20 gauge blunt needle attached via an arterial line to a syringe. A 1·14 kg weight was placed on the plunger of a vertically mounted syringe and measurements were taken at 23°C (operating room temperature) and 37°C. Other investigators have used a similar weight to approximate the force a surgeon could easily sustain.[18] This experiment was done to simulate closely the actual conditions encountered in using the oil delivery system in the operating room.

RESULTS
The mean times for the ceramic balls to fall 3·7 cm at 25° and 37°C were 4·67 seconds and 3·67 seconds respectively. Times for the nylon balls were 107·60 s and 83·15 s for the same respective temperatures. Sphere velocities at each temperature were computed and change in velocity recorded. because of the direct relationship of sphere velocity to liquid viscosity it was shown that increasing the temperature of the silicone oil resulted in an approximate 22% decrease in oil viscosity.

The mean time for 3 ml of oil to flow through a 20 gauge needle under 1·14 kg at 23°C was 22 minutes. At 37°C the time was reduced to 15 minutes, a decrease of 32%.
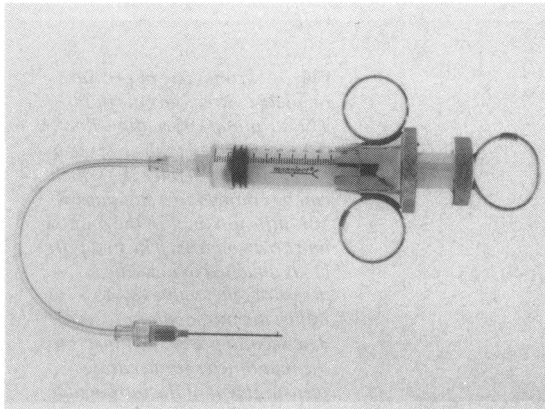
Fig. 4   *Manual delivery system for warmed medical grade silicone oil. The oil is placed in a 12 ml disposable syringe mounted in a convenient finger control attachment and is pushed through a 6 inch (15 cm) arterial monitor line with Luer lock connections (Medex Inc, Hilliard, Ohio, No. MX54OR) and 20 gauge blunt tip needle directly into the pressurised eye without the need of any pump.*

Discussion

The viscosities of several lubricating fluids, including silicone oils, at a variety of temperatures were examined by Murphy *et al.*[20] and plotted on a viscosity-temperature chart. From the straight line part of the chart they calculated the slope of a silicone oil having the same density as the oil used in our study (0·97 g/ml) to be 0·207. Using their chart to measure the change in viscosities from 25° to 37°C as a function of a given slope we calculated that an oil having a viscosity of approximately 1000 centistokes at 25°C will have a viscosity of approximately 750 centistokes at 37°C. This represents a percentage change in viscosity similar to our measured value.

The 1000 centistoke (measured at 25°C) silicone oil used in this study is the same oil viscosity used in the National Institutes of Health (NIH) approved National Silicone Oil Study and is in common use. We are aware that some surgeons use oil of higher viscosity. Increasing the temperature will decrease the viscosities of these oils as well, but the exact characteristics of other oils were not examined in this study. We[21] and others[22] have found that injection of oil is best done through a vitrectomy port with a short 20 gauge blunt needle while constant manual pressure is maintained (Fig. 4). However, this makes it necesary to inject under higher pressures than is achieved with larger bore needles. Temperatures in the operating room typically are set at 23°C, and the viscosity of fluids is higher than at standard room temperature (25°C). Our experiments show that under a constant force there is a 32% decrease in injection time when silicone oil is warmed from 23°C to 37°C.

Manual injection of silicone oil under these usual operating room temperatures is possible but requires considerable plunger force from the assistant. Warming the oil to 37°C with a readily available blood warmer decreases the viscosity, as shown in our study, and allows it to flow into the eye with less effort. This technique has the advantage that no additional instruments are required to express oil from the syringe. Although we did not test any higher viscosity oils, resistance to injection should theoretically be significantly decreased. There have been reports that emulsification can occur in lower viscosity silicone oil.[23] However, we have not experienced this with our method of injection. The 1000 centistoke silicone oil is prewarmed to body temperature only, and there should be no adverse effects attributable to this. It has been shown that light toxicity to the retina from the intraocular fibreoptic probe may occur during infusion of hyperthermic solutions[24] and we cannot recommend heating the oil to temperatures above 37°C. Because we inject the oil at the very end of the procedure there would probably be no phototoxicity. We have had no difficulty injecting silicone oil into the eye by this method and have used it, without complication, in the last 50 cases at our institution.

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