Update on D2E7: a fully human anti-tumour necrosis factor α monoclonal antibody

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Rheumatoid arthritis (RA) is characterised by persistent joint inflammation and concomitant joint destruction, and in severe cases with extra-articular manifestations, multiple joint involvement, and a significant reduction in life expectancy. In addition, functional decline and disability inevitably accompanies joint destruction. The extent to which most standard medical approaches have a positive impact on the course of rheumatoid disease is the subject of debate. Intense research effort has focused on understanding cellular inflammatory mechanisms that may serve as therapeutic targets.

Tumour necrosis factor α (TNFα) is a pleiotropic cytokine overproduced in rheumatoid joints primarily by macrophages. Although the causes of RA are not fully understood, TNFα seems to play a cardinal part in a variety of events in inflammatory synovitis and articular matrix degradation, and is therefore a prime target for directed immunotherapy in RA. Accordingly, antibodies and soluble TNF receptors that bind TNFα with high specificity neutralise its activity and have been developed for use as therapeutic agents. However, current anti-TNFα treatments for RA may be limited by their capacity to elicit immune responses to their non-human elements or artificially fused human sequences. The high specificity neutralisation potency of a previously perfected murine monoclonal antibody was transferred to a fully human IgG1 antibody format (D2E7). D2E7, a high affinity, recombinant, fully human anti-TNFα has no non-human or artificially fused human sequences. Therefore, D2E7 may have low immunogenicity and possibly greater therapeutic potential. D2E7 effectively neutralised a broad range of TNFα biological activities both in vitro and in vivo. For example, D2E7 inhibited binding of human TNFα to its p55 and p75 receptors on human cells and is highly selective for TNFα. It prevented severe polyarthritis in human TNFα expressing transgenic mice in a dose dependent manner and is currently being evaluated in clinical trials to treat RA.

Phase I studies
Several randomised, placebo controlled phase I trials have evaluated the safety and efficacy of D2E7 (table 1). All studies enrolled patients with longstanding, active RA. Efficacy was assessed using composite criteria, such as the American College of Rheumatology improvement criteria (ACR20). Study DE001 was the first exposure of patients to intravenous D2E7 treatment. After completing the double blind portion of the trial, patients were offered the opportunity to continue open label long term D2E7 treatment (DE003). Weekly subcutaneous administration of D2E7 was evaluated in study DE004. As monotherapy is often inadequate to control symptoms and rapid progression of RA, study DE010 evaluated D2E7 (1 mg/kg as a single subcutaneous or intravenous injection) as combination treatment in patients whose stable dose of MTX (median dose, 15 mg/week) was insufficient to control symptoms.

In these three phase I therapeutic trials, 198 patients have been treated with D2E7 as a single agent and in combination with MTX. The mean ages of patients ranged from 53 to 60 years, the mean duration of RA extended from 10 to 12 years, and the mean number of previous disease modifying antirheumatic drugs (DMARDs) received by patients in the trials was approximately 3.5. Used alone, single and multiple dose treatment with D2E7 produced ACR20 response in between 56% and 80% of patients. In contrast, the proportion of placebo treated patients achieving ACR20 response ranged from 0% to 16%. The therapeutic effects of D2E7 became evident within 24 hours to one week after administration and reached maximum effect after one to two weeks, with dose response plateauing at 1 mg/kg D2E7. Subcutaneously and intravenously administered D2E7 provided similar D2E7 plasma levels and comparable ACR20 response rates. At a dose of 1 mg/kg, subcutaneous and intravenous administrations were safe and efficacious when given with standard, stable doses of MTX. In the long term open label extensions, a high percentage of patients continued to receive treatment with D2E7 indicating that long term treatment with D2E7 in the dose range from 0.5 to 10 mg/kg was well tolerated.

<table>
<thead>
<tr>
<th>Study number</th>
<th>Number of patients receiving D2E7</th>
<th>Concurrent DMARD</th>
<th>Maximum ACR 20 response</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE001/003</td>
<td>120</td>
<td>No</td>
<td>80%</td>
</tr>
<tr>
<td>DE004</td>
<td>24</td>
<td>No</td>
<td>70%</td>
</tr>
<tr>
<td>DE010</td>
<td>54</td>
<td>MTX</td>
<td>67%*</td>
</tr>
</tbody>
</table>

MTX = methotrexate; iv = intravenous; sc = subcutaneous; DMARD = disease modifying antirheumatic drug. *With subcutaneous administration.
Update on D2E7

**Median values. JSN = joint space narrowing.**

The dose response relation of placebo and D2E7 (20, 40, and 80 mg), given in a double blind fashion as weekly subcutaneous injections, was evaluated in study DE007. A total of 283 patients were randomised into the trial. The mean age of patients was 52 years and the mean duration of RA was 10 years. Patients had previously taken a mean of 3.8 DMARDs.

All three doses of D2E7 were efficacious (49% to 57% of patients achieved ACR20 responder status compared with 10% with placebo, p<0.0001) and no dose response relation was apparent at month 3.

**Safety**

Patients with RA have been treated with intravenous and subcutaneous D2E7 for more than 12 months. Treatment with D2E7 has been well tolerated. The rate and severity of adverse events were comparable between all dosage groups of D2E7 and placebo. Large long term phase III trials comparing D2E7 with placebo or MTX are underway to further investigate the safety and efficacy of this fully human anti-TNF antibody.

**Conclusion**

Collectively, these early data suggest that the fully human anti-TNF antibody D2E7 is safe and effective as monotherapy or in combination with MTX when administered by single and multiple intravenous and subcutaneous injections. Additional studies are underway to further define optimal use of this novel treatment.

**Table 2**

<table>
<thead>
<tr>
<th>Duration of D2E7 treatment</th>
<th>6 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease duration (y)</td>
<td>12.1</td>
<td>12.6</td>
</tr>
<tr>
<td>Ratingen score*</td>
<td>35.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Sharp erosion score*</td>
<td>49.5</td>
<td>45.0</td>
</tr>
<tr>
<td>Sharp JSN score*</td>
<td>47.5</td>
<td>49.0</td>
</tr>
</tbody>
</table>

*Median values. JSN = joint space narrowing.

**Figure 1**

Effect of D2E7 on ratingen radiological progression score in 22 patients with films before study enrollment.

**Figure 2**

Effect of treatment with D2E7 on pro-matrix metalloproteinases (pro-MMP 1: solid square; pro-MMP 3: solid circle).

**Effects on pro-matrix metalloproteinases**

The pro-matrix metalloproteinases (pro-MMPs) play key parts in mediating inflammation and joint destruction in RA. The effects of D2E7 on levels of pro MPP-1 and 3 were investigated in a group of patients who took part in DE001/003. Pro-MMP1 and pro-MMP3 serum levels decreased by up to 50% within the first six months of D2E7 treatment (fig 2).

**Phase II study**

The dose response relation of placebo and D2E7 (20, 40, and 80 mg), given in a double blind fashion as weekly subcutaneous injec-

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