Teat-end Hyperkeratosis:
1. Mechanical Forces Applied by the Liner

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Smooth Ring (S) Rough ring (R)

Photos: Utrecht University
De Man, Schukken & Koeman
(Courtesy: F. Neijenhuis, 2002)

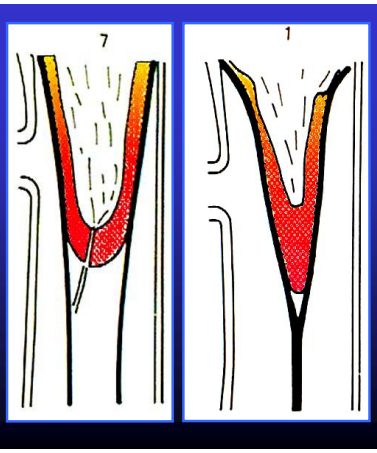
Main factors influencing the degree of teat-end hyperkeratosis

- Climate and local environment
- Milking management
- Teat shape and milk yield

- Milking machine effects
  - milking time at low flow rate
  - "strength" and rate of pulsation
  - liner characteristics

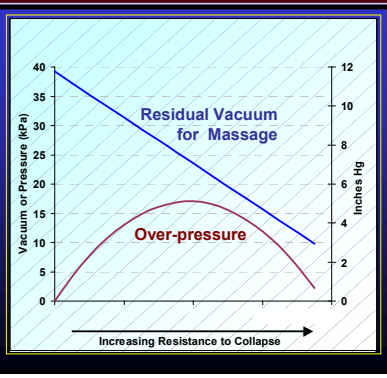
Over-pressure ("Compressive Load") applied to teat by the liner

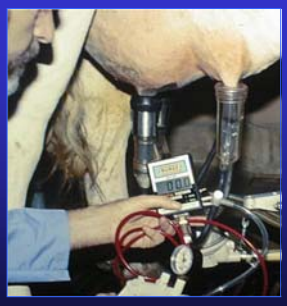
"The pressure, above atmospheric pressure, that is applied to the teat-end by the liner as it closes around the teat in each pulsation cycle."

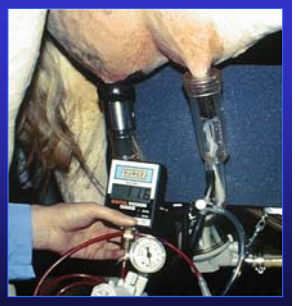


Ardran *et al* (1958)

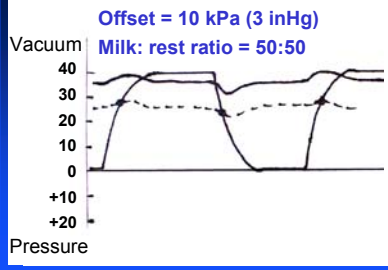
Over pressure applied by a liner and "residual vacuum available for massage"



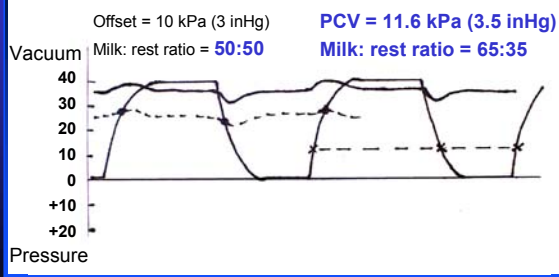




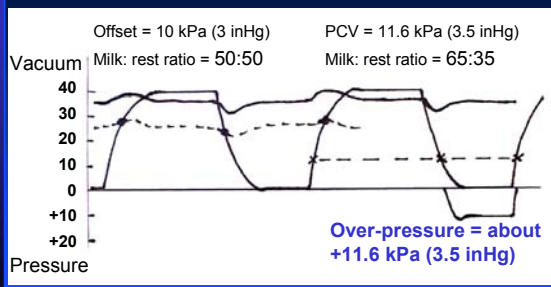
Liner offset, milk:rest ratio and "residual vacuum for massage"



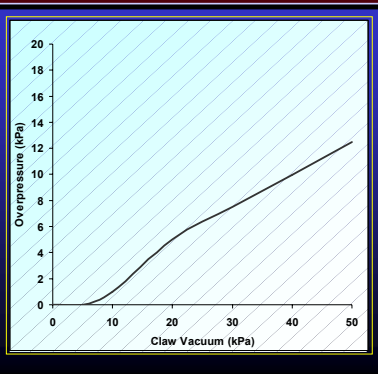
PC vacuum at start of milk flow and the true milk: rest ratio



PC vacuum at start of milk flow and "over-pressure" applied to the teat



Over pressure applied by a liner plotted against increasing vacuum level



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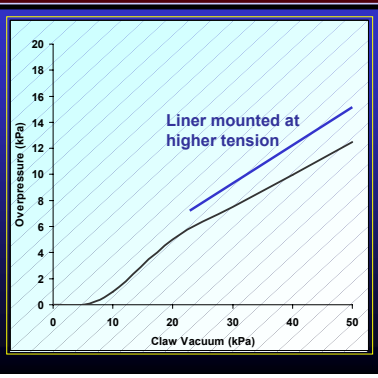
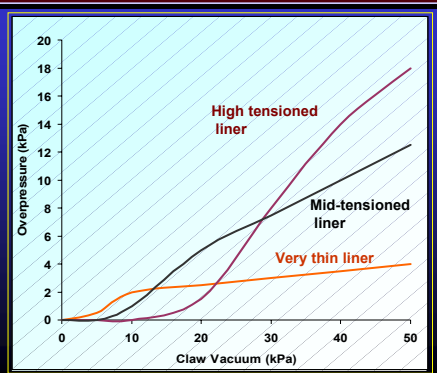
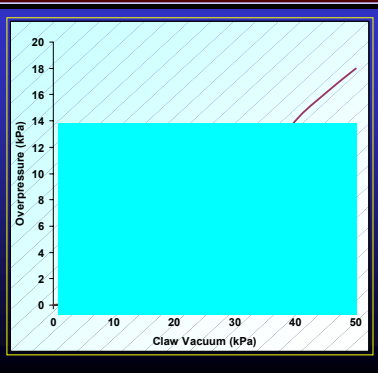


Over pressure applied by different liners with increasing vacuum level



Over-pressure applied by different liners relative to the pressure required to relieve congestion and edema

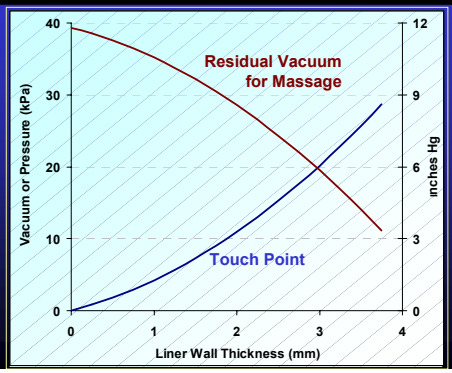


Excessive pressure causing hyperkeratosis

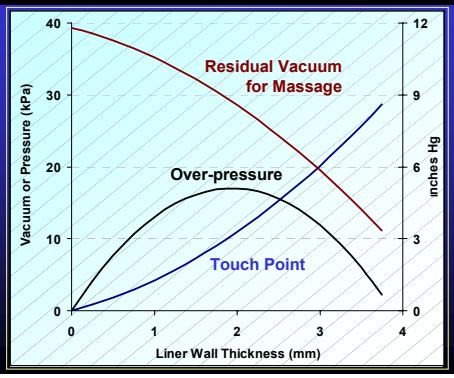
Range of required pressure

Too little pressure causing congestion

"Touch Point" and "Residual Vacuum" for 18 different liners



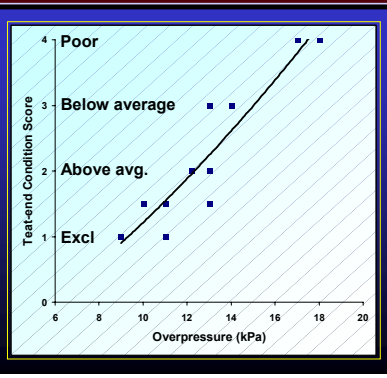
Over-pressures produced by these 18 liners



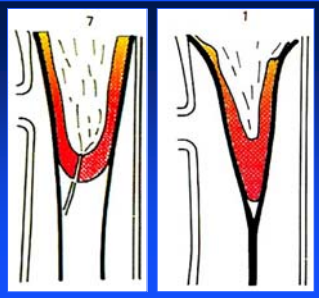
What happens in the "real world"?

- Over pressure applied to cows' teats can vary from 3-20 kPa (1-6 inHg) for exactly the same pulsator settings!
- Over pressures less than about 8 kPa (2.5 inHg) appear to be too low to relieve teat congestion
- Some liners apply too much pressure to the teat. This appears to induce increased teat end hyperkeratosis

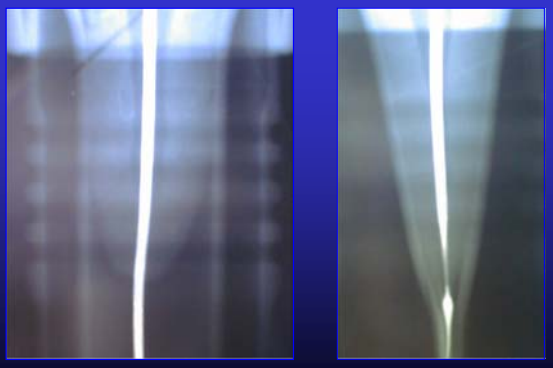
Over-pressure applied by 7 different liners plotted against ranking of teat-end condition in US herds



Information from radiographic studies



Ardran *et al* (1958)



Liner open

Liner closed

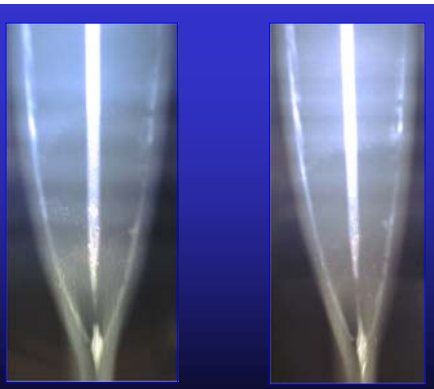
How the teat canal is closed by pressure applied via the closing liner

PCV = 8 inHg

4 inHg

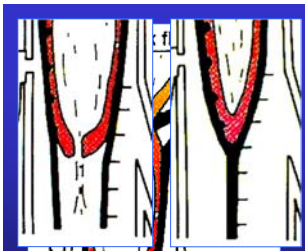
2 inHg

0 inHg

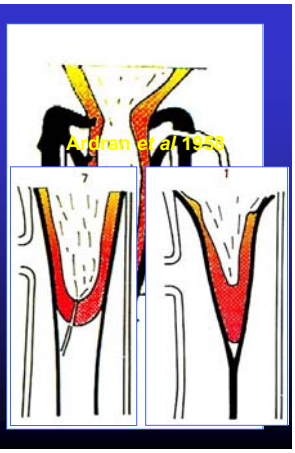


Shell length = 127 mm (5.0 in)

150 mm (6.0 in)



Main *et al* 1973



Ardran *et al* 1958

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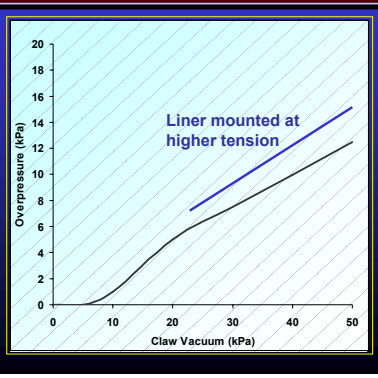

Conclusions:
Mechanical Forces Applied to the Teat

1. The skin around the teat orifice is subjected to an inherent dilating force applied by a calf, a hand-milker or by the "over-pressure" applied by a liner.
2. The dilating force is higher when the liner is closed than when it is open!

   eg, 12.5 inHg in the open liner

   (12.5 + 6) inHg in the closed liner

Conclusions:
Over-pressure applied to the teat

3. Over-pressure is increased:
   - at higher vacuum level;
   - with 2X2 pulsation (relative to 4X1);
   - with higher liner tension.
4. Over-pressure is a better and more direct indicator of effects on teat-end condition and the true milk: rest ratio than the liner "touch point".

Conclusions:
Reducing Teat-end Hyperkeratosis

5. Over-riding factors are climate, milking management, teat shape and milk yield.
6. If desired, machine effects can be reduced by:
   - minimizing the total time per day that milk flow rate is less than 1 kg/min;
   - reducing the number of pulsation cycles per milking

Conclusions:
Reducing Teat-end Hyperkeratosis

6. (continued):
   - reducing the mounting tension of some high-tensioned liners;
   - controlling the pressure difference applied across the liner walls during the D-phase of the pulsation cycle.