INTRODUCTION:
Bone grafting is a well-established procedure for achieving stable implant fixation in conditions with poor bone quality or bone defects e.g. revision joint replacement. Ceramics such as tricalcium phosphate (TCP) and hydroxyapatite (HA) are used as bone graft extenders, as the supply of biological bone graft material is limited and is associated with morbidity.

Strontium is an antosteoporotic drug and is thought to be a "dual action bone agent", which stimulates osteoblastic differentiation as well as inhibits bone resorption. Strontium can substituted for Ca2+ in HA to form strontiumhydroxyapatite (SrHA). In this material, the strontium will inhibit bone resorption and may possibly stimulate bone formation. The strontium hydroxyapatite granules used in this study were synthesized with 5% Sr2+ substitution of Ca2+.

MATERIALS AND METHODS:
A paired experiment was conducted in 10 skeletally mature American Hounds, approved by the Institution’s Animal Care and Use Committee. Each dog received two porous-coated 6 x 10 mm Ti implants (DePuy) surrounded by a 2.5 mm gap in the proximal part of humeri.

The gap around the implants was impacted with (Fig. 1):
1. Allograft (50% by volume) + HA (50%)
2. Allograft (50%) + SrHA (50%)

The HA and SrHA granules were 0.6-2.0 mm in size and non-porous. Five percent of the calcium ions in the hydroxyapatite (Ca10(PO4)6(OH)2) were substituted by strontium ions in the SrHA group.

Implant fixation was evaluated blinded by biomechanical push-out test (axial shear, 5 mm/minute) after 4 weeks observation time. One set of samples had to be excluded due to misplacement of the implant during surgery. Normal distribution could not be assumed, and the data was evaluated by Wilcoxon sign rank test.

RESULTS:
The implants treated with SrHA as a bone graft extender had improved implant fixation in terms of shear strength, shear stiffness, and total energy absorption in the implant-graft interface, however not statistically significant (Table 1).

<table>
<thead>
<tr>
<th>Strength, [MPa]</th>
<th>Energy [J/m2]</th>
<th>Stiffness [MPa/mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA</td>
<td>1.20 (0.98-3.00)</td>
<td>157 (113-413)</td>
</tr>
<tr>
<td>SrHA</td>
<td>1.74 (1.26-3.35)</td>
<td>350 (193-588)</td>
</tr>
</tbody>
</table>

DISCUSSION:
In this study of in vivo primary response to SrHA bone graft extender we observed a trend towards improvement of all the mechanical parameters, indicating a stronger fixation of the grafted Ti implant with SrHA. This difference, however, was not statistically significant. Our findings correlate well with early experimental studies of strontium, which showed a strong anabolic and anti-catabolic effect, carried out on rodents and the in alveolar bone in monkeys. In our case the model was a challenging circumferential gap (2.5 mm) around a Ti implant. The latest clinical study of strontiumranelate used for systemic treatment of osteoporosis indicated a positive effect of strontium in terms of increased bone mass. Also in that study the increase was not significant. Our study was designed to detect a 30% increase in mechanical fixation, but suffered one exclusion and non-parametric data distribution. It may have been underpowered to detect more subtle effects of Strontium.

CONCLUSION:
Strontium doped HA granules as bone graft extender shows a tendency to improve implant fixation. The effect of the 5% substitution of Calcium with Strontium was insignificant probably due to too small a sample size. No deleterious effect of the strontium was observed.

ACKNOWLEDGEMENTS:

REFERENCES:
1 Marie,P.J. (2006). Bone 38, S10-S14
2 Xue,W. et al. (2007). Surface & coatings technology 201, 4685-4693
3 Liao,D.P. et al. (2000). Shanghai Kou Qiang. Yi. Xue. 9, 73-75